12-2021

Designing Digital Antiquity: Classical Archaeology in New Virtual Applications

William Loder
University of Arkansas, Fayetteville

Designing Digital Antiquity: Classical Archaeology in New Virtual Applications

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Arts in Comparative Literature and Cultural Studies

by

William Loder
University of Arkansas
Bachelor of Arts in Classical Studies, and History 2015

December 2021
University of Arkansas

This thesis is approved for recommendation to the Graduate Council.

_____
Rhodora Vennarucci, Ph.D.
Thesis Director

_____
David Fredrick, Ph. D.
Committee Member

_____
Luis Restrepo, Ph. D.
Committee Member

Abstract

In this thesis, I argue that the combination of existing archaeological theory with game design theory offers an innovative avenue for creating serious 3D applications of archaeological sites in virtual reality that can be productively used for pedagogical, research, and outreach solutions. In this thesis, I engage with the archaeological theories of phenomenology and sensory studies, briefly touching on structure and agency as well as discussion of some current digital applications in use in the field. For this project, I am interested in game design theory as it relates to education and I view Virtual Reality as an important tool for enhancing the effect of interactive education since it encourages embodiment and presence in virtual landscapes, a key component of phenomenological studies. To test my arguments, I have designed a VR application for the Virtual Roman Retail Project (VRR), which aims to create plausible interactive scenarios within an ancient Roman shop to explore commercial behavior in the ancient world.

The result is a digital application, downloadable for free on the Oculus Quest and Quest 2 headsets, that allows the player to enter a reconstructed shop scene in Pompeii. The shop's design, based on careful research of the historical, visual, and material data, was realized through a combination of photogrammetry and 3D modeling procedures in, for instance, Metashape, Blender, and Photoshop. While embodied within the shop space, the player can interact with objects in the scene, recreating the act of browsing for goods in a shop, opening up new Questions and creating new data for this aspect of Roman social and economic history. I conclude with a discussion of the future role of VRR and its planned expansion to include shops in other Roman towns as well as my methodology's applicability beyond the shop to other archaeological sites and its larger role in digital humanities applications.

Acknowledgments:

I would like to thank the multiple faculty members and acknowledge the grants that helped supported me throughout my program and enabled me to complete this project. I would like to thank the CLCS department for a collaborative research grant to kickstart this project in 2018, the Provost Collaborative Research Grant for app development and travel support to attend the 2019 Consumer Culture Theory conference, the Sturgis International Fellowship for supporting my final semester of research travel to Italy to plan the next phase of Virtual Roman Retail, and the Graduate Student Congress for the Research Grant for Technology support, which funded technology that I used to refine the app. I would also like to thank the Tesseract Center for Immersive Environments and Game Design for sharing digital resources and providing technical support for my project over the past few years.

Personally, I would like to thank Dr. Restrepo for his support in the program throughout my graduate studies. I would also like to thank the Classics department, faculty, and students for their fellowship and academic support. Special thanks to Dr. Fredrick, for opening doors and showing directions into a fulfilling career path that combined interests in ways I did not think possible, and most importantly, to Dr. Vennarucci for her unyielding support, guidance and providing countless opportunities for growth, advice and mentorship.

Contents

Introduction		1
Chapter 1	Theoretical Approaches	11
Chapter 2	Methodology	36
Chapter 3	Discussion of Preliminary Outcomes	64
Chapter 4	Future Applications and Conclusion	72
Additional Figures		77
Works Cited		78

Introduction

Classical archaeology, with both its rich material evidence and literary corpus, provides ample evidence for the recreation of past environments. In the last few decades, technology has evolved to create more accurate methods for recording and visualizing the material remains on archaeological sites, leading to new interpretations and discoveries. While these digital approaches allow archaeologists to visualize data in new ways, they often lack a strong theoretical grounding in how they are designed and used beyond a visual aid in publications and conference presentations that limits their utility for driving research in new directions. This thesis argues that a theoretical background is necessary to inform and disseminate digital reconstructions in archaeology and offers an overview of some of the theoretical movements relevant to this process, including phenomenology, game design and in this case study consumer behavior research and theory. In the second section, I discuss how to put that theory into practice by sharing the methodology and workflow I designed while building an interactive VR recreation of the Felt Shop of Verecundus (IX.7.6) from Pompeii for the Virtual Roman Retail Project. I end with a discussion of future directions for the project, including plans in the works for applying my workflow to digitally reconstruct the *Taberne di Pescivendoli* (IV.V.1) at Ostia Antica as part of VRR's second chapter, and the broader applicability of my methodology for archaeological sites.

Digital approaches are prevalent in archaeology for recording material evidence from the use of GIS mapping to 3D recording with photogrammetry[1]; however, there is not much solid consensus on the meaningful and theoretical interpretation of the digital products, as much of

[1] Photogrammetry is the process of creating 3D models from a set of pictures taken around an object that are then used in computer software to re-create those objects to scale and size in digital space. See below Chapter 2 for a detailed discussion.

this data is presented alongside conference presentations or as images for publications. Representing the material culture from an archaeological site has an inherent issue that textual sources do not need to reckon with—there is a material component that can be described and analyzed but also irreducibly subject to visual perception. This has been done a multitude of ways over many years, with increasing accuracy. As classical archaeology became more scientifically focused, it developed more accurate and technologically grounded means for visual representation. For example, in the early 20th century, Italian archaeologist and superintendent of Pompeii V. Spinazzola took pains to record his excavations of the city's *Via dell' Abbondanz*a with elevation plans of the street façades and rare photographic evidence, as well as charcoal drawings and watercolors of the decoration shortly after it was uncovered. These records are invaluable for my current project, as they contain details now lost.[2] Building on Spinazzola's excavation records, J. Hartnett has also applied a phenomenological approach to a detailed study of the visual, material, and textual evidence to reconstruct a hypothetical "walk down the block" of the *Via dell'Abbondanza* in *The Roman Street*.[3] Other scholars use maps and GIS to describe and recreate the context of the material evidence, aiming for hyper-accuracy in their reconstructions. For example, a number of scholars such as E. Poehler and E. Viitanen have used GIS mapping to conduct spatial analysis on traffic patterns and graffiti distributions within the city of Pompeii.[4] Meanwhile, the Ancient Graffiti Project directed by R. Benefiel uses sketching and photography to record graffiti at Pompeii that is difficult to see with the naked eye, mapping its spatial distribution across the city.[5] The majority of these scholars, however, still publish their analyses in textual form via books or on map-based research interactive websites. The challenge

[2] Spinazzola 1953, vol. 3.
[3] Hartnett 2017, p. 259-293.
[4] Poehler 2017, Viitanen 2012.
[5] Benefiel, R. 2013-2021. http://ancientgraffiti.org/Graffiti/.

for archaeologists remains how to describe 3D physical environments with rich architectural and decorative details through 2D methods.

Alongside text and 2D images, digital reconstruction has become integral in the past 20 years for representing buildings and destroyed sites in ways that give more context than ever before. Most of these reconstructions are published in the forms of fly-through videos or informational applications that aim to represent the data with a high degree of visual fidelity and show much promise for the potential of continuous 3D development in the field. Take for instance the Rome Reborn project, directed by Bernard Frischer. This project focuses on digitally recreating the entire city of Rome based on the famous *Plastico di Roma Antica* model by Italo Gismondi in the early 20th century, which represents Rome as it may have appeared in the 4th c. CE.[6] The project, whose first digital model appeared in in 2007,[7] is now under the direction of Flyover Zone, a virtual tourism company established by the director B. Frischer.[8] The model, having undergone numerous updates and refinements, has only recently become accessible (for a fee) to a broader audience. While the player exploring Rome Reborn is able to "walk through" the streets of Rome in 3D, there is little other interactivity to educate them about the spaces they are investigating, hold their attention, and build a sense of presence in the virtual landscape. It succeeds in making a digital facsimile of Gismondi's *Plastico* model; however, the Question of what the project is trying to recreate remains open: is it the image of Rome's built landscape, or is it the lived urban experience of a city? If the latter, the quiet, clean, empty streets of Rome the player encounters in the model are problematic.

---

[6] Gismondi 1933-1955, currently housed in the Museo della Civilta Romana, 2017. http://www.museociviltaromana.it/it/collezioni/percorsi_per_sale/plastico_di_roma_imperiale.
[7] Moltenbrey (2008) gives an overview of the project.
[8] Frischer 2021, https://www.flyoverzone.com/.

The UC Pompeii visualization project[9] encounters some of the same problems as Rome Reborn, as does this video walkthrough of the House of Caecilius Iucundus by the Swedish Pompeii Project.[10] Lithodomos VR sells high fidelity models of ancient cities and architecture for cultural heritage tourism and education purposes, but they rely on static rendered images that offer players limited fixed viewpoints of the landscape that are strung together into a predetermined virtual tour of a site.[11] These visualizations have much more detail and information represented; however, they both run into a problem of access and purpose. Virtual recreation focused on producing the material evidence with a high level of accuracy are very valuable, and serve an important purpose to preserve standing remains and visualize what has been lost. While the amount of fidelity and detail in these representations is impressive, they lack the potential for designed interaction in real time, with player choice. For video games, designed interaction is fundamental to creating the sense of being in that space.

Therefore, digital heritage reconstruction requires more theoretical framing than simply saying, "how accurately can we reconstruct this ancient structure in digital 3D space." Key Questions have to drive what is behind the application, similar to any research project or book. If the aim of an application is to engage its players, or to preserve cultural heritage by maintaining an archaeological site for future generations, or to provoke new interpretive Questions and understanding of the past, then there must be a coherent design for the project grounded in a theoretical approach to match these goals. For the purposes of this paper and potential future projects, I will also focus on certain game design principles, including meaningful choice,[12] the

[9] This is part of the University of Cincinnati Porta Stabia Project, directed by Steven Ellis. UC Pompeii, 2020, https://twitter.com/ucpompeii/status/1327280213588385793?lang=en.
[10] Lund University 2016, Oct. 4. https://www.youtube.com/watch?v%3DETd7pszxhnc&sa=D&source=docs&ust=1635335089976000&usg=AOvVaw0D9zbEU05MO3mWmvelWz9f.
[11] Lithodomos 2021, https://www.lithodomosvr.com/ancient-world/.
[12] Schell 2015, 179-182; Salen and Zimmerman 2003, 73-75.

"magic circle" and rule systems as possibility spaces within games and play,[13] learning principles applied to game design and immersion,[14] the procedural rhetoric of games,[15] and how these guiding principles are tied to the body through "proprioception"[16] and proxemics, and, finally, the anthropological study of sense of presence within a space.[17]

My work on VRR is influenced by the Virtual Pompeii Project (VPP) (2017-present) under the direction of Dr. Fredrick and Dr. Vennarucci.[18] VPP runs players through decorated and undecorated recreations of Pompeian houses to determine how the spatial configuration of a house and its decorative features affect human movement in these houses. The movement of players through these spaces is tracked and studied against the predictive spatial analyses (e.g., network topology) conducted on the spaces. VPP and VRR share a main research Question regarding how layout and decor of a space shape human movement and behavior. Where VPP is interested in private houses, VRR looks at public commercial spaces, specifically shops and the street. While VPP's methodology involves 3D models of the houses published on a WebGL platform and playable on a PC, VRR chose a virtual reality platform because it affords a different kind of immersion useful for exploring Questions of multisensory consumer experience.[19]

Phenomenology, a relatively new movement in archaeological thought, is extremely applicable to a 3D application. Phenomenology focuses on the experience of the individual, and an interactive 3D application or game is inherently concerned with emulating a similar experience. Phenomenology provides a unique opportunity for the experience of the body to be

[13] Salen and Zimmerman 2003, 105-111.
[14] Gee 2008.
[15] Bogost 2008.
[16] Shinkle 2008; Schell (2016) and Hunter (2016) discuss this in their development blogs on VR design.
[17] Hall 1966.
[18] Fredrick and Vennarucci 2021, Fredrick et al 2021(forthcoming).
[19] Fredrick et al 2021(forthcoming), 14-19.

used in the interpretation of an archaeological site. In the 21st century, phenomenology involves more than the experience of a lone archaeologist responding to the setting and remains of a given site. It has embraced a wide array of different types of digital methods, ranging from being applied in GIS mapping[20] to mixed reality headsets.[21] By observing the origins and current directions of the theoretical movement, I highlight why the approach can provide a substantial context for experiential cultural heritage applications using VR technology.

I suggest that integrating phenomenological archaeological approaches with principles of game design and pedagogy will allow for the development of a more immersive application that can function as both a research and pedagogical tool to go beyond traditional scholarship as well as a fresh approach to digital recreation that prioritizes interactivity alongside accurate reconstruction. Phenomenology, for instance, can be tied to the player's "learned experience" within a game and agency allows the player to make "meaningful choices" in the application. In bridging archaeological and game design theory, this thesis provides a framework for developing 3D applications that can faithfully and thoughtfully represent archaeological data while still engaging a more interactive and meaningful theoretical basis, grounded in phenomenological archaeological theory paired with relevant game design principles. This can provide better experiences that are more holistically accurate because they immerse players and researchers in the embodied context of the designated sites.

Classical archaeology has traditionally been conservative in adopting new theoretical approaches. Because of this, archaeology has often been viewed as the handmaiden for history, valued for its ability to find new objects or texts for philologically trained classicists to interpret

[20] Gillings 2012 601-611.
[21] Eve 2012 582-600.

and analyze.[22] The field has been - and to an extent still is, by looking at recent online discourse by scholars[23]- looked down upon by other disciplines within classical studies, who continue to privilege the text over the dirt. Classical archaeology finally started to engage with theory from other archaeologies in the late 20th century. Ian Hodder, for instance, championed the use of post-processual methodology in excavations in the Mediterranean, pulling from the debates in broad archaeological theoretical backgrounds and not just classical ones.[24] Today classical archaeology is as open as it ever has been to ideas such as object agency[25], sensory studies[26] and embodiment discussion, as I mentioned earlier, is ripe for digital recreation and representation.

However, digital re-creation alone needs constant interpretation and iteration to continue its relevance to archaeological study. Archaeology being the study of the past human environments, computers will never be able to fully interpret these sites on the data alone. Using VPP as an example, when generating a network graph of the rooms in a given house, how exactly should one represent the *atrium*, typically a large room with a central *impluvium* (water catchment basin), around which traffic must circulate? Is it one node or is it several on the network since users typically walk around it?[27] There is a certain amount of deduction and inference to establish how exactly these spaces are interconnected, which can lead to inaccurate results and requires constant revision, study, and reasoning. When recreating a space, how detailed should you be given the amount of material evidence? What is likely to be in the house and the decoration when there are gaps in the records, and how do you justify filling them? Furthermore, when designing different scenarios for research how does one design experiments,

[22] Trigger 2006, 62-67.
[23] Topper 2019 writes about this divide between art history, philology and archaeology in their blog post.
[24] Dyson 1993.
[25] Van Oyen and Pitts 2017.
[26] Betts 2017, Toner 2014, Hamilakis 2013.
[27] Fredrick et al 2021, 193.

user interface, etc. to gather data? All these Questions go into the development of VRR and the design possibilities of a Roman shop visualization that would allow the player to enter from a street, see what goods are available, complete a transaction of some kind and then leave. The environment is created by a mixture of photogrammetric and 3D models based on the archaeological data and research, making it as grounded in the evidence as possible.

Within the scope of VRR, the shop app I designed will be used to investigate ancient consumer behavior through recreating individual shopping interactions, allowing the project to explore how different environmental stimuli could have affected ancient economic behaviors. For instance, I have created historical lighting scenarios and recorded different viewsheds from the point of view of a passerby walking by the shop front at different times of day. This information helps us understand how the decoration on the shop's façade may have impacted the passerby and how visible the merchandise on display on the shop counter would have been. Immediately, this option in the application allows players to posit and answer research Questions about lighting scenarios through experiencing and recording data. Since it is a relatively accurate rendering of a shop, the player can seek out different approaches from the point of view of an outsider walking in.

Using the model, researchers can also incorporate modern day market analysis and retail atmospherics theory,[28] which is used to study how consumers navigate a retail space. P. Underhill in *Why We Buy* discusses the idea of when someone first walks into a space, they need to have time to reorient themselves within the new building, which he found out because in the event of a store placing advertisements right next to the entrance, they were almost universally ignored by customers he was studying.[29] By applying this approach to ancient retail, as well as

[28] Murray 2016, 45-63.
[29] Underhill 2009, 43-46 describes the “decompression zone”.

visibility analysis, it can be determined through testing rather than sole interpretation how signage may or may not have been effective for a shop in Roman towns. To expand on this visualization a bit further, one could experience walking from the street to the shop. This becomes more complicated, especially if a developer has to design either more characters or other buildings, but the prospective results are promising. If you could test this on individuals to see how they interact with the shop and notice any general patterns, then the possibilities lie open to make thoughtful insights into the Roman local economy and how, in whatever its conceptual status, ancient marketing would have looked and worked. Ancient retail and streetscapes are a relatively understudied area of antiquity (compared to Pompeiian houses and grandiose public architecture), and an application like this would lend itself immensely to helping to establish new ideas of how ancient local economies may have worked to accompany recent work in the field.[30] Preliminary qualitative user results gathered from a conference poster presentation in 2019[31] indicated through some of the individual responses what the potential of testing will do for a later stage in the project.

