DIGITIZING DELPHI: EDUCATING AUDIENCES THROUGH VIRTUAL RECONSTRUCTION

Student researcher Kate Koury utilizes digital technologies to create a virtual space in which audiences can explore the debates and decisions that underlie archaeologists' reconstructions of ancient sites, such as the Tholos at Delphi.

Abstract

Implementing a 3D model into a virtual space allows the general public to engage critically with archaeological processes. There are many unseen decisions that go into reconstructing an ancient temple. Analysis of available materials and techniques, predictions of how objects were used, decisions of what sources to reference, puzzle piecing broken remains together, and even educated guesses used to fill gaps in information often go unobserved by the public. This work will educate users about those choices by allowing the side-by-side comparison of conflicting theories on the reconstruction of the Tholos at Delphi, which is an ideal site because of its unique shape, history, and presence of missing information. Data used in the reconstruction includes images taken on site, original archaeological renderings and measurements, and existing theories of the temple's construction. The final virtual model will allow for side-by-side comparison of these differences. Furthermore, previous 3D representations are generally made for professional audiences and are rarely interactive. This model is also designed to elevate the current archaeological process from static representations into a format as dynamic as the process of reconstruction itself. The next step for this project is to fully integrate and experiment with how users engage with the model in an interactive application. Using modern technology to explore ancient artifacts creates new and exciting processes that show looking back to history can be just as powerful as envisioning the future.

Keywords

historical reconstruction, virtual reality, Delphi, Greece, architecture, history, digital reconstruction, temple, Tholos, archaeology

Visualizing how ancient ruins would have looked in their prime is a challenging process. The surrounding theories have been handled, adjusted, drawn, and redrawn by innumerable researchers over many years. The processes used to reconstruct these spaces are as varied as they are fascinating, spanning everything from painstaking analog drawings and measurements to more modern processes of digital scanning and rendering. This paper details an exploration of using a virtual space to educate audiences about the reconstruction of historical sites and the basis for an interactive environment where users can explore different theories about what the Temple to Athena Pronaia at Delphi, often called the "Tholos" due to its circular shape, would have looked like. In this paper, I review how archaeologists have approached virtual reconstruction and the methods applied to create a model of this temple, and I discuss disseminating knowledge about historical processes.

BACKGROUND

During a study abroad trip to Greece in the summer of 2022, specifically when visiting the ancient religious site of Delphi, I, along with other Honors College students, focused on thinking critically about what decisions are made when presenting and reconstructing historical sites. At the entrance to the city of Delphi lies the Tholos, a round temple dedicated to the goddess Athena. The ruins have been preserved for well over one hundred years since their excavation, and it is hard to envision a static space filled with broken rock as a place where people actually lived and conceptualize why it was so important in the past. It is even harder to determine the processes used to uncover what we know about the site. Most of the information about the reconstruction process is time consuming to obtain and geared toward archaeologists doing intensive studies. However, as an important historical location, it has visitors from all over the world who have an interest in learning about this site's past and preservation. This larger community is a stakeholder in archaeological knowledge. A partial physical reconstruction on site in lighter colored stone, as seen in Figure 1, strives to depict what it might have looked like. However, an average visitor to the site may not recognize which parts are reconstruction or how missing pieces were filled in. A historical site like Delphi has existing conceptual and physical reconstructions

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based on primary evidence and careful estimation, but audiences often only see the end result. This paper strives to demystify the decision-making process around archaeology, then distribute this knowledge in a dynamic and engaging way through use of an immersive digital environment. I seek to fill a gap and further explore how computers could be used to preserve history.

Guided by a diverse profile of mentors and specifically Dr. Katie Jarriel, a professor at Purdue with her PhD in Classical Archaeology from Cornell, this work aimed to explore the question: In what ways can a virtual space be used to instruct a general audience about choices archaeologists make while reconstructing historical sites?

The process began with photographing *in situ* data. Images like Figure 1 and Figure 2 were taken on site in Greece over the summer of 2022 and provided valuable information not only about the temple itself, but also about the surrounding environment; both of which were necessary to accurately recreate the temple in a 3D environment. These photos, however, did not contain vital measurements necessary to accurately reconstruct the site. Taking measurements on site was out of the question as obtaining a permit for a student investigator would have been a painstaking and lengthy process. To supplement the onsite data, I reviewed classical archaeological data on the reconstruction of the Tholos. Finding adequate site documentation proved more difficult due