While my case study is focused on a Roman shop and Questions of consumer behavior, my integrated theoretical approach and design methodology is widely applicable for developing applications at a range of archaeological sites. In terms of which theoretical approach is best suited, I believe it is one that is rooted in the principles of phenomenology, which informs both archaeology and consumer theory, with input from structure and agency and married to the game design principles inherent for interactivity and education, specifically for Virtual Reality. The digital model must engage the player with the theories that informed its development, and it must do so in a meaningful way or else the result is an incomplete and inaccurate depiction, negatively

[30] Ellis 2018, Holleran 2012, Vennarucci 2015, Flohr and Wilson ed. 2017.
[31] See additional Figure 1 for the poster from this session.

impacting its utility for research and teaching. Many projects are already embracing digital recording, only more and more visualizations and applications will continue to appear. Which also means more “Rome Reborns” will dominate the popular market and classrooms. In order to truly engage academics and audiences with digital archaeological applications, immersive interactivity deeply informed by archaeological theory and game design principles must become a larger part of the picture.

Chapter 1: Theoretical approaches

Classical Archaeology: Traditional Approaches and Problems

Much of the early history of excavation in the Mediterranean focused, to the detriment of the field, on finding characters or evidence from stories passed down through textual sources, often biased and presented through a narrow elite male lens, or focused on flat out treasure hunting and grave-robbing, often for the noble elite of Europe of the day.[32] Classical archaeology, emerging against the long history of ancient Greek and Latin literary texts, as a field has a historical setup different from New World Archaeology and the archaeological discipline as a whole, though the two have become more closely aligned over time. Classical archaeology has its roots in art history and only recently in the latter half of the 20th century did it incorporate more scientific archaeological approaches across in study, research, excavation, and teaching.

The philologically focused study of ancient texts, Classics has held a particularly privileged place in academia (it's even in the name) and has held onto more conservative theories and practices longer than most, but that has changed in recent years with more digital applications and practices becoming the norm, embracing different theories from other archaeological disciplines, and slowly diversifying those working in the field. The gap is still prevalent today, as Kamash shows by analyzing attendance and presentations at Roman Archaeology Conferences over the past 20 years, with the results showing European male dominance not only in the demography of the academics but also a focus on places studied within Europe despite the ancient Mediterranean encompassing Africa and the Middle East;

[32] Trigger 2006, 62-67 presents a valuable overview of how classical Archaeology evolved out of classical studies and art history. Also see Foss 2007, 28-38 in *World of Pompeii* for the history of excavation of Pompeii specifically.

however things are changing slowly as Kamash's data shows.[33] While this article focuses only on the TRAC organization which is based in the UK, it is indicative of the field as a whole. In addition to growing diversity, more and more digital applications have become commonplace in Classics and Classical Archaeology, as the technology has become more accessible and affordable, and in many ways allows for more diverse viewpoints and opinions to experience aspects of the ancient world.

Traditionally, Art historical approaches have heavily influenced the way classical archaeologists view the ancient Roman world, fostering a top-down, elite perspective, which largely ignored the practices and behaviors of the majority of ancient Romans. The dominate elite lens is also reflected in the fact that the majority of modern scholarship has been produced by Euro-centric, highly educated, affluent white men. More specifically for this thesis and project, the study of architecture and urban layout was focused more on elite traffic patterns or on mass movement of crowds, focused on monumental structures. While important, it does not get at the importance of individual behaviors and tends to ignore the significant cultural differences of those from across the empire. The evidence for their existence is blatant not only from mention in numerous references in written sources, but also in the material record of inscriptions and graffiti. Pompeiian graffiti, which is from a provincial town in the early Empire, includes Latin, Greek, and local languages such as Oscan.[34] In addition to the languages written, the visual impact of wall painting and graffiti allows for another form of communication, likely cross-cultural for the widest audience possible. Despite this, importance in scholarship has been

[33] Kamash 2021 p. 5-23, 10.
[34] J.P. Descoeudres 2007, 9 discusses the diversity of Pompeii's inhabitants in *The World of Pompeii*. Also see Berry 2013, 7.

frequently given to Latin inscriptions and focus on the architectural remains has been on large houses of the elite.

Part of the reason for this focus is the textual evidence of Vitruvius, the Roman architect and client of Augustus who describes the ideal house in *De Architectura.*[35] He lays out suggestions based on ancient philosophical principles for proportions of an ideal house in one book, while the majority of his ten books focuses on public and urban architecture.[36] A scholar using Vitruvius as a model interprets a small, richly decorated room off the *atrium* of a Roman house as a *cubiculum*, because Vitruvius says this is where a bedroom should be located in an ideal house. Once the scholar has identified the space on as a bedroom based on Vitruvius' text, the assumption is that the space was used for sleeping. However, the material record is completely ignored. What if loom weights were found in this space? The Vitruvian model limits understanding of how people actually used these spaces. Therefore, the resource is flawed in its reception because every interpretation of Roman domestic architecture is indebted to this narrow elite voice due to its primary source value and would be colored by its influence either in direct interpretation or direct rejection.

Starting in the last 20th century, scholars started to attempt direct interpretation of the material evidence, specifically trying to find how the people inhabiting the house may have used the rooms within it. A. Wallace-Hadrill's foundational work, known as the "Public-Private" and the "Grand-Humble" axis,[37] helped model how some elite houses were used. His model provides a structure for understanding how people used the space in relation to their familiarity to the

[35] Vitr., *De arch*. 6.
[36] In short, here is a quick definition of the rooms as they are generally defined. *Atrium* is defined as a large room to allow light and typically has a water feature, a *cubiculum* is interpreted as a small bedroom, *tablinum* as a meeting room, and a *triclinium* as a dining room. See *De arch.* 6. for more information.
[37] Wallace-Hadrill 1994, 38-61.

owner of the space as well as their perceived social status, still in relation to the owner. The structure does allow for a more nuanced approach that includes primary sources as well as interpretive thought, but heavily focuses on existing concepts of Roman society in its interpretation, such as the elevated social status of the *dominus* as well as the role of women, slaves and other lower classes in relation to the accepted hierarchy. P. Allison discusses the problem with models and typologies based largely on literary evidence and argues for more consideration of the archaeological evidence in room classification, which paved the way for archaeological evidence to be more widely considered in scholarship[38] and M. Flohr discusses how the axial-structure as presented by Wallace-Hadrill for representing social relations and movement can be applied to a domus converted into a *fullonica* (laundry), being that is adapted but still a major force in interpretation.[39]

While the nomenclature and various frameworks continue to be challenged and rethought in recent scholarship, the names given to rooms by Vitruvius remain the standard in materials (e.g., house plans, textbooks) disseminated to general public and in academia. Classics as a discipline focuses on showing the ideal wealthy elite viewpoint, which may not inherently be wrong but it is inherently limited, and the approach is likely due to the overwhelming amount of written and archaeological evidence that exists from elite contexts. The approach is still used in many pedagogical materials, for example many introductory Latin textbooks deal with a story through the eyes of a wealthy family or famous elite figure.[40]

These perspectives are also not entirely accurate. For instance, the description of the eruption of Vesuvius by Pliny the Younger was accepted as accurate for centuries; however,

---

[38] Allison 2001, 195-197.
[39] Flohr 2011.
[40] Kitchell and Sienkiewicz in *Disce!* (2011) focus on a lower class family, though also a wealthy one. Balme and Morewood (2006) focus on a fictionalized version of the life of the poet Horace as a child.

recently the date given (24 August 79 AD) has been refuted by archaeological remains multiple which suggests that the eruption occurred later in the fall.[41] Despite the evidence, many academics would continue to cite the textual source as the date, for instance in the fairly recent *World of Pompeii* volume in chapter 2, an historical account[42], and chapter 4 in the *World of Pompeii* volume, which is a detailed and geological account of the eruption.[43] Recent excavation in 2018 revealing a charcoal description with an October date finally concretely supported that the eruption date occurred later in the fall.[44] This discussion above highlights that complicated history classical archaeology has had with the textual record. Re-evaluation of the archaeological data rather than the text can be extended to how we analyze existing structures, and how they might have been experienced by using phenomenological exercises combined with architectural analyses. The traditional models of how the Roman world "was" have been challenged more and more as archaeological evidence and innovative research in the respective areas are implemented. This movement away from traditional interpretation can also apply to theoretical approaches used in the field. Post-processual techniques such as phenomenological analysis were accepted by Classical Archaeology after being adopted by the archaeological field as a whole, and while much of the discipline still holds up traditional models of analysis that were based in elite interpretation, more and more archaeology is at the forefront of challenging these long-held biases through innovative interpretive methods, digital applications and updated analyses.

Phenomenology and its Applications in Classical Archaeology

Phenomenology in archaeology, taken from philosophy, has its roots in the "experience", and is defined by Johnson as "...the study of the structures of human experience and

[41] Berry 2007, 20.
[42] Descoudres 2007, 20.
[43] Sigurdsson 2007, 52.
[44] Segreti 2018.

consciousness".[45] Those roots are based, however, in the experience of prehistoric landscape archaeology in the UK. Initially phenomenology was conducted by archaeologists able to easily access prehistoric sites and landscapes with evidence of human settlement, and walk through them in a way that recorded their own physical experience in addition to gathering data from more traditional excavation methods. For example, Johnson provides an example from Tilley's description of viewsheds, as describing what goes in and out of his sight as he travels across the Dorset Cursus (a Neolithic landscape in the United Kingdom), data that is not present from traditional landscape methods which focus on the aerial and plan views.[46] Critiques of this approach are focused on the fact that Tilley is not, in fact, a prehistoric man and therefore is likely heavily biased in his interpretation of the surrounding landscape. However, and this is what Johnson highlights later on, the core of what he argues is something inherent to archaeology, that experiencing a place is a key essence to the understanding of a site that cannot be understood through top-down plans alone.[47]

Viewsheds provide important intra-site visual connections to the surrounding environment and can be one of the most important functions of said site (for example, a watch tower). They are especially important in determining the importance of an urban armature, what a city does to reflect its overall design, be it a skyline or a streetscape. Sightlines within houses factor into the interpretation of domestic space[48], and are significant for the interpretation of the spaces used, so already there is some overlap in ideas around experience in Classical Archaeology, though it is not as fully developed as full phenomenological analysis until later. Phenomenological case studies brought important data and interpretation of the archaeological

[45] Johnson 2012 p. 272.
[46] Tilley, cited in Johnson p. 274.
[47] Johnson 2012, 279.
[48] Wallace-Hadrill 1994, 41.

record forward that was difficult to properly capture before through traditional site reporting, because it focused on an individual's experience of the space around them in a unique way not considered before.[49] A viewshed can encompass a large or small area, depending on the context of each site. For the Roman World a viewshed can be the visibility on the street of a Roman town and its graffiti, or it can be the views framed within a domus, especially in regard to Roman wall painting. Analyzing this material evidence through phenomenological means brings forth important ideas of place, space, and movement that traditional archaeological reporting, which consists of photographs, journaling and written description and cataloging of material evidence, is not as robust at doing.

Many criticisms of early phenomenological practice focused on the similar issues outlined above in the previous section on Classics; it was white elite men giving their bodily experience of landscapes as the definitive human experience and would not adequately take into consideration cultural or identity differences. Interpretations and analyses of private spaces continued, while the street was focused on large-scale top-down analyses in a more scientific and systems-based approach.[50] These analyses are significant, but do not usually focus on the individual bodily experience but instead on the perceived social-cultural status. Later interpretive efforts to build upon and add to existing interpretive models, again rely heavily on the textual sources and are focused on thought exercises but are more open to individual embodiment through sensory studies and social historical interpretation of the space.[51] Space and movement in the Roman house also has a prime focus because these are some of the best examples of preserved and designed space from the Roman world. However, when one looks at the sheer

[49] Johnson 2012, Eve 2012.
[50] Laurence 2008, Poehler 2016, Weilguni 2011.
[51] Toner 2014, Hartnett 2017, Betts 2017.

number of *tabernae*[52] remaining[53], albeit in typically more ruinous states, the material evidence begins to highlight a major flaw in the scholarship: so much of the Roman experience happened outside of the *domus*, and the parts that did occur inside the house are only a sliver of the general picture in the population. Shops are an excellent example of experiences outside the home due to their ubiquity. For a long time, they have been generally disregarded as "shop" or just briefly described as a room without much study due largely to a lack of evidence and ergo a lack of elite status.[54]

The evidence is overwhelming for the large-scale presence of small-scale economic function and retail throughout Roman society, and the individual decoration on these spaces deserves attention to understand how retail and social behaviors affected the economic function within society. Many of the streets of these ancient cities are lined with *tabernae*, and in the case of Pompeii many of these storefronts, upon excavation, have preserved wall paintings and graffiti revealing a glimpse into the lived experience of those who inhabited these spaces. Art and graffiti allow us to see what kinds of things storekeepers would do to advertise their shop such as barmaids supporting or refuting local politicians[55], and the graffiti gives us an idea of what the people who may have been patrons of these establishments thought about, including political endorsements, which paints a vibrant and active community of opinions and behaviors.

To get at the exact behavior of what ancient consumers did is impossible to assert. But it would be a mistake for Roman social and economic historians to avoid the effort, however provisional, to model these interactions. This is where phenomenological analysis steps in and allows us to create experiential models that generate their own data through which to understand

---

[52] The term *taberna* applies to likely remains of shops and food stalls, with their purposes ranging widely.
[53] Ellis 2018, 4 provides the number of tabernae at Ostia in the 800s, while at Pompeii it numbers in the 600s.
[54] Flohr 2017 1-16; Ellis 2018, 1-27.
[55] Hartnett 2018 p. 269 .

likely behavior in Roman streets and shops. Data gathered can range from tracking movement within a digital space to emotional responses to qualitative survey Questions specific to the experience. The research Question is broad: What was the behavior of people in these shopping centers and places? Broad Questions require a similarly broad and holistic approach. If that is done with a digital product designed to bring out seemingly natural and culturally determined behaviors in people, then that data can begin to bring out some likely outcomes. This approach is more valid than a traditional "expert's analysis" of Eurocentric academia because it is trying to not just answer what was this one viewpoint, but what was the experience of a plurality of viewpoints.

As noted above, phenomenology has been around in archaeology since the advent of post-processualism, but it has not been widely accepted or received in classical archaeology until relatively recently.[56] Much of what could be construed as phenomenological analysis is done alongside and overlapping with sensory studies. Specifically, these focus on textual sources to describe their sensations, which is valuable but also only a first step. More and more, analyses are being done to show and discuss experiences of places from an embodied point of view. However, they are text on the page, and still come from within a limited audience: a privileged academic one which has typically studied the ancient world for many years. The informed experience, research and analyses are great for coming up with plausible hypotheses for behavior at these sites; however, someone does not need a Ph. D. to experience a space and give their thoughts on what that experience meant on a personal, qualitative level, and academic analysis is certainly not the end of investigation. If testing different demographics in the contemporary population produces data that are significantly different, then the data gathered is not "natural"

[56] Hamilakis 2013, Betts 2017, Toner 2014, Hunter-Crawley 2019.

human behavior, but culturally constructed differences in behavior. The play of these differences is what can allow researchers to make more nuanced hypotheses about "Roman" behavior, which itself included many different demographics.

As a classic example of using a phenomenological approach in Roman archaeology through an experiential lens, I turn to Bettina Bergmann's seminal piece *The Roman House as Memory Theater*.[57] This classic work is an example of highlighting the importance of Roman wall decoration in influencing how someone would move around a space. Bergmann even goes one to present a small diorama of how these spatial relationships would have worked as a "possible viewing itinerary".[58] If this article was written today, a digital application would be the *de facto* way to visualize her theory of movement through a house in action. However, the focus on the experience in the article and positing that the art's placement in a house is a phenomenon to be studied and can be extrapolated through intelligent analysis of an experience. This is an infusion of phenomenological principles into Roman archaeological study which Bergmann does not necessarily call attention to. Bergmann uses the textual evidence in conjunction with existing archaeological data to determine an experience for the senses and body, and creates a potential series to imagine what may have guided the experience of houses. Another, much more recent example is J. Hartnett's book on the Roman Street, which gives a well-researched and documented analysis of an individual approach and brings to life the viewpoints of so many based on the evidence from the stretch of the *Via dell'Abbondanza*, and culminates it in a chapter with possible stories.[59] This is valuable work that brings to life so many scenarios that could happen, and is incredibly informative in what an experience would be along these hyper-local

[57] Bergmann 1994.
[58] p. 243.
[59] Hartnett 2018 Ch. 9.

areas. However, as for showing those experiences, that only goes as far as the description on the page and supplemental images-the reader cannot interact with these described scenarios to explore on their own. Alongside and connected to phenomenology is the new movement of sense history and sensory archaeology. For instance, J. Toner et all explore various aspect of the sensory world in antiquity in his edition *A Cultural History of the Senses in Antiquity.* The *Senses of Empire* volume by E. Betts includes the work of archaeologists, such as Veitch, who reconstructs the soundscape of shops at Ostia from their physical remains.[60]

In archaeology there have been limited attempts to use phenomenology together with digital technologies, but the two approaches have generally been held apart. Gillings gives a critique of how archaeologists cannot play nice together and offered an interesting theoretical binding idea of affordance to phenomenological and GIS approaches. To round off the discussion on phenomenology, Gillings gives us an explanation of the conflict between Phenomenology and digital analysis through GIS, and tries to provide a solution that would allow for archaeologists to develop their own theories along their own lines but being informed about the other movement.[61] Although Gillings seems pessimistic about actual collaboration, this does highlight an area where some of the design and learning principles from Gee could bridge this gap, drawing on broader principles of game design and immersion within a digital environment. Traditional GIS mapping software was never designed to provide 3D immersive experience and was meant to be abstractive 2D elements to represent many layers of built spaces. Eve, as mentioned previously talks about using phenomenology and augmented reality to

[60] Veitch 2017. The volume also includes work on sight, touch, smell and other sensorial experiences.
[61] Gillings 2012, 610.

visualize lost remains onto existing landscapes, which I will go into more detail later in this chapter.[62]

Other approaches: Structure and Agency

Other theoretical concepts in archaeology, such as structure and agency, are inherent to designing choice for the player of the application. An application designed to explore ancient consumer behavior must grapple with the Roman economy as its structure, and due to games being essentially structures (or systems) inhabited by agents purposefully for the sake of interaction there is overlap, in that measuring the consumer behavior is similar to seeing how players interact within the possibility space of a game. By determining the parameters of how someone can interact with and within the digital environment, a player can use their own agency to affect outcomes - their choices have consequences that directly impact their virtual world. The historical and archaeological records must inform this concept of a constructed agency, and therefore careful consideration of what the player can "do" must be accomplished in order to maintain a faithful, holistic and academic experience of virtually reconstructed past landscapes. This is what VRR aims to do in its representation of retail spaces in the ancient world, and these spaces specifically have extremely high potential for players to explore how the structure (the ancient Roman economy) was formative for the agents (shopper, shopkeeper) in the scenario.

Agency can be very easily embraced for a digital application. If the application is geared toward an individual player character, then the designer can give them specific kinds of agency to work within the games structure. However, what is the structure that these agents existed in? The question when it comes to a digital application becomes more thorny, because the underlying tension between structure and agency is something that must be navigated by the

[62] Eve 2012

designer. This is where theoretical approaches from the game design discipline can be used in conjunction and as justification for incorporating the archaeological approaches. The concept of a meaningful choice can help to solve this tension.[63] Essentially, a meaningful choice is something the player makes and either feels rewarded or that they made something happen. Agency in games tend to try and override the developer's intention and "break" the game out of fun, but also in testing the limits. The principle of testing the limits by the player, or "fish tanks" from Gee, comes into consideration.[64] By testing the limits, in a theoretical scenario a player could understand the limits of their agency or the limits of their structure. Either way, it is a learning opportunity for the player to discover how these concepts work with or against each other. For instance, as will be discussed in detail in Chapter 3, in designing the Roman shop application for VRR, I had to determine what actions the player would be able to perform in the shop and what objects within the shop they could interact with and how. As the designer, I had to consider how to help the player distinguish the interactive objects.

Game Design and Archaeological Applications

In the creation of a digital application, developers have an immense amount of control over what is shown and experienced by players. Game environments are built from the ground up and can have a variety of different physics, lighting scenarios, 3D landscapes that are only hindered by technological or imaginative limits. Everything is up to the developer to create and influence the player experience. From impossible scenarios in fantasy worlds or space systems, power-ups that create superhuman traversal abilities, and recreating historical environments, the spectrum of games that have been made show what is possible. Development tools have advanced and spread to new levels of availability in the past ten years, and game engine

[63] Salen and Zimmerman 2003, p. 73-75
[64] Gee 2008 p. 31.

technology has been made accessible for anyone to download and start, as well as many curricula and online tutorials.[65] Game interfaces have also been made to replicate sensory stimulations as well as haptic feedback to reinforce ideas and designs narrators are presenting.

Game design principles can broadly apply to sensory archaeology applications, in a capacity limited by the real material evidence and plausible reconstructions. The ability to replicate viewsheds innately with the first-person camera perspective in a particular place is a strong feature, especially in VR. The developer of such an experience will run into similar issues that archaeologists using phenomenology do in communicating its interpretations and data. The fact of the matter is, though, that humans made and experienced archaeological sites, just as they design 3D environments. While it is impossible to recreate sites exactly as they were, through focusing on the development of either a landscape site or structure with meaningful interactions and well-informed representation of data, I am hard pressed to find a reason why phenomenologically informed 3D reconstruction would not aid in the pedagogy and interpretation of an archaeological site. I do not intend phenomenology to be the only theory to inform design of a framework, but the main one in terms of understanding what will happen in an experience and in shaping the kind of data the experience is designed to produce.

There are some aspects which are meaningful and must not be ignored when creating an application or project that someone besides the developer will interface with. For example, a major piece of crossover is the role of affordances in archaeology and in games. Objects and structures in archaeology are studied meticulously to determine their general uses, and affordances are often sought out to help in interpretations of landscapes[66] or has also can be

[65] Unity and Blender have integrated learning programs as well as extensive online communities that support learning and development for the software.
[66] Gillings 2012.

described as object agency[67] when attributing usage to smaller objects such as pottery. The idea of designing affordances in games is crucial for a designer to have their players engage with the simulation. What can happen in the game, then is objects that need to be picked up may have subtle outlines or glows, and paths to take may be highlighted while paths you cannot take are blocked. Also, for example, visually unappealing areas are made to repel the player, and environmental stimuli are placed to guide and reinforce movement into areas with the correct direction or goals.[68]

Eve attempts to combine phenomenology and digital interfaces in their article which describes how augmented reality (AR) could be applied to archaeological sites in phenomenological analysis, in conjunction with GIS technology. While ahead of their time, Eve provides an excellent proposition for how data from GIS analysis could be incorporated into the landscape and augment it. In 2012, this was a long shot, but now total recreation even becomes more feasible as VR headsets improve in efficiency and capacity for running more intricate applications. Eve wishes to combine AR with traditional phenomenological analysis, thus keeping one foot in each world. He goes on to describe his own phenomenological methods, discussing how he took video of his pathways, and recorded observations of when exactly certain structures or objects became visible for them.[69] They even go on to admit that they did not have a formal methodological approach, thus again highlighting the issue of subjectivity within phenomenology. However, the subjectivity problem could be addressed by giving access to a wide swath of the public to an accessible, well-designed application with planned out sections to test and see if the research application works to provide results or not. Eve is essentially arguing

[67] Van Oyen 2017.
[68] Bond 2012, Schell 2014.
[69] Eve. 2012 p. 585.

for the synthesis of phenomenology and digital recording without discussing how games could play a role in bringing the two together.

This can even be augmented in the design of the game to highlight affordances that may not be obvious in archaeological remains. The built environment provides affordances, affordances are used in both archaeology and game design as ways to describe or design that objects, landscapes, etc. communicate their uses or functions to a viewer. Affordances are at the forefront of asset creation, and in archaeology studying them allows for researchers to determine pathways or potential behaviors of players in an environment. Affordances are essential in VR to communicate an appropriate and meaningful environment for the player to believably inhabit and behave as they would within a physical one. Put another way, the object is represented believably in the virtual environment by communicating the right affordance. An affordance for objects is how its design silently communicates how it is to be interacted with. A sidewalk in Pompeii, for instance, may have a smoother surface than a road, which is made up of multiple stones and is not very level, thus communicating to someone walking that they should walk there rather than in the street. Affordances are important in game design and archaeology,[70] given that the goal is to either interpret or determine what kinds human behavior occurred through interaction with these objects.

In terms of 3D game development, the designer works with the assets and tests them over and over again, going through spaces to determine what information is being conveyed, how it is being conveyed and if the intended "vision" of the project is apparent to the player, but in the interactivity of the medium something new emerges. What arises from this is a new form of media, Murray posits, from player interaction combining with design to create a wholly new

[70] Eve 2012, Salen and Zimmerman 2004.

experience that cannot exist without each other.[71] The "vision" of the designer must be clearly communicated to the player, yet the player's behavior often surprises the designer. This is where traditional phenomenological processes tended to fail. In an archaeological context, the excavator wants to be as neutral as possible when displaying data. In early phenomenology, this was impossible due to the individuals practicing it. While intentions may have been good to try and paint a fuller picture of what archaeological sites encompass, it is impossible for someone from the 20th century-on to experience a site the way its original inhabitants would, especially when a diverse society like ancient Rome had a deep diversity of experiences. So, while the exact experience is impossible to attain, there are certain things about the environment that a solid walkthrough can ascertain. Through measuring multiple diverse experiences across one dataset and taking a quantitative inclusive approach, details of more holistic trends and experiences can emerge. Out of many experiences of a sight a broader, more accurate conclusion can be reached. General sense of place, relation to major landmarks and a sense of presence within an environment would vary but have some general commonalities between humans of different cultural periods. However, the different interpretations of place can then be gained through quantitative analysis. Female, differently abled, minority or transgender embodiments of the space allow for qualitative analysis and interpretation to take place that previously would not under traditional phenomenological approaches. It is problematic to believe that experts publishing in the field can fully account for the entire diversity of general Roman experiences, or that every user would need to be familiar with historical figures and treatises on Roman society while they walked down the street to a *taberna* to go get their next meal. And while cultural factors are heavily influential, any similarities or general nuanced trends that could arise from a

[71] Murray J. 2016, 113-119.

phenomenological dataset of multiple users can begin to fill in the more accurate picture of human experiences, not just one human experience.

The information sought after is the diversity of these experiences of the masses to find a more accurate and diverse picture of the ancient world. As explained, contemporary player experiences are not the exact scenario of Romans, but the power in gathering large amounts of different experiences is valuable for discovering patterns of use and movement. More experiences can reveal more ways of use, and this is all from the idea of Diverse Proxy Phenomenology[72], which relies on the premise that there is no way to get a 100% accurate reconstruction of the ancient Roman behaviors, but by sampling a large swath of players from multiple backgrounds and ethnicities can create a dataset that is more plausibly in line with likely Roman behaviors than from a strictly academic, highly privileged perspective.

One of the focuses for game design is about engaging the player, and having them feel like they are making meaningful choices. Otherwise, why would they want to play your game? In general, you want the application to convey multiple things. First, what options are available to the player, what are the rewards or consequences and how do I start? The player must have a careful amount of guidance through these applications in order to have meaningful choice, as Schell maps out in *The Art of Game Design.*[73] Schell, as well as Gee, define what concepts of good games are important for making players engage and want to play a game. Gee focuses on learning, outlining specific principles like identity, pleasant frustration and continued practice while Schell focuses on different parts of game design to create essential experiences and is geared more towards designers. Another concept would be the magic circle, which is described

[72] Fredrick, Vennarucci and Loder 2021 (forthcoming) discusses this idea alongside interaction and digital design, and it is discussed briefly on the VRR project website (2021) as well as the Virtual Pompeii site (2020).
[73] Schell 2015, 179.

as the imaginary area entered when playing a game.[74] Players need to buy into this to use the lusory attitude[75], which fosters a more engaging attitude with reasonable buy-in from the rules and systems. Phenomenological and sensorial principles of embodiment can allow the player to buy into that circle to create a meaningful and memorable experience for the player, one that engages them not just to learn but to want to learn as buying into the cultural system, possibly through mechanics or a player identity, portrayed as that "magic circle". To gamify a phenomenological approach would not be a huge stretch, exemplified by the high number of first person exploration games in the medium that tackle serious issues, including *Gone Home*[76] where you explore a childhood home to reveal family issues around LGBT expression, *Umurangi Generation*[77] where you are invited to explore set pieces that tell visual stories about colonialism through dystopian images and UN occupiers, and *The Outer Wilds*[78] where you play an explorer who must research and explore a local solar system to discover the secrets of an ancient civilization-and it's in a time loop where the star explodes every 22 minutes if the player does not solve the mysteries of the galaxy.

Specifically for VR development, the ideas of embodiment and immersion are essential to creating a believable environment. The idea of "procedural rhetoric" is key for learning and immersion and about designers using mechanics as a means of interpretation and to make creative arguments to users, where the player learns and acts within systems to learn them as well as accomplish tasks through interactivity rather than solely reading about them.[79] So, for example, games about Roman cultural systems can be created to make arguments or test

[74] Salen and Zimmerman 2003, ch. 9 105-111.
[75] p. 109.
[76] Fullbright 2013.
[77] Origame Digital 2020.
[78] Mobius Digital 2019.
[79] Bogost 2008, 125.

hypotheses about what actual Roman culture may have been like. Tying into all of this are proxemics and digital embodiment as tied to phenomenological embodiment. Proxemics, the study of space and the body, was introduced in the 1960s by E. Hall as a way in anthropology to describe a sense of presence felt in addition to the normal senses and measured changes in behavior based on changes in physical space and sensory perception.[80] Digital embodiment would have to occur solely through a flat screen, but this would change with VR headsets, as they fully transport the conception of the body into something different yet informed by the player's sensory experience.[81] This is incredibly important for VR, because when you put on a headset it blocks out the world around you and replaces that visual reality with a new one. Motion sickness can occur if movement is too fast or off-putting, immersion can fall if the application does not run at a high enough frame rate, or if objects do not react in ways that they might seem they should. Schell explains that when players in his VR game tried to use a knife as a screwdriver, but it did not have that functionality, they provided a tip which explains in character why the knife would not work.[82] Schell was able to compromise on functionality without breaking immersion. In VR development it is essential to create believable scenarios to keep immersion, and keeping the importance of how proprioception and proxemics affects movement as well as what kind of procedural rhetoric may be important to build into movements teaching the scenario in mind while designing, scaling and building environments will allow for phenomenological approaches to be used highly affectively.

Both broad disciplines present in this project, game design and classical archaeology, come together and overlap in a core experiential tenet which involves essential experiences in a

[80] Hall 1966, 40-63.
[81] Shinkle 2003, 2008, 2012.
[82] Schell 2016. https://www.gamedeveloper.com/design/making-great-vr-six-lessons-learned-from-i-expect-you-to-die.

built environment (digital or physical). Within archaeology, this focuses on the use of phenomenology and sensory studies for how archaeologists approach a site with the intention of determining the effect on a human individual. This broad definition hinges on an individual's experience, specifically their sensory experience. What could they see and hear as they walked through a landscape or through a city street? Smell and touch also factor into this phenomenological analysis but are more difficult than sight to get an idea of the landscape and the visual stimuli around the area. In game design, the focus is on getting the user to interact with the game system and have an experience playing it. With these game design principles in mind, I will now further discuss case studies of how digital approaches are realized focusing on the Rome Reborn Project, the Gabii Archaeological research project. I will also discuss VRR's direct influences from VPP and the *Saeculum* game course, which is a role playing game created by the Tesseract center set in a 3D re-creation of Rome across different eras of its history and is used in a semester long course for teaching Roman Civilization, and how this theoretical approach of combining archaeological theory and game design principles are applied to the Rome Reborn project as examples of how they use the above principles, how that affects the stated goals of each project and end discussion with how VR technology falls into the digital landscape.

The Rome Reborn Application, mentioned in the introduction, is currently for sale in its multiple parts by a company that bills itself as marketing flyovers of historical reconstructions.[83] The history of this project has been complicated to say the least, and suffered from an immense scope that was impossible to correctly engage its research questions with the resources afforded to its team. The result was the Rome Reborn application, which was a squeaky clean white and

[83]B. Frischer. https://www.flyoverzone.com/.

red 3D model that looks like a digital version of a plastic diorama. Interactivity was always a Question, and a final product was hard to find outside of the occasional product video. Now the VR application has arrived and appears to be an improvement on the application. Mostly that being that people can finally access it (for a price) and "travel through Rome". However, this is still a very clean, whitewashed model that has little to no semblance of what actual Romans would be doing. In my opinion, this is an example of a project that does not have any phenomenological influence on what they are doing or focus on digital embodiment. By omitting possibilities of everyday life, Rome Reborn instead of spreading knowledge and understanding inhibits it by asserting an empty incomplete picture as, in fact, "how Rome used to be". But again, being immersed in a clean, blindingly white, whitewashed, and empty Roman forum is not an accurate representation of Rome. Rome was a city full of people from across the known world, not a toy set. Rome Reborn seems to approach the city in a clinical way, one not informed from a phenomenological point of view but one that is removed from the actual city and its archaeological record. Rome Reborn succeeds in its stated goal of recreating the Roman city at the large scale, and a flyover of this can be incredibly useful. The flyover application with key viewpoints highlighted throughout the city establishes a broad context for introductory study of ancient Rome, though the project is very much out of the dirt of the city.

The Gabii project[84] published their findings with an article and a 3D web application which allows researchers to view basic reconstructions, photogrammetry models and see them placed within the context of the site. This application is successful due to its synthesis of all of the different parts of research into a general interface and reaches out to the academic community well, and the creators are trained archaeologists and academics well-versed in

[84] Opitz et al. 2016 https://www.fulcrum.org/concern/monographs/n009w229r.

archaeological theory. However, the interactivity is limited to the displaying of the archaeological results and does not necessarily provide creative interpretations as one could in a game scenario, to fully immerse someone in the data and experience. Gabii exists as an excellent resource, and proof that 3D content has a place that can be expanded upon within academia.

Case studies which I am very familiar with are some of the projects at the Tesseract Center for Immersive Environments and Game Design, which employs game design principles to teach not only game design but to create interactive visualizations, focusing on classical themes. For example, one of the running projects at Tesseract has been visualizing Pompeiian houses. Virtual Pompeii has grown to become a more holistic modeling and analytical approach to space in Pompeiian houses. The multiple aspects of this project include the traditional 3D model of the House of the Prince of Naples, which the player can walk through and interact with different aspects of the house to learn more about the different aspects of the decoration, infrastructure and spatial analysis, and also uses detail textures to convey a "lived-in" sense. This 3D model is also available in VR, which creates a much more immersive and affective environment for the player, as mentioned in the discussion of VR design in the earlier section. In addition to this, there is also spatial analysis of the houses done in Pompeii through ARCGIS and Gephi to predict and visualize (based on spatial network analysis including values such as Betweenness and Eigenvector centrality)[85] to show which rooms (signified by nodes in the network) were likely to have the most traffic to people travelling through the space. Finally, the project also incorporates photogrammetry data captured from a student trip in 2017 combined with Roman period 3D art assets, providing an interesting dichotomy of what a populated scene may have looked like in the past in conjunction with the appearance of its current ruined state.

[85] See Brughmans 2013 for network analysis, and Fredrick and Vennarucci 2020 for how it has been used in testing and study against human subjects.

One of the intriguing things about the VPP project is the fact that it does try to span quite a large array of areas and methodologies to portray a fuller picture of the space in Pompeii, ranging from the individual to the larger structure. Through cognitive spatial mapping and analysis, the data gathered can be used to predict potential behavior in the structures from more data driven analysis rather than individual study and interpretation. The ideas from Bergmann and Wallace-Hadrill in their articles can apply and inform where wall painting may have been combined with their theoretical frameworks. The axis from this theoretical structure posited how much access was afforded people, and where they might go. With VPP not only can we test these ideas, but we can also map out possibilities of pathways someone on potentially any point of the Wallace-Hadrill axes would move through a space through the network analysis. The different values represent how well-connected nodes are to one another. Betweenness is a measurement of how well a node is connected to the rest of the nodes in a network. Eigenvector centrality is a measurement of how well a node is connected to well-connected nodes, similar to how Google's PageRank algorithm works with returning search results.[86]

VPP continues to publish its research and has recently co-hosted a virtual conference with Kiel University, which I helped organize, titled *If Data Could Walk* (July 2021). The conference focused on using the large body of data from Pompeii in recreation and analysis, both digital and phenomenological.[87] So as it is engaging with the archaeological record, VPP directly examines the systems of analysis existing within archaeology by generating a new top-down approach in its network analysis, and a bottom-up approach in the way it incorporates user data through different movement scenarios.

[86] Brughmans 2013 636-638.
[87] http://tesseract.uark.edu/if-data-could-walk/.

Based on this brief survey of applications in classical archaeology, a variety of approaches exist ranging from basic recreation with minimal interactivity for tour companies and the general public, archaeological recording and interpretation displayed through open access websites, and guided movement testing as well as pedagogy in using games to teach Roman civilization. VRR stands among these as being directly influenced by VPP and *Saeculum*, but also gathers firsthand data via photogrammetry in conjunction with 3D asset creation and designed scenarios. Phenomenology and embodied game design guides VRR in its development and its project vision as it expands. Photogrammetric models are placed alongside the 3D assets to enhance the realism in the space, archaeological plans stand as backdrops to fill space while the user chooses to walk through the space, interact with the inventory and view different lighting scenarios. Multiple theoretical approaches have culminated in one overarching dominant principle to guide VRR, that experience drives the design and vice versa. Phenomenological ideals from archaeology about said individual experiences[88], sensorial and descriptive details combined with digital embodiment[89] and thoughtful game design centered around learning with meaningful choice, procedural rhetoric brings forth a myriad of possibilities for creating digital products in VR for research and pedagogy. VRR aims to utilize these approaches in its visualization and its creation of interactive scenarios while being influenced by the theory in game design and archaeology to create a serious application that produces meaningful results.

[88] Tilley 1992, Bergman 1994, Hartnett 2017.
[89] Shinkle 2008 p. 908.

Chapter 2: Methodology

Introduction

This chapter is intended to lay out a more technical groundwork of how the theory discussed in the previous is applied to the development of the application and its execution, highlighting obstacles and showing solutions to problems that arise. Something to note is that this is an ongoing project, and so therefore the methodology section will include not only work done, but also planned work for the application past this thesis. By integrating 3D photogrammetry data with assets created from plans and photographs of the archaeological evidence, as well as artistic assets from the Tesseract Center game *Saeculum* about Roman civilization, I was able to create a reasonably accurate reconstruction of the shop space. The application of game design and playtesting methodology helped me create a prototype application for the digital shop space that is viable for research purposes. The choices for certain types of 3D data generation were informed by both theoretical approaches as well as available funding and resources.[90] Overall, the workflow as laid out in this chapter starts in a linear fashion, but quickly becomes entangled with other aspects of the development as the product moves forward, thus requiring development on multiple fronts to happen at the same time. The flow begins with research and designing areas and situations, followed by data capture and more artistic focused study for the creation of bespoke assets or mechanics. Then that data is processed and used to create assets, followed by mechanics development via the Unity game engine and some coding, finished by frequent testing. Testing requires these steps to be revisited quite a bit, but this gives a good overview of what is typically expected. See the figure below for a general overview of the sections of the game design workflow.

---

[90] I would like to mention here that financial support from the CLCS department, Provost Collaborative research Grant, GPSC and Sturgis International Fellowship all helped with the research and development of this application.

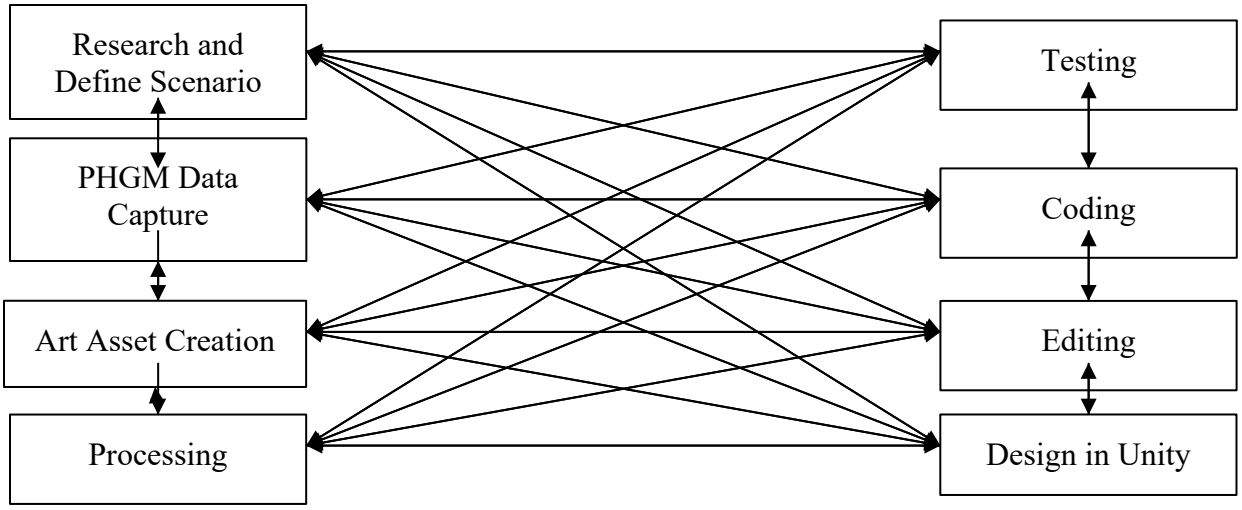


Figure 2.1 shows the major steps for the development process of this application, all interrelated to each other. Source: Loder 2021.

Photogrammetry

Photogrammetry is a digitization process that is widely used in archaeology and cultural heritage management today[91], and is being increasingly used in games as a way of generating 3D assets, as seen by the Unity game engine releasing a technical workflow in 2017.[92] It requires a large set of still photos taken in sequence and next to each other, typically of an object or landmark, and those are then used to create a scaled 3D object of the real-world subject. Photogrammetry is one of the most cost-effective and realistic ways of recreating real world physical phenomena for efficient use in digital applications. The photogrammetry (PHGM) object is a 3D mesh with an applied texture that is proportionally correct in its representation of a real-world object without needing to have a reference scale. Most archaeological projects do use targets in their models to tie in GIS coordinates for mapping that have precise measurements in their visualizations; however, in a game about individual interaction this precise degree of

[91] Sapirstein and Murray 2017, 337.
[92] Lachambre and Lagarde 2017.

accuracy is not necessary, and the positional and scale data can be approximated with plans within the 3D game engine space.

In recreating the shop for VR representation, what is important is that it is scaled to something representative of its original measurement to evoke a more faithful experience of the space. While georeferencing is appropriate for other research and digital applications, it makes little to no difference in the 3D representation of the space. The objects are still checked for measurement accuracy, but they are not linked to real-world spatial coordinates. For a digital experience, as long as the object is believable within the style you have established in your world then it can work for immersion.[93] While a high level of accuracy is not necessarily a bad thing, pursuing it in PHGM creation is irrelevant for games because it is more important that the application run smoothly rather than the high-quality art asset be entirely accurate, which is, in fact, an impossible goal. Accurate measurements are used for original asset creation from archaeological plans, but the proportionality to create believable representations is a key part of the process for PHGM creation. I took the photos, but the program then ties them together for a 3D object scaled into an accurate digital facsimile of the remains as they were at the time of capture based on the matching pixels from the overlapping photographs. The sheer amount of detail and color as well as physicality of the object in its space goes far beyond the ability of the written word to describe the intricacies gathered from an embodied presence, and placing these objects in 3D space allows for even more individual interpretation than reading a description and viewing pictures.

What follows is a description of the steps necessary for re-creating a 3D asset in Metashape, and then I will point out where the relevant theory is applied or reflected.

[93] Salen and Zimmerman 2004; Murray 2014.

Photogrammetry creation entails taking multiple photos around a stationary object in a static environment. For a street curb, I travelled to Pompeii in 2018 and walked to the street where the majority of shops are, the *Via dell'Abbondanza*, using a DSLR as well as my high-resolution cell phone camera and then took a series of photographs of the street and curb while there were as little tourists or other disturbances as possible. Each photograph needs to be taken in flat lighting, typically overcast or all in a light shade if possible to avoid reflection[94], and there needs to be enough overlap with each subsequent photo for the software to recognize and extrapolate the position of the camera in the 3D space of the software. Typically, depending on the time of day I visited, I would be more successful with shadows on one side of the street than the other, which led to multiple trips back and forth. Some lighting can be taken out through de-lighting algorithms[95]; however, these are not as ideal as having flat lighting to begin with. In taking these photos, I had to wait for people to leave, circle around and frequent mundane sections like curbs and corners to capture details. The results are street and curbs in the application scaled and gathered from the site for the player to inhabit. The lighting is significant for the creation of the texture, which is created from the color gathered in each photograph. The software then takes each photo and compares them against all the other photos, which in turn estimates the camera positions and creates a point cloud to recreate the matched points in 3D space. As a rule of thumb, each photo needs to have significant overlap between each other to match up the corresponding pixels of the 3D object. In processing, the photos must go through a series of steps: Alignment, dense point cloud generation are the main preliminary steps, and many times I

[94] Reflection in photogrammetry is unable to be accurate processed because of the lack of pixel data present in photos to match between them. Glares and smooth surfaces are difficult for photogrammetry to process and typically end in inaccurate models.

[95] Unity and Metashape both now have "De-Lighting" tools that can help with the texture creation, though they can have limited success compared to an object being captured without shadows in the first place.

would run these functions with different point limits and parameters depending on the fidelity or model I was making. At this stage is also when I would discover if I captured enough photos, or was using too many and unable to create the models due to overprocessing. Much back and forth is required, and when the dense point cloud is accurate is when you generate a solid mesh. Typically, because these assets can always be decimated or edited to a lower quality, I created high fidelity versions of each model, preserved those and then would decimate a copy so that I would always have a version to work from or go back to. Figures 2.2 through 2.4 show the steps and variables in Metashape when dealing with recreation of a preliminary mesh for the east shop of the Tabernae di Pescivendoli (IV.V.1) in Ostia and the street curb in Pompeii.

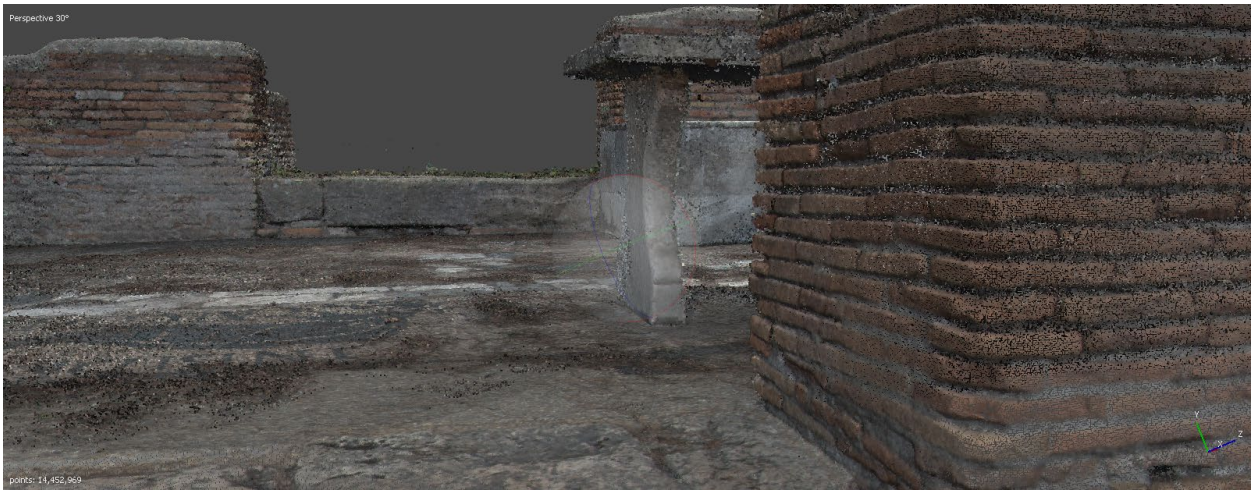


Figure 2.2a: A dense cloud of individual points zoomed in, with 14,652,969 points altogether. Metashape allows high medium and low-quality designations that correlate to the number of points, though this typically requires testing based on the size of the model. Source: Loder 2021.

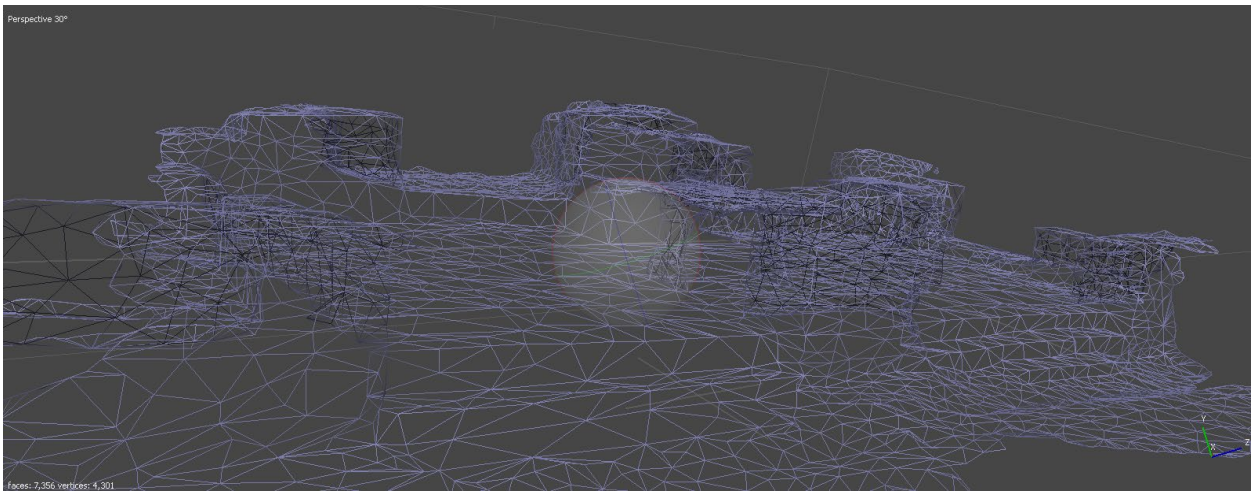
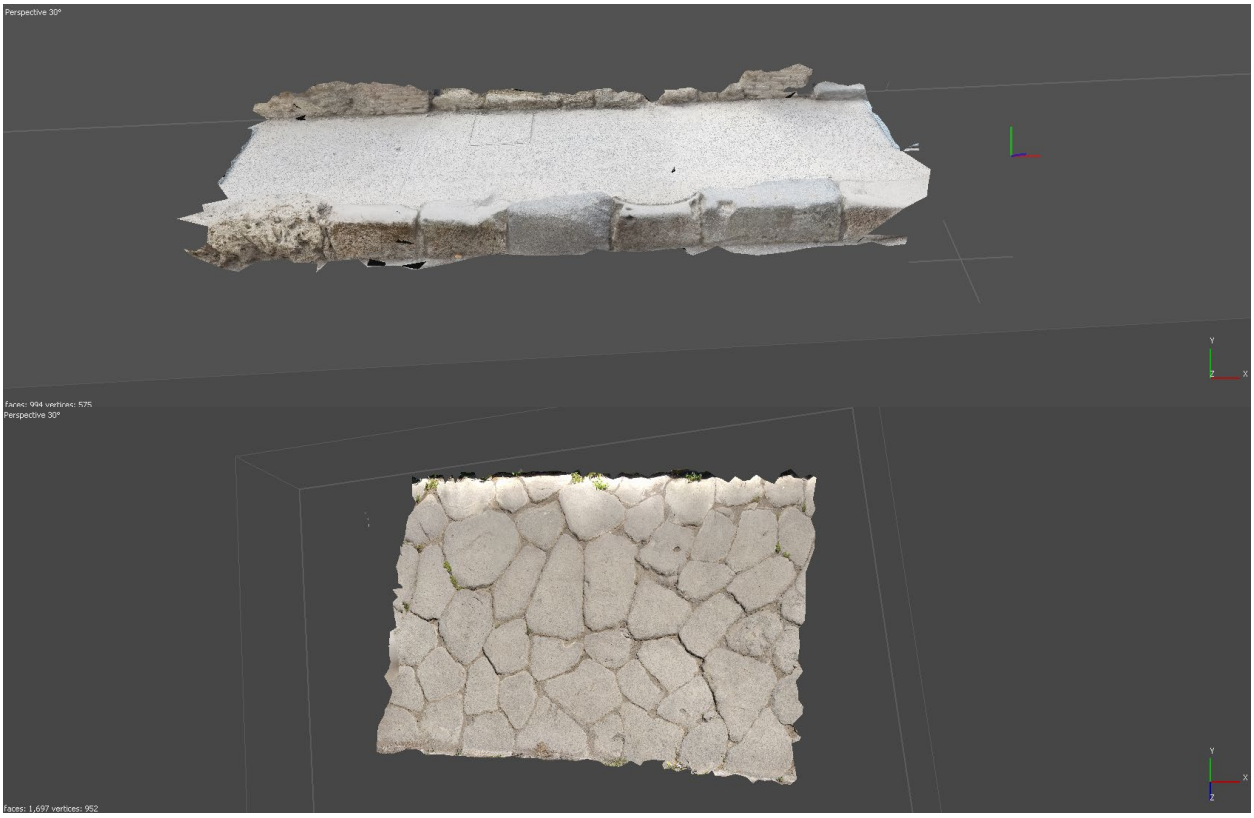
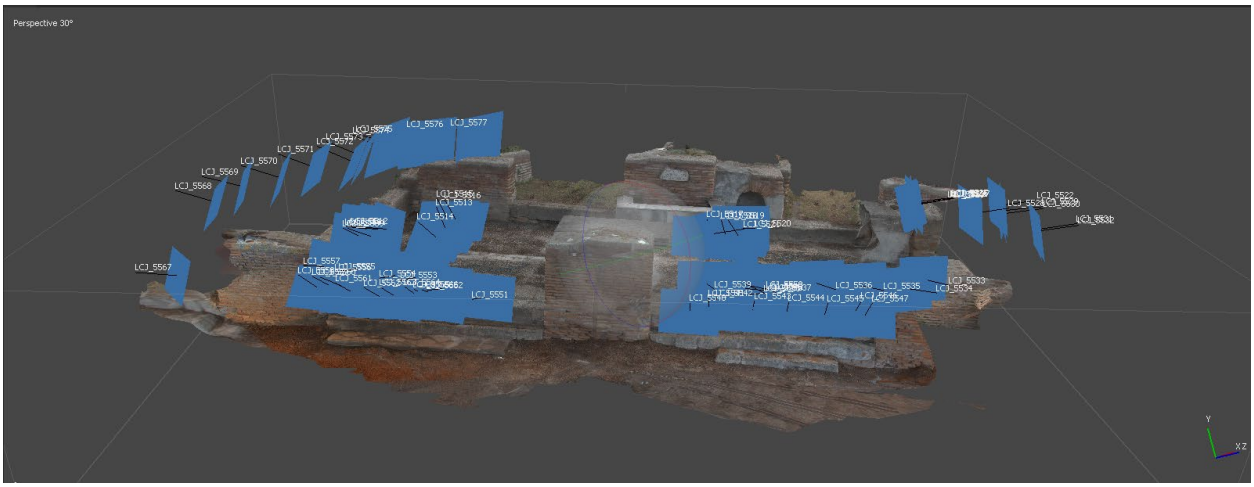


Figure 2.2b: This is showing the polygons that make up the model, though there is no texture applied to this. Polygons are automatically generated in Metashape, and tools like Blender can be used for more precise editing to remove polygons and improve performance. Source: Loder 2021.



Figures 2.3a and 2.3b show the curb and street objects taken from Pompeii. Source: Loder 2021.



Minimal obstructions, multitudes of pictures and processing time (and power) are required to get a recreated object that scales correctly. Targets can be used to get more accuracy, though this is not necessary for this kind of embodied visualization because, as stated above, absolute accuracy of a model that is proportional to itself is not necessary if the object is able to convey the correct sense of spatial presence. After processing, some editing is required to get rid of data that is either incorrect or outside the range of what is needed for that specific object, thus tying into the design and research of the designated scenario. During the editing process, the idea of the whole experience is important to keep in mind, as each part informs each other one. Metashape also exports the 3D file and maps its texture into a ready state for game engines to use directly. However, even with some of the refining tools, it is not typically enough for smooth runtime efficiency, and especially in VR.

While these broad strokes tend to work with simple applications, typically photogrammetry assets are large files with complicated geometry and textures that need many passes of optimization and decimation to get them to work in 3D applications. Virtual reality requires even more optimization due to the high frame rates needed for immersion to be effective

and useful: for instance, 60-90 frames per second (FPS) is the standard for VR development[96] because of additional rendering and the possibility for players to experience motion sickness, while traditional 3D and 2D games try to have a baseline of around 30 FPS. Other programs are needed to truly transform the 3D assets into their most efficient, yet still realistic state. These additional programs include work in the Unity game engine, texture work in Photoshop, and possibly further editing in a 3D modelling program such as Blender or Maya. Basic digital literacy with all programs is required for the application to be most performant, hence why most game design is done in teams of multiple specialists. After exporting the models from Metashape into Unity I would test to see how the player controller performed with frame rate, and then re-topologize[97] in either Blender or Metashape depending on the complexity of the geometry. Occasionally I would have to re-work the textures in Photoshop for them to project onto the model correctly, in a process known as UV mapping. The workflow outlined in this section is meant to be flexible enough to change but also informative enough to be used effectively.

Affordance Design

For the phenomenological experience, these assets create a sense of realism and presence needed for digital interactivity and embodiment. For instance, with the photogrammetry in the application, I was able to create incredibly high-resolution models of the sidewalks and then place them together, which then promptly led the game to crash and not load. By significantly reducing the number of polygons while keeping the shape and textures accurate to what a sidewalk looks like, I was able to work with the PHGM to be usable, with some texturing work to add depth known as normal maps. This is significant for creating environments in digital

[96] Schell states this in their post-mortem blog in 2016, and it is part of the development requirements for publishing Oculus (2021) applications.

[97] This is when you reduce and sometimes fully re-create polygons of a mesh to make them more usable in an application.

applications: players must be able to intuitively navigate and use the surrounding areas, and the 3D assets need to be usable while still communicating their environmental affordances. Accuracy is very important in 3D re-creation of cultural heritage sites, however only a certain level of detail is needed to recreate something with the necessary effect on the individual. If something is recognizable, say the sidewalk, a shop counter, a seat or an awning, then the player in the digital environment will accept that object as what it represents and interpret it as such. Achieving this level of realism and understanding is what gets players to accept recreations and digital applications, and for that to run in an interactive scenario, the highest fidelity possible is not useful.

Incorporating The Archaeological Records and Resources

Once the photogrammetry process was complete, it was possible to determine what else needed to be 3D modeled to complete the environment. The process of getting the PHGM to match with the objects in the Unity 3D engine requires frequent testing, editing within the set of software tools to achieve desired accuracy and appearance. Plans were frequently checked for the creation of the assets to maintain accuracy. In Unity, 1 unit of measurement equals one meter[98], and because of this I was able to import a high-quality scan of the archaeological plan, which then acted as a reference throughout the rest of the building process.

[98] Unity Technologies, 2020. https://docs.Unity3d.com/2019.3/Documentation/Manual/BestPracticeMakingBelievableVisuals1.html.

Figure 2.5 Cropped section of high-resolution plan used in VRR. Source: Dobbins 2007.

Figure 2.6 outlining different parts of shop and process used. The curb and street were photogrammetry, the frescoes were traced in Photoshop, the 3D assets were curated and selected from the *Saeculum* some re-topologizing in Blender, and the roofs and structure were made in Probuilder and Blender. Source: Loder 2021.

The plans that were used for the street façades in the area of the shop are from early 20th century excavations of the Via dell'Abbondanza by Vittorio Spinazzola[99], and the ground plan is from hi-resolution images from the *World of Pompeii* volume.[100] Although taking place before the advent of processual archaeological theory with emphasis on more meticulous recording processes, these excavations nonetheless produced plates, plans, early photos (some of which are color) in a high level of detail, and are some of the only available resources for street decoration and buildings which are now lost due to exposure and deterioration from the elements. The plans stand measure against the photogrammetric recreation and are a reference. There are some discrepancies between the two; however, these are minor and do not affect the overall experience of the virtual space. As stated above, in VR and digital worlds the spaces created have to be believable, not precise. Pursuit of photorealism can seriously slow down the workflow and often the model produced, while visually accurate, causes performance problems in the application, disrupting the experience you are trying to convey to your player.

Spinazzola's strategy was to excavate a central thoroughfare through the town, the *Via dell'Abbondanza*. The public facing decoration along the street can be compared to decoration in Pompeian houses which, while it had an important role to play with visitors, was not as visually available to the public. The fact that these decorations were placed on the fronts of shops in the street suggest a vibrant, visually literate shopping culture heavily intertwined with graffiti, politics and religion. Spinazzola would excavate the entirety of the street between 1910-1923 although the excavation records would not be fully published until 1953. The records and plates were totally scanned by the University of Arkansas libraries and the data stored by the Tesseract

[99] Spinazzola 1953, vol. 3.
[100] Dobbins 2007.

center, which have provided invaluable resources for Pompeiian recreation and for VRR, as well as students and faculty. The frescoes on the façade of the shop, its main decorative feature (although note the interior is unexcavated), are explicitly outlined and well documented in color plates in the excavation records.[101]

Figure 2.7 Venus figure and felt workers Source: Spinazzola 1953 *Tav.* 12.

[101] Spin 1953, vol 3.

Figure 2.8 Mercury wealth and shop scene underneath. Source: Spinazzola, *Tav.* 11.

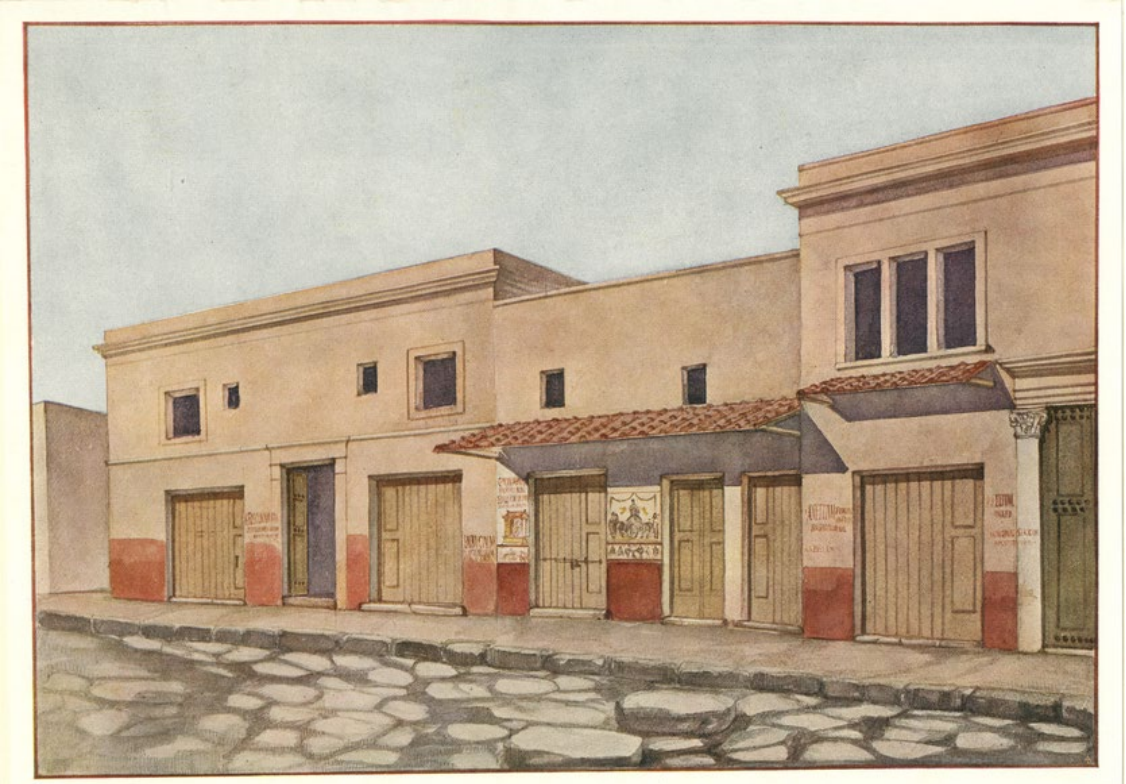


Figure 2.9 Watercolor Interpretation of the Shop façade. Source: A. Sanarica in Spinazzola 1953, *Tav.* 2.

In addition to the records from the excavation, resources like Pompeii in Pictures[102], which is a website that includes photographs of every accessible property in Pompeii, and the book/website *Pompeii Perspectives*[103], which recreates the façade plans by Spinazzola by high resolution photomosaics of what is extant today, allows for crucial comparisons to inform recreation. For instance, Spinazzola's façade plans would highlight existing evidence but also include hypothetical reconstructions of the rebuilt façade. By comparing the façade plans to the façade photomosaics in *Pompeii Perspectives*, these resources guided development of the app to produce a faithful reconstruction that is accurately scaled and grounded in the archaeological record. Especially important to note is that the destruction of Pompeii by Vesuvius destroyed hopes of an absolutely accurate kind of stasis, so this places more importance on the excavator's perspective since they were the ones to witness and direct the excavation of the evidence that remains. The excavation records are also supplemented by on-site photos of the properties in question as to their current state. In addition to the photos I have taken for photogrammetry, I have also taken photos of obscure or hard to see aspects of the evidence to document details for later reference or revision.

[102]Dunn J. and B. Dunn, 2021 https://pompeiiinpictures.com/pompeiiinpictures/.
[103] Stephens J. and A., 2016.

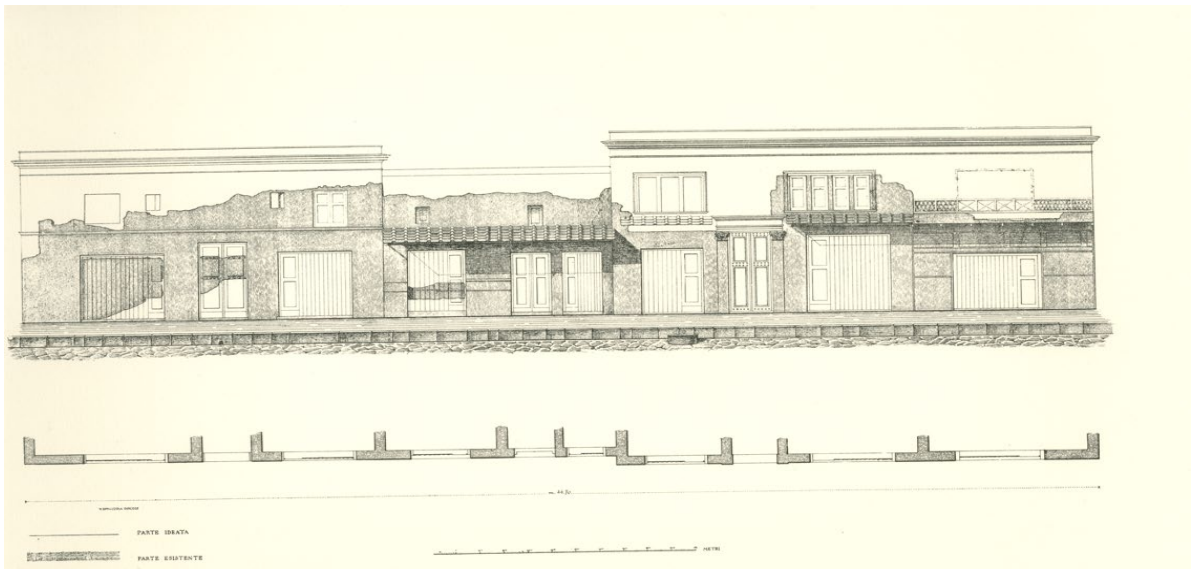


Figure 2.10, the north façade with the Shop of Verecundus. Source: Spinazzola 1953, *Tav.* 61.

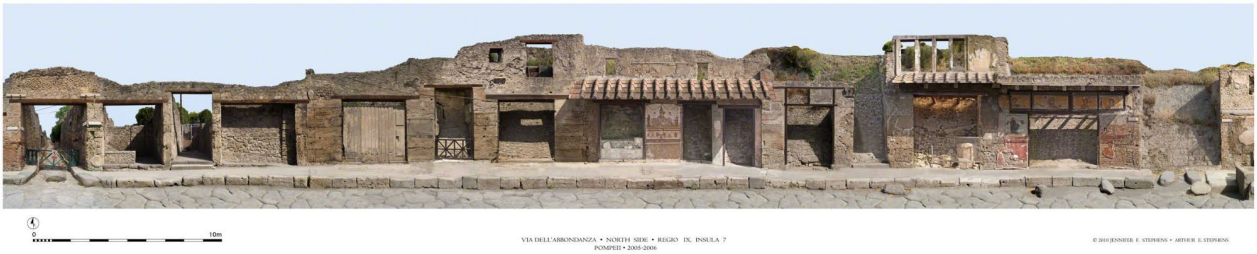


Figure 2.11 Pompeii Perspectives photomosaic taken in 2005-6 Source: Jennifer and Arthur Stephens 2016.

Figure 2.12 Shop with lighting, plans and PHGM curb and street and populated shop. Source: Loder 2021.

Putting all these assets in the context of the site is when our reconstruction begins in the game engine. The photogrammetry of the shop is put into the game engine along with the elevation plans from Spinazzola, depicting the street's north and south façade. The elevation plans extend for a block on both sides of the street and helps to create a sense of scale and presence for those exploring the shop space. The shop itself is unexcavated, which means there is little evidence about what the interior looks like. Hartnett[104] has already provided a detailed discussion of the façade décor, and so I will not repeat it here. I will, however, focus on the shop scene to the left of the shop's entrance, which shows a female shopkeeper possibly with a customer, or maybe even Verecundus showing off his wares as Hartnett suggests. Although the accuracy of the scene as a representation of the interior cannot be proven without more excavation, it is generally interpreted as a reflection, perhaps idealized, of how the shop's interior may have appeared, and it guided my reconstruction of the interior in the app. I used assets from *Saeculum* to match the interior, which worked out well because the bench had the same legs as the bench in the fresco due to the research on Roman furniture done by the Tesseract Center at the time.

Figure 2.13 Close-up version of shop scene. Source: Spinazzola 1953 *Tav.* 12.

[104] Hartnett 2017, 284-288.

Figure 2.14 Shop Interior from application. Source: Loder 2021.

The scene also informed the interaction I designed for the app, which is centered around browsing for *soccii,* slippers worn for dining parties and by typically wealthy members in Roman society, which players do in the VR application. Tesseract's game course Saeculum has many created assets of researched Roman furniture, tables and couches which are represented in the outer façade drawing. The façade creates a possibility, an idealized one likely due to the notion that this a potential type of advertising, but a realistic possibility nonetheless of a scenario that can be recreated in Virtual Reality and have a strong historical grounding in visual evidence. So, in building the app we configured the placement of the furniture, goods and realistic character of the female shopkeeper with likely position data. It is not 100 percent accurate because that is not possible or known, and likely irrelevant to the goal of creating scenarios that could represent different types of shopping experiences. The overall experience was probably quite fluid and never exactly the same, and it would be reductive to assume there was only one way of economic transaction happening in the ancient Pompeii.

In addition to using the archaeological records and photo records available, current academic discussions of spatial analytics of hyperlocal areas are useful in the recreation of this

scenario. Perhaps most relevant is Hartnett, because of the work's conclusion in a world-building exercise in its final chapters, specifically along the street where the felt shop of Verecundus exists.[105] In it, he specifically focuses on the graffiti, space, decoration and religious imagery as well as architecture intertwined with the commerce and political activity present for his inspiration. Hartnett discusses different meanings implicit in the shop frescoes, with the Mercury fresco being a representation of wealth and likely marketing of the felt wares[106] and the Venus Pompeiana showing local pious deference. The felt makers represented under Venus Pompeiana on the right echoes the shop scene on the left, which suggests planning and coordination. Hartnett also points out that the name, Verecundus meaning "Mr. Modest" is written under a figure holding a finished cloth, suggesting a certain pride in their work, or trying to outshine possible local competitors.[107] All of this advertising combined with a busy street and with a smelly *fullonica* nearby, the scenario is brimming with sensory details from his analysis and description.

Where Hartnett ends is where VRR begins, focusing on not only visualizing but embodying one of these possible experiences and seeing, not just thinking about, what an actual person might do in this scenario. Many other types of analysis tend to take the large scale, top-down approach as indicated in the previous chapter, specifically ones that would greatly affect behavior is the water distribution or spatial analysis of traffic patterns.[108] This is still useful in the creation of a hyperlocal scenario not only because of the representation of data on a map but showing what overall trends may have influenced the general populace. If there were any general anxieties around resources, say a water shortage or grain supply disruption, traffic flows or

[105] Hartnett 2018 283-288.
[106] p. 284.
[107] Hartnett 2017 286. Also see the lower portion of figure 2.7 for the depiction being described.
[108]Weilguni 2011, Poehler 2016.

knowledge that can be revealed from the different parts of the city, that type of information can be presented to the player through dialogue or character behavior in an interactive application. Combining these approaches begins to create the holistic picture of these spaces, however that can be hard to test. Recreations that incorporate this intellectual history and tradition can be a ground for testing these types of research questions, and while funding may be limited, a 3D application that is a playable version of some of the most studied sites in archaeology may be highly useful for continued research, analysis and understanding beyond what is currently only available to a small portion of people with the economic means to physically visit.

3D Assets

For recreation in 3D modelling programs, the photos and plans are essential to creating the geometry, which in the case of these building façades are started with blocks and then cut out and added to as necessary for windows, doors, etc. The programs used with this are typically Autodesk Maya or Blender[109] to do more advanced modelling, but Unity also has an in-engine solution to build these art assets called Probuilder. The biggest difference in these programs and the built-in solution with Unity is the ability to accurately apply and display textures on the objects, a process called UV mapping, as well as fewer detailed modelling tools in general. Probuilder has a very limited toolset in how the texture can be edited and displayed, and at the time of creation the plugin had multiple bugs which caused workflows to slow and the program to crash. However, it was able to work for a placeholder scenario. After creating them with Probuilder, taking the objects out of Unity into Blender, I was able to simplify the geometry and create a level of detail that performs well but is also visually rich enough to create the sense of realism needed for the application. Some of the biggest hurdles in game development is with the

[109] I used Blender for this project, though the assets used from the *Saeculum* game were initially created in Autodesk Maya.

art assets, which basically refers to everything visual within the scene. Probuilder is very much a first step for blocking out the environment, and usable for a prototype. By taking these assets and editing them using Blender, the assets created are more robust while also being less memory dependent. The revision process includes a lot of deletion of polygons or parts of objects that are never seen, but their presence in a scene's application would take up memory and make the application run less smoothly. Revision is crucial to the creation of these assets because of the various performance benchmarks required for 3D applications and rendering, especially in VR.[110]

Lighting:

After the creation of the assets, they are then placed within the Unity scene and lighting scenarios are then designed and determined. For many applications, baking lighting is a scenario which allows for higher quality lighting to happen by rendering the lighting data into textures rather than rendering it in real time through lights in the world space. This can help because memory is not taken up at runtime generating lights, thus allowing for smoother gameplay, and better immersion. However, for this application, we want to explore the viewsheds and phenomena with different times of day. Shopping likely did not happen at a static time of day, and so within the app there is the option to choose from 3 distinct options, morning, afternoon and early evening (see figures 2.15-17). Setting up three distinct lighting scenarios within Unity, the player can press a button and turn the scenarios off and on, cycling through each one. Through some simple coding, I was able to tie activating lighting objects which mimic the different times of day to button presses in the application.

[110] To not go into too much detail above, VR essentially requires 2 rendering passes of a scene because each eye works as a camera. Because of this and the requirement of a higher frame rate than traditional software required for immersion in VR, art must be much more efficient in its creation than typical applications.

Figure 2.15 Morning. Source: Loder 2021.

Figure 2.16 Afternoon. Source: Loder 2021.

Figure 2.17 Evening. Source: Loder 2021.

The position of the sun can be replicated within 3D space as well as the intensity of the light. In order to get the historical sun position, I used a tool provided by the United States National Oceanic and Atmospheric Administration's (NOAA) Global Monitoring Laboratory[111] which calculates positions of the sun based on rotation and estimates through equations with a

[111] NOAA, 2021, https://gml.noaa.gov/grad/solcalc/index.html.

small margin of error. As seen on their site, the tool allows players to select a location and then input a date to calculate the sun position. The calculator works historically, and after inputting the calculated date, I chose time of day based on the 24-hour format. The date chosen in coordination with Dr. Vennarucci was September 10th, 61 CE. The year was significant because it is before the earthquake of Pompeii in 62, and also gives the application a plausible date to be free of the graffiti that was discovered on top of the frescoes on each side of the shop entrance. The azimuth and horizon data is then put into a Unity tool called Sunlight, made by the asset developer Hessburg[112], which then places a light object in the skybox of the scene, creating the sun position. For the sake of the prototype, we assume a relatively clear day to get the best idea of how shadows were created in the street and shop front.

The significance of this is to test how the awning functioned in providing shade in front of the shop, and how that might impact consumer/player behavior. The project is also interested in how much natural light reaches the interior of the shop, impacting the visibility of the merchandise on display, at different periods of the day, and players would be asked after their experience about which lighting scenario was preferable to them. If shade was a factor, this kind of data would likely appear within their responses. Performance wise, these three scenarios are good to start with but, importantly, moving forward these lighting scenarios can be adjusted and changed following playtesting and input.

In practice, this is not the most performative solution because baking the lighting would be more efficient and play at the higher frame rate. The lighting switches between 3 different real time lighting objects. Again, here is where the balance between accuracy and immersion comes into play. A higher frame rate allows the player to be more immersed in the game and less likely

[112] Hessburg, 2019 https://assetstore.unity.com/packages/tools/particles-effects/sunlight-location-based-time-of-day-66399.

to notice it lagging, but this might come at the sacrifice of more accurate lighting scenarios, which also may result in the loss of some immersion due to shadows not behaving as they might to a player walking in the real world. If a player reports that some aspect of the app, like the lighting, is sensorially overwhelming or breaks their immersion, the project can adjust it to create a more realistic experience. Moving forward, this lighting will be adjusted or updated when the project is able to test more players, hopefully experts in the field who can provide informed input on the viewsheds or meaningful responses to what kind of environmental factors would affect the lighting conditions.

Soundscape and Environment:

Sound factors heavily in the presence of a place. Game engines are generally quite good at placing sound in environments and having the ability to re-create different generic soundscapes. Recent games in historical settings, like *Red Dead Redemption 2*[113] and *Assassin's Creed Odyssey* [114] have multiple scenes with crowds or streets that are brimming not only with browsing opportunities, people and other visual stimuli, but also rich soundscapes. Carts, animals, people all traveling in their own directions set by the game elicit a busy soundscape. Currently, development in VRR focuses on other aspects of the environment and there is not a city soundscape existing in the build. But plans are designed for this to include a busy streetscape sound similar to previous applications that have included soundscapes. Due to performance and resource constraints, sophisticated AI to control NPCs (non-playable characters) are not included in the development plans. However, going back to game design, just having the sound in the application without the apparent sources still adds to its presence, the player will still take this

[113] Rockstar Studios 2018.
[114] Ubisoft 2018 I selected this as an example because it is an open world exploration game with a realistic historical city, populated and has multiple shops and stores to enter and interact with.

cue and subconsciously think that they are somewhere where the street is crowded, and it still has an effect on their behavior. There are plans to include a believable soundscape of people walking and talking as they would in a street. In describing Ostia's soundscape, Veitch provides an excellent comparandum to base Pompeii's soundscape off, and in combining Veitch's research to match existing sounds VRR will manage to aid immersion into the streetscape as well as create the soundscape for the Ostian shops.[115]

Additional character models would also be included and populating the scene with them posed in different areas can be placed in the editor to block out the space, but would require significantly more artistic input for VR character design and modelling, as these characters are essentially being retrofitted for Virtual Reality. Much of the process I have had to do for decimation and re-topologizing of the existing art assets I described above I would need to do for each character included in the scenario. I have done an amount of this within Blender, including decimating mesh and removing multiple polygons by hand to create a more usable figure. The original character model used for the role of the shopkeeper is a model from *Saeculum* re-used with permission here, as is the furniture in the shop.[116]

Game Scenario

Currently, the player can walk down and across the street, go up to the shop and pick up the slippers. In testing the player movement, speed was consistently altered as this affected the possibility for motion sickness as well as immersion and believability, as well as the amount of space needed. Ideally, users could create a large enough space but can move with the joysticks if they are constrained. This interactivity is key for our designed scenario, the last major piece of

[115] Veitch 2017 68-69.
[116] Tesseract 2015. These assets were created by a team of artists and students who heavily researched furniture and characters and hairstyles for the game characters and art across multiple periods of Roman civilization.

the immersion puzzle. This is drawn together in a forthcoming chapter in an edited volume, which places the player in 72 AD, is a freedwoman spouse of a freedman for the emperor Vespasian to oversee reconstruction from the 62 AD earthquake but they need a pair of dining slippers (*soccii)* for their dinner this evening to make an important social impression.[117] The player character is established as independently wealthy and multilingual, and you have an enslaved attendant who is non-Roman. Already, multicultural lenses and identity can broaden the complexity of the 3D experience solely through initial exposition. To continue, the player must navigate through the city and discover a felt shop that has the slippers for the occasion, all the while making choices throughout (turn here, talk to this person, haggle at the shop) which would influence the exploration of the space, use of the digital/archaeological affordances and whether they complete their purchase. The impression the player wants to make on their hosts would be positive, and this encounter could be developed in several ways using social historical research in Pompeii to create plausible and significant situations that would affect behavior.

By having these situations and then running players through them, we can take the input and apply this to other time periods, other scenarios to spur a deep engagement with the source material that scholars like Gee and Murray[118] provide, such as teaching early learners to read or how embodied narrative can be forwarded by digital tools. Archaeologically speaking, material remains, and the study thereof provide an excellent opportunity for these types of interactive scenarios, due to the rich existing evidence and sophisticated interpretations surrounding them. For instance, elementary Latin students could use the application to enact a shopping scenario where they need to use vocabulary related to the products being purchased, similar to a real-

[117] Fredrick, Vennarucci and Loder 2021 p. 22-23 (forthcoming) in the last section describes this potential scenario in detail.
[118] Gee 2007, 2008; Murray 2014.

world scenario for students learning languages. With plausible scenarios, players will be able to experience and learn about sites in a more engaged and meaningful way than traditional text and online sources, and possibly better than an actual site visit because most sites are ruined or completely destroyed or have restricted access as well as crowds, whereas re-creation and simulation could generate new insights on the ancient world by offering broader access to the materials.

Future Directions

The Felt Shop of Verecundus represents phase 1 of the Virtual Roman Retail project. In phase 1, I worked closely with my co-directors to develop and test a workflow for designing a VR app for a Roman shop. In the project's second phase, I will apply this workflow to developing a second app for the *Tabernae di Pescivendoli* (IV.V.I) at Ostia (figure 2.18), Rome's port city that developed over multiple centuries and has material evidence preserved from longer periods than Pompeii. Ostia would eventually become abandoned, but much of the city's rich urban fabric remains from 2nd -3rd century CE. Here, these shops are at a major intersection of the western *decumanus* where 5 streets come together, as seen in figure 2.19. What is interesting about these shops is the presence of marble tanks where fish would be present for customers to view and purchase, as well as expensive mosaics depicting an aspect of the fisherman's culture as well as characteristic of Roman art, it is an image of a dolphin with the words "INBIDE CALCOTE", meaning "Envious one, I trample you", all of which combines for quite the sensory experience.

Figure 2.18 the Fish Shop with the tank and table, as well as mosaic floor. Source: Loder 2021.

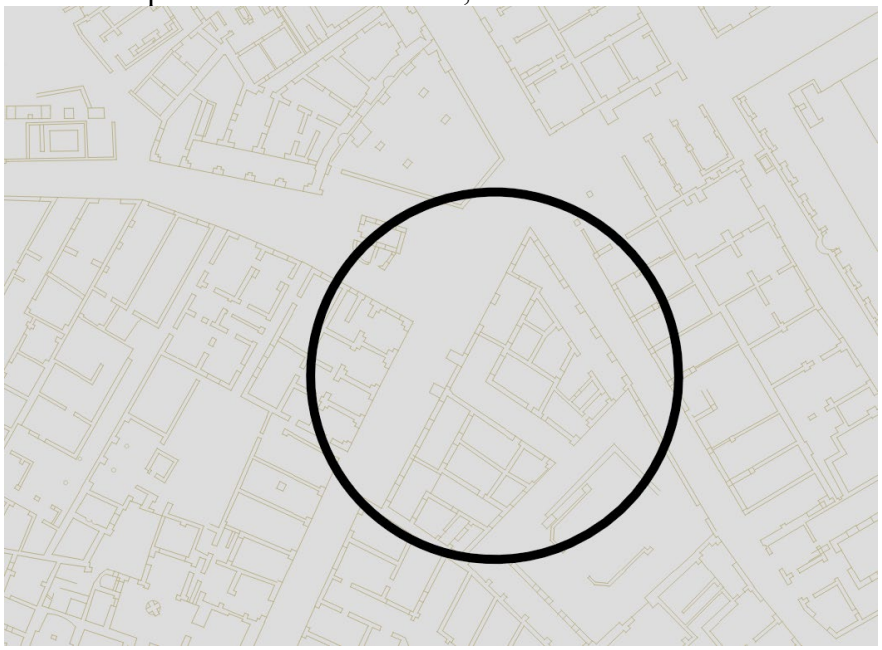


Figure 2.19: Intersection of *Bivio del Castrum,* with the fish shops circled. Source: Parco Archeologo di Ostia Antica 2017.

This mosaic text has been interpreted as the fishermen depicting a creature that may interfere with their trade, the dolphin, and a figurative way for them to exact a sort of revenge. But what this also does is invite the player/shopper to a scenario that they can also "trample" on the envious entity to the fishermen, thus using a sort of interactive marketing since the customer

would be able to fully read the saying once inside the shop for the shopper to involve themself in as part of the fisherman's experience.[119]

I am currently in Italy now on a Sturgis Fellowship to start work on phase 2. Francesco Bedeschi, Director of the University of Arkansas Rome Center, was able to introduce myself and my co-director, Rhodora Vennarucci, to Ostia's Funzionario, Dott.ssa Claudia Tempesta. Thanks to a productive meeting, we have successfully secured permissions from the archaeological park's director, Dott. Allesandro D'Alessio, to capture detailed photogrammetry of the Ostian fish shops. I will be working on a prototype of the model over the next few months.

[119] Vennarucci 2015 p. 153.

Chapter 3: Discussion of Preliminary Outcomes

The results of the above methodology are a working prototype where the player can walk up and down a section of the *Via dell'Abbondanza*, change the lighting, and pick up the slippers at the shop's counter. The application can be thought of as a living project, as much of the groundwork has been laid and content can continue to be added as it is created. For instance, the scenario of needing to go buy slippers for dinner is something that exists on paper as a narrative and the basic design is complete. To fulfill this condition, multiple iterations will need to occur, but once the groundwork is laid out in the code with specific conditions, the game is essentially there. Simple narrative prompts can appear to fulfill the necessary setup for the scenario, which then can be fleshed out, characters can be added, etc., and the framework for collecting and gathering player data needs to be finalized.

The player is able to reach out and take the slippers by holding the lower trigger on the oculus touch controller to grab them. The presence of the controller is significant, because it provides a physical weight and resistance in the player's hands. Oculus allows for hand tracking which enables the use of VR without the controllers. With the controllers, you are holding something in your hand. This may become less apparent as time goes on and the player gets used to the virtual experience. Once a slipper is picked up, the controller remains, almost like a reminder that it is still there and is a connection in real space to the players hands in virtual space to help establish embodiment and interaction with affordances, and the player now is holding a slipper. (see Figure 3.1) The player must continue to hold down the controller's trigger to keep holding the slipper, otherwise it would fall to the ground, just as in reality. Ideally the controller would vibrate as it is picked up to further reinforce the sensation of something being picked up.

Figure 3.1 The player holding *soccii* in the shop. Source: Loder 2021.

Movement wise, the player is encouraged to walk around and can do so safely thanks to Oculus' guardian system and within a fairly large play space created by the player, which provides a blue cage to appear once the player walks near the edge of the safe play area. Walking freely provides the best immersion for the experience because the cameras on the headset allow for the player's movement to be tracked throughout the room space which translates into virtual space, but the player can also move the joysticks to navigate if the player gets stuck or needs to move further around. The movement speed has been meticulously tested and altered to make sure that nausea is not a factor in the movement within the app, and is slow but perceivable enough that most users will not lose immersion. However, with more testing and development, this can change as we continue to have more users test and play the application. This combination is how players move throughout the experience, and it is embodied for them because it relies on their physical presence in the real world to synthesize with the virtual presence they have in Pompeii as is necessary when inhabiting digital versions of the body.[120]

[120] Farrow and Iacovides 2014, Shinkle 2008.

The lighting currently turns on when the player presses a button on the controller. To turn that lighting scenario off, the player needs to press that button again. Three different buttons are assigned to the different lighting scenarios: morning, afternoon and evening. What the prototype is lacking is a clear UI solution to communicate to the player how they can switch lighting. A UI that is subtle enough to be placed within the play space and not be distracting but usable is key. It must be in the play space and not tied to the screen because as opposed to traditional applications where the user looks at a screen, the screen in VR is attached to the movements of the users head and a UI attached to that could break immersion as well as induce some mild nausea. Minimal and sleek design is ideal for this, and UIs are being designed at the time of writing. A slight problem is that all three lighting options can be on at the same time, creating an overbright and unrealistic scenario which needs to be resolved. But what is significant is the accurate re-creation of lighting and shadows on a highly visible shopping street using scientific readings and 3D visualization. Recreating these lighting patterns can help our understanding of the placement of awnings and frescoes, which can lead to more accurate recreations and analysis in the future when it comes to making new digital recreations as well as informing research into how these storefronts were built and how they were decorated. Going further, the ability to walk around and export screenshots would help out researchers using the application to gather data on these viewsheds.

Another outcome of this project is the establishment of the Virtual Roman Retail project framework and the plans to apply this design structure to a specified list of shops and streets throughout the ancient Mediterranean world. It uses this prototype as its proof of concept, with plans and future goals to expand down the street in Pompeii, as well as recreate shops in Ostia and other parts of the Roman retail Mediterranean, which will then add on to and amplify

different kinds of functionality as the project gathers resources and traction and the goal of VRR is to present a holistic through time and space of retail interaction throughout the Roman empire. There is a website[121] designed by the VRR co-directors and myself which details this ongoing research project and hosts descriptions of methodology (as well as has an early walkthrough video of the application), future plans and theoretical approaches. The workflow outlined and argued for in this thesis, along with digital assets and photographic evidence, will be available to the project directors for the future direction of VRR and any students who may be interested in continuing the project forward.

The prototype was presented and informally tested by players at the Consumer Culture Theory conference in Montreal in 2019 as part of a poster session[122]. In this session we engaged with researchers on consumer and retail behavior and invited them to try our scenario out. Many of them had little to no experience in VR, and we gathered initial feedback on movement, lighting, and engagement. Our poster presented some of the theoretical underpinnings of the application as well as more in-depth discussions of consumer theory and behavior.[123] The project drew significant interest in the use of VR for this kind of work. Many, if not all, of the people involved were not classical archaeologists or scholars, but they understood the possibilities and potential of research into consumer behavior using not only VR but also studying where consumption and shopping was used and its origins in societies. VRR was also the subject of presentations at the 2020 American Institute of Archaeology conference, where the implications for research were presented alongside the technical overviews of what went into development and data capture. The application was informally tested there with an audience of classical

[121] Vennarucci et al, 2021. "Home Page" https://vrr.uark.edu/.
[122] Vennarucci et al. 2019.
[123] See additional Figure 1 for an image of the poster from the conference.

archaeologists, which provided additional critique for its state and Questions about the research and evidence.

The broadest outcome of this project so far is the theoretical framework utilized to justify and build upon the use of VR in an historical site. Specifically, the powerful immersion VR provides allows for researchers and students to create and learn about hypotheses regarding Roman behavior, movement and economic factors. This framework is applied and built upon in VRR, and aspects of it are shared with a as well as informed by work on the Virtual Pompeii project and other projects at the Tesseract Center for Immersive Environments and Game Design at the University of Arkansas. Essentially, this thesis presents is a practical way for digital humanities projects to create meaningful VR applications, and, as I argue, highlights the importance of well-designed scenarios along with immersive technology to gather and build upon perspectives that can be used in research and analysis of the ancient world or any other archaeological environment. The Felt Shop of Verecundus draws upon the evidence of the frescoes to populate the shop with a keeper and furniture, and then allows the player to interact with a built environment. The level of embodiment and interaction is not possible outside of this space, and if players can immerse themselves in applications such as these, then data gathered on their behavior is valid for the research of Roman archaeology and consumer culture. VRR can capture screenshots and video walkthroughs in its current state, and with access to the Tesseract Center resources it likely will be possible to incorporate the player tracking tool from VPP which would allow for more granular tracking of position and movement data. Not only does it incorporate historical theoretical approaches throughout the field, my suggested framework and workflow draws upon established principles and theoretical trends relevant across the fields of

archaeology and game design to drive its research and pedagogical uses forward with tangible application.

I designed the application with the aim of facilitating future development. For instance, additional interactions could be added to the shop app or player movement style in the Pompeian shop scene can be easily placed in the Ostian shop scene. The app's framework can also be exported to other non-ancient Roman shop related projects. While a certain level of basic digital literacy is necessary to master the workflow, Unity, for instance, allows for quick buy-in despite the long time it takes to master. The software is free to use as is Blender for 3D modeling, and there are free image editing alternatives to Photoshop[124], therefore the workflow I have developed is a viable option for researchers to engage with and apply it to their own research projects.

Obstacles and Hurdles

In VR development, much time is spent testing with headsets and loading the build (a working application). Until recently, much of Oculus' developer tool sets have been focused towards developers with the traditional resources of a studio. Access is free and available to those with a Quest, though this does bring up a sign of the times. While buying a Quest is becoming more affordable, a Facebook account is necessary to run it, and a companion application on a smartphone is required for setting up and managing accounts. For individual players and developers this can set up some barriers to access, especially for privacy concerns. They also have gated their content to have strict quality settings above what may be usable in a

[124] Gimp, a free photo-editing software, for instance will do much of the basic texture work and handling Photoshop does 2021."GIMP." *GIMP*. https://www.gimp.org/.

testing scenario[125], which hampered development of this application by not being able to easily load and distribute the application to Quest users in the field. Third party communities such as SideQuest[126] have allowed for developers to distribute applications without following Oculus' guidelines. These quality guidelines can be more restrictive than necessary for development of small-scale projects, particularly those with minimal art loads or interactivity for visualizing simple environments and lighting conditions and can be especially hampering for small development teams. This seems to be loosening with Oculus creating new development channels for the release of prototype applications that would benefit from wide ranging feedback. VRR would overwhelmingly benefit from the ability to share the application across and within institutions easily with other scholars, who could give essential input and feedback for the development of scenarios, features, etc. Limits to the testing process ultimately hurt developers, and so taking these restrictions off will foster new creativity and apps for developers and researchers to use and create. Currently, we have submitted our prototype to the Oculus "App Lab", which is meant for different kinds of VR experiences than typically commercial products. Upon submission, I received a performance report with specific diagnostics to address, specifically art asset fidelity and lighting scenarios. I have re-topologized several of the art assets since receiving this feedback, as well as worked with different lighting scenarios to allow for better performance, as outlined in my lighting section above. However, the application is still available to players by invitation, and once the newest version is approved players can search for the app and download it for free on the store.

[125] See the requirements laid out by Oculus in their publishing guidelines, which states 60 hz/fps as a minimum for the App Lab applications and 72 hz/fps for the Quest store. "VRC.Quest.Performance.1 | Oculus Developers." . https://developer.oculus.com/resources/vrc-Quest-performance-1/.

[126] SideQuest, 2021. "SideQuest: Early Access Virtual Reality." SideQuestVR. https://sideQuestvr.com.

Publishing and testing settings, as well as products and plugins consistently update or change, requiring frequent updating of code and assets, and VR publishing has changed drastically since this project started.[127] Some processes are streamlined and easier, while others are deprecated quickly.[128] There are many hurdles to creating accurate recreations as well as access to consumers. Headset access is not as prolific as computer access is. Furthermore, in person use of headsets in public places has become unfeasible during the Covid-19 pandemic, thus driving up the individual cost of buy-in as well as shrinking the player pool to those who have safe access to a headset. The Oculus Quest 2 starts at $300, which again limits the player pool to those who have the resources to spend on a VR headset, or at least can borrow one. However, VR headsets are a growing industry and likely to grow in their ubiquity.

The recreation is in its prototype stage, and so due to that player engagement fades quickly. Other things that could be done to flesh out the rest of the environment is to make low-poly versions of the different properties around to replace the plans currently standing in their places. Other environmental stimuli are missing from the current application, though this is something that can be added based on different types of conditions, perhaps tying the sound to the time of day or choosing from a selection of quiet, busy, or crowded options.

[127] For instance, Oculus App Lab did not exist in the initial stages of this development, and providing builds was done individually through project computers to headsets.
[128] In the course of this project, I had to eventually abandon Probuilder and remove it from the project due to its instability.

Chapter 4: Conclusions and Future Directions

As a project framework, this thesis lays out the methodology and theoretical backing used in the digital development of the VRR project to be applied to multiple archaeological shop sites existing in the Roman world. I argued that existing archaeological theory and methodology could be applied to VR development in a way that prioritizes experience and interactivity over fidelity and preservation, and it resulted in a project that combined software game development with archaeological recording. Travel and documentation of these sites are needed to develop the different scenarios, which includes gathering measurements, plans and research for photogrammetry as well as spatial awareness of the shop and its surrounding areas. The framework for development focuses on highlighting and outlining theories used. Further work could be focused to develop mechanics or scenarios that highlight trade networks, show off how multisensory stimuli affect environments, or re-create elements and phenomena that would have occurred within the environment. Digital humanities projects continue to proliferate within the academy, and the private sector largely drives 3D creation of heritage sites as highlighted above. Many museums create 3D models and share them with the public[129], but in terms of gameplay or designed interaction to garner involvement, examples dwindle. The goal is for the app to be published on the Oculus store, as well as have a public VR exhibition at a cultural or educational institution for players to test the application as well as get more user feedback to incorporate into future development. This way players can access and experience the shops as is comfortable for them, and can be in a guided environment with expert access to assist them in any Questions or situations that may arise.

[129] Sketchfab, a major 3D asset website, has a specific department dedicated to 3D models in cultural heritage and partners with multiple major museums across the world. 2021. https://sketchfab.com/museums.

In addition to the Pompeiian shop, work is currently underway at incorporating models from the Ostian fish shops mentioned in the previous chapter, and permission has been secured for data capture as well as the possibility for use in public outreach. VRR wants to expand past these two shops and create a third environment that focuses on the 5th-6th century shops in Sardis in present day Turkey. With all three shops together, the application focuses on interactive retail environments throughout different time periods as well as localities across the Roman world. It reinforces the pluralistic approach to this subject by showing how different cultures at the individual level experienced this essential interaction in everyday life, and to research more nuanced outcomes to see how retail interaction varied in spaces and cultures despite them all being in the "Roman" world. By granting access to players across these scenarios, VRR can provide a pedagogical tool for teaching Roman daily life across time periods in antiquity as well as be used to study the differences in archaeological material in these different but related locales. Ideally, this creates an intellectual and creative space for scholars to determine what is unique to the sites, what is similar and how this can draw new conclusions from the embodied experiences at all three of them. Not to mention the cost of travel to all three locations is substantially more expensive than the cost of the headset and technology to run it. In addition to the application work being done, the application is has been presented on at national and international conferences[130], and I am the co-author on a forthcoming piece about using the application in the context of digital embodiment.[131]

Data gathering would have to be in the app for this as well, which would allow as many people as possible to provide feedback. This could be a form with Questions that could be

[130] Consumer Culture Theory Conference in Montreal 2019, and the Archaeological Institute of America in Washington, DC 2020.
[131] Fredrick, Vennarucci and Loder 2021 (forthcoming).

optional after the completion of the application. Being optional, it would need to supplement stricter planned testing, as mentioned either in universities or in cultural institutions like museums. Other forms of data that could be gathered for testing include movement tracking and capturing the camera playthrough of users (possible to do on the Quest), both of which are internal capabilities of the VPP project and used in that project's research. At the moment, data gathering is not implemented in the VRR prototype, but as exemplified in the Virtual Pompeii Project [132] it is technically possible and with support and a team and infrastructure in place.

Beyond VRR, a true test of the proposed framework would be applying it to an entirely different scenario or material culture. There would be significant changes especially in research Questions centered around the difference in built environments, however the idea and planning process could be replicated as a way to create applications, focus Questions and further the ideas that researchers are working on as a way to break out of the academy and into more public spheres, democratizing archaeological thought and research through diverse proxy phenomenology. VR is the most accessible it has ever been, and so the time is ripe for researchers looking into ways to supplement and expand their work to adopt the technology as well as the methodologies to create their own projects and engage with the public. Classics especially could do so much more than it currently does to reach out and involve the public in its research, given that much of the material culture belongs to the state and its people in Italy and other nations. Many private firms are doing this, but it is missing the crucial point of involving the public. Civic engagement in research could be something that drives interest and support of academic goals, and VR could be a major tool to drive that.

[132] Fredrick and Vennarucci 2021, fig. 10.

Launched earlier this year, the App Lab is the Oculus' official response to hosting content that is not as rigorously tested as other games and applications, and streamlines the process to allow smaller and more independent projects to become available and reach consumers[133]. While still pending approval at the time of this writing, the VRR application is currently available to players who would like to use it by invite, and they can request access to download via contacting the project directors. Ideally, a version of the application would be published for use in other types of VR headsets, though this kind of publishing support is outside the current scope of the project. The application has been shared with a preliminary group of academics as examples of what can be done, and a project website is published with the University of Arkansas via their WordPress portal.[134] The website discusses the project, it's theoretical underpinnings as well as video walkthroughs and links to the application in the oculus store.

Tools made available to developers also need to continue to change and evolve to broaden the pool of people making content. There are different types of working groups out there and accessible; however, the people making these are typically spread out across institutions instead of regularly coming together and sharing ideas and knowledge. In conjunction with the Unity game engine and other free tools out there, there is a vibrant and thriving development ecosystem with an increasingly lower cost barrier to entry than ever before. There are also multiple learning platforms and courses that are lower cost available, such as Unity Learn[135], which allow players to create the content they envision and imagine. By using a variety of different theoretical backgrounds and frameworks, it becomes relatively easy to determine what

---

[133] Oculus VR 2021, 2 February.
[134] Vennarucci and Loder (2021) designed and created the vrr.uark.edu website detailing all parts of the Virtual Roman Retail project.
[135] Unity, 2021 https://learn.Unity.com/.

kind of application and mechanics could be made to test archaeological hypotheses, represent data or use as pedagogy for teaching. Digital apps that integrate phenomenology and game design theory and are grounded in archaeological and social-historical records have great potential for helping us understand lived experiences of past peoples in past landscapes, and to varying degrees how the environmental factors would have influenced them as they might influence players today. Digital products focused on classical archaeological subjects like ancient Rome can be developed with more meaningful intention and thought by tying existing archaeological theoretical approaches to game design principles in order to create an application for research and pedagogy that is fully grounded within the discipline. VRR as an application and project stands as a proof of concept to allow further development, and shows the interactive potential for the blending of photogrammetry with traditional 3D art and archaeological plans. The approach allows for accuracy without a high level of workload or sculpting. The plans, photogrammetry and recreated architecture all combine to create a holistic experience. While this method does not recreate photorealism, the model is a faithful representation of the original structures/objects, allowing for the inclusion of other elements, like object interaction and sound, that help establish a sense of presence that is essential to recreating spaces within digital environments. Creating the holistic environment for players to see and engage with allows for research and study.

Additional Figures

Additional Figure 1: CCT 2019 Poster discussing the early stages of Virtual Roman Retail. Source: Vennarucci et al. *Days of Future Retail Past: VR Tracking of Consumer Behavior in an Ancient Roman Shop*. Conference Poster 2019. Consumer Culture Theory Conference Poster Session, Montreal, CA. Source: Vennarucci, Fredrick and Loder 2019.

Works Cited

Agisoft “Agisoft Metashape.” Agisoft, 2021 . https://www.agisoft.com/.

Actus. “Nadis WebGIS.” NADIS. Parco Archeologico Ostia Antica, 2017. https://gisnadis.parcoarcheologicostiantica.it/.

Allison, P.M. 2001. April. “Using the Material and Written Sources: Turn of the Millennium Approaches to Roman Domestic Space.” *American Journal of Archaeology* 105 2 (April): 181. doi:10.2307/507270.

Benefiel, R. 2021. “Ancient Graffiti Project.” . http://ancientgraffiti.org/Graffiti/.

Bergmann, B. “The Roman House as Memory Theater: The House of the Tragic Poet in Pompeii.” *The Art Bulletin*, vol. 76, no. 2, 1994, pp. 225–256. *JSTOR*, JSTOR, www.jstor.org/stable/3046021.

Bogost, I.. “The Rhetoric of Video Games."The Ecology of Games: Connecting Youth, Games, and Learning.Edited by Katie Salen.The John D. and Catherine T. MacArthur Foundation Series on Digital Media and Learning. Cambridge, MA: The MIT Press, 2008. 117–140.doi: 10.1162/dmal.9780262693646.117

Balme, M. G., and J. Morwood. 2006. *Oxford Latin course*. Oxford: Oxford University Press.

Berry, Joanne. 2013. *The Complete Pompeii*. London: Thames & Hudson.

Betts, E., ed. 2017. *Senses of the empire: multisensory approaches to Roman culture*. London ; New York: Routledge, Taylor & Francis Group.

Brughmans, Tom. “Thinking Through Networks: A Review of Formal Network Methods in Archaeology.” *Journal of Archaeological Method and Theory*, vol. 20, no. 4, 2013, pp. 623–662. *JSTOR*, JSTOR, www.jstor.org/stable/43654602.

Dobbins, J.J., and P.W. Foss, eds. 2007. *The World of Pompeii*. The Routledge worlds. London ; New York: Routledge.

Dunn J. and B. Dunn. 2021 “*Pompeii, Herculaneum, Stabiae, Oplontis and areas: pompeiiinpictures.*” . https://pompeiiinpictures.com/pompeiiinpictures/.

Dyson, S. L. “From New to New Age Archaeology: Archaeological Theory and Classical Archaeology-A 1990s Perspective.” *American Journal of Archaeology* 97, no. 2 (1993): 195–206. https://doi.org/10.2307/505656.

Ellis, S.J.R. 2018. *The Roman Retail Revolution: The Socio-Economic World of the Taberna*. First edition. Oxford, United Kingdom: Oxford University Press.

Eve, S. “Augmenting Phenomenology: Using Augmented Reality to Aid Archaeological Phenomenology in the Landscape.” *Journal of Archaeological Method and Theory*, vol. 19, no. 4, 2012, pp. 582–600. *JSTOR*, JSTOR, www.jstor.org/stable/23365980.

Farrow, R., and I. Iacovides. 2014. June. “Gaming and the limits of digital embodiment.” *Philosophy & Technology* 27 2 (June): 221–233. doi:10.1007/s13347-013-0111-1.

Flohr, M., and A. Wilson, eds. 2017. *The Economy of Pompeii*. First edition. Oxford studies on the Roman economy. Oxford: Oxford University Press.

Flohr, M. 2011. “Reconsidering the atrium House: Domestic fullonicae at Pompeii.” In *Pompeii: Art, Industry and Infrastructure.* Havertown: Oxbow Books., 88-103 https://public.ebookcentral.proQuest.com/choice/publicfullrecord.aspx?p=1154215.

Frischer B. “Flyover Zone – Bringing the world’s great monuments to your home and school.” 2021 https://www.flyoverzone.com/.

Fredrick, D., and Rhodora G Vennarucci. 2021. “Putting Space Syntax to the Test: Digital Embodiment and Phenomenology in the Roman House”. *Studies in Digital Heritage* 4 (2):185-224. https://doi.org/10.14434/sdh.v4i2.31521.

Fredrick, D. “If Data Could Walk – Tesseract.” 2020. http://tesseract.uark.edu/if-data-could-walk/.

Fredrick, D. “Home.” *Tesseract*, 2014, tesseract.uark.edu/.

Fredrick, D., R. Vennarucci, and W. Loder. 2021, forthcoming. “What Remains of Pacuius Proculus: Video Game Bodies in Virtual Pompeii.” In *Archaeology Out of the Box*.

Foss, P.W. 2007. “History and Historical Sources.” In *The World of Pompeii*, edited by John Joseph Dobbins and Pedar William Foss. The Routledge worlds. London ; New York: Routledge.

Fullbright . 2013. “Gone Home: A Story Exploration Video Game.” . Annapurna Interactive. https://gonehome.com/.

Gee, J.P. 2007. *What video games have to teach us about learning and literacy*. Rev. and updated ed. New York: Palgrave Macmillan.

Gee, James Paul. 2008. *Good video games and good learning collected essays on video games, learning and literacy*.

Gismondi, I. 1933. “Model of imperial Rome | Museo della Civiltà Romana.” . Museum Collection website. Museo della Civilta Romana. 2017. http://www.museociviltaromana.it/en/collezioni/percorsi_per_sale/plastico_di_roma_imperiale.

Ghisleni, M., Emanuele Vaccaro, Kim Bowes, Antonia Arnoldus, Michael MacKinnon, and Flavia Marani. 2011. "EXCAVATING THE ROMAN PEASANT I: EXCAVATIONS AT PIEVINA (GR)." *Papers of the British School at Rome* 79. Cambridge University Press: 95–145. doi:10.1017/S0068246211000067.

Gillings, M. "Landscape Phenomenology, GIS and the Role of Affordance." *Journal of Archaeological Method and Theory*, vol. 19, no. 4, 2012, pp. 601–611. *JSTOR*, JSTOR, www.jstor.org/stable/23365981.

The Gimp Team. 2021. "GIMP." *GIMP*. https://www.gimp.org/.

Hall, E.T. 1966 *The Hidden Dimension*. Gloucester, MA: Peter Smith Pub, 2nd ed. 1992. Print.

Hamilakis, Y. 2013. *Archaeology and the senses: Human Experience, Memory, and Affect*. New York, NY: Cambridge University Press.

Hartnett, J. 2017. *The Roman street: Urban life and Society in Pompeii, Herculaneum, and Rome*. New York, NY: Cambridge University Press.

Hessburg. "SunLight – Location based Time of Day | Particles/Effects | Unity Asset Store." . https://assetstore.Unity.com/packages/tools/particles-effects/sunlight-location-based-time-of-day-66399.

Holleran, C. 2012. *Shopping in ancient Rome: the retail trade in the late Republic and the Principate*. Oxford: Oxford University Press.

Hunter-Crawley, H. 2019. October 28. "Classical Archaeology and the senses: A paradigmatic shift?" In *The Routledge Handbook of Sensory Archaeology*, edited by Robin Skeates and Jo Day. 1st ed. Routledge, October 28. doi:10.4324/9781315560175. https://www.taylorfrancis.com/books/9781317197478.

Hunter, A. 2016. March 9. "Get started with VR: user experience design." *VRINFLUX*. March 9. http://www.vrinflux.com/the-basics-of-virtual-reality-ux/.

Hunter, A. "Reducing cognitive load in VR – Virtual Reality Pop." Virtual Reality Pop, Virtual Reality Pop, 30 Aug. 2016, virtualrealitypop.com/reducing-cognitive-load-in-vr-d922ef8c6876.

Johnson, M. "Phenomenological Approaches in Landscape Archaeology." *Annual Review of Anthropology*, vol. 41, 2012, pp. 269–284., www.jstor.org/stable/23270711.

Kamash, Z. 2021. Rebalancing Roman Archaeology: From Disciplinary Inertia to Decolonial and Inclusive Action. Theoretical Roman Archaeology Journal, 4(1): 4, pp. 1–41. DOI: https://doi.org/10.16995/traj.4330

Kitchell, K., and T. Sienkewicz, 2011. *Disce!* Boston: Pearson Education.

Lund University. 2016 *Walk around in a 3D splendid house from the ancient Pompeii*. https://www.youtube.com/watch?v=ETd7pszxhnc.

Laurence, R.. City Traffic and the Archaeology of Roman Streets from Pompeii to Rome. The Nature of Traffic in the Ancient City. Ludwig Reichert, 2008. Archival material.

Mobius Digital. 2019. "Outer Wilds." *Mobius Digital Games*. Annapurna Interactive. https://www.mobiusdigitalgames.com/outer-wilds.html.

Moltenbrey, K. 2008. December. "History in the Making | Computer Graphics World." . December.https://www.cgw.com/Publications/CGW/2009/Volume-31-Issue-12-Dec-2008-/History-in-the-Making.aspx.

Murray, K.B. 2016. "Inside the store." In *The American retail value proposition: crafting unique experiences at compelling prices*. Toronto ; Buffalo ; London: University of Toronto Press.

Murray, J.H. 2017. *Hamlet on the holodeck: the future of narrative in cyberspace*. Updated edition. Cambridge, Massachusetts: The MIT Press.

Sketchfab. "Virtual Reality & 3D for Cultural Heritage." *Sketchfab*. https://sketchfab.com/museums.

Oculus. "Oculus Developer Hub: Unity | Oculus Developers." . https://developer.oculus.com/documentation/Unity/ts-odh/.

Oculus VR. 2021. February 2. "Introducing App Lab: A New Way to Distribute Oculus Quest Apps." *Oculus Developer News*. Oculus VR, February 2. https://developer.oculus.com/blog/introducing-app-lab-a-new-way-to-distribute-oculus-Quest-apps/.

Oculus VR, 2021. March 31. "How to Prepare for a Successful App Lab Submission." *Oculus Developer News*. Oculus VR, March 31. https://developer.oculus.com/blog/how-to-prepare-for-a-successful-app-lab-submission/.

Oculus. 2021 "VRC.Quest.Performance.1 | Oculus Developers." . https://developer.oculus.com/resources/vrc-Quest-performance-1/.

Opitz, R., N. Terrenato, and M. Mogetta. 2016. *A Mid-Republican House from Gabii*. Ann Arbor, MI: University of Michigan Press. doi:10.3998/mpub.9231782. https://hdl.handle.net/2027/fulcrum.n009w229r.

Origame Digital. 2020. "Umurangi Generation | Red Sky." . Origame Digital. https://www.umurangigeneration.com/.

Poehler, E. "Measuring the Movement Economy: A Network Analysis of Pompeii." In *The Economy of Pompeii*, edited by Miko Flohr, and Andrew Wilson. Oxford: Oxford University

Press, 2016. Oxford Scholarship Online, 2017. doi: 10.1093/acprof:oso/9780198786573.003.0007.

Stephens, J. and Arthur. 2016 “Home - Pompeii Perspectives.” . https://www.pompeiiperspectives.org/.

Salen, K. and Zimmerman, E. Rules of Play: Game Design Fundamentals, 2003. Print.

Schell, J. The Art of Game Design: A Book of Lenses. Boca Raton: CRC Press, 2015. Print.

Schell, J. “Making Great VR: Six Lessons Learned From I Expect You to Die” http://www.gamasutra.com/blogs/JesseSchell/20150626/247113/Making_Great_VR_Six_Lessons_Learned_From_I_Expect_You_To_Die.php 06/26/15

Segreti, G. 2018. October 16. “Charcoal inscription points to date change for Pompeii eruption.” *Reuters*, October 16, sec. World News. https://www.reuters.com/article/us-italy-pompeii-idUSKCN1MQ2CR

Shinkle, E. 2008. November. “Video games, emotion and the six senses.” *Media, Culture & Society* 30 6 (November): 907–915. doi:10.1177/0163443708096810.

SideQuest. 2021. “SideQuest: Early Access Virtual Reality.” SideQuestVR. https://sideQuestvr.com.

Sigurdson, H. 2007. “The Environmental and Geomorphological Context of the Volcano.” In *The World of Pompeii*, edited by John Joseph Dobbins and Pedar William Foss. The Routledge worlds. London ; New York: Routledge.

Sapirstein, P., and S. Murray. 2017. July 4. “Establishing Best Practices for Photogrammetric Recording During Archaeological Fieldwork.” *Journal of Field Archaeology* 42 4 (July 4): 337–350. doi:10.1080/00934690.2017.1338513.

Spinazzola, V. 1953. *Pompei alla luce degli scavi nuovi di Via dell'Abbondanza (anni 1910-1923)*. Roma: Libreria della Stato.

Trigger, B. G. 2006. *A History of Archaeological Thought*. 2nd ed. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511813016.

Toner, J.P., ed. 2014. *A cultural history of the senses in antiquity*. London ; New York: Bloomsbury.

Topper, K. 2019. August 1. “Blog: Addressing the Divide Between Art History and Classics.” . Text *Society for Classical Studies*. August 1. https://classicalstudies.org/scs-blog/kathryn-topper/blog-addressing-divide-between-art-history-and-Classics.

Touati, A. M. L. ‘Water, well-being and social complexity in Insula V 1. A Pompeian city block revisited’, *Opuscula. Annual of the Swedish Institutes at Athens and Rome* (*OpAthRom*) 3, 105–

161. Stockholm 2010. ISSN: 2000-0898. ISBN: 978-91-977798-2-1. Softcover, 224 pages. https://doi.org/10.30549/opathrom-03-06

UC Pompeii. “https://twitter.com/ucpompeii/status/1327280213588385793.” *Twitter*. https://twitter.com/ucpompeii/status/1327280213588385793.

Underhill, P. 2009. *Why we buy: the science of shopping*. Updated and rev. New York: Simon & Schuster Pbks.

Unity Technologies. “Learn game development w/ Unity | Courses & tutorials in game design, VR, AR, & Real-time 3D.” *Unity Learn*. https://learn.Unity.com/.

Unity Technologies. 2020. “Unity - Manual: Preparing Assets for Unity.” . https://docs.unity3d.com/2019.3/Documentation/Manual/BestPracticeMakingBelievableVisuals1.html.

US Department of Commerce. “NOAA Solar Calculator.” *ESRL Global Monitoring Laboratory - Global Radiation and Aerosols*. https://gml.noaa.gov/grad/solcalc/index.html.

Vitruvius Pollio, Translated by Morris Hicky Morgan, and Herbert Langford Warren. 1926. *Vitruvius, the ten books on architecture*. Cambridge, Mass: Harvard University.

Van Ness, A,. "Indicating Street Vitality in Excavated Towns. Spatial Configurative Analyses Applied to Pompeii." (2014). Print.

Veitch, J. 2017. In *Senses of the empire: multisensory approaches to Roman culture*, 55–70. London ; New York: Routledge, Taylor & Francis Group.

Vennarucci, R. G. 2015. “Marketing an Urban Identity: the shops and shopkeepers of ancient Rome.” In R. A. Hawkins (ed), Crossing Boundaries, Spanning Borders: Voyages Around Marketing’s Past, Proceedings of the 17th Biennial Conference on Historical Analysis and Research in Marketing (CHARM). Long Beach (CA): CHARM Association: 135-158. Refereed.

Vennarucci, R. G., D. Fredrick and W. Loder. *Days of Future Retail Past: VR Tracking of Consumer Behavior in an Ancient Roman Shop*. Conference Poster 2019. Consumer Culture Theory Conference Poster Session, Montreal, CA.

Wallace-Hadrill, A.. Houses and Society in Pompeii and Herculaneum. Princeton, N.J: Princeton University Press, 1994. Print.

Weilguni, M., and Anter K. Fridell. Streets, Spaces and Places: Three Pompeiian Movement Axes Analysed., 2011. Print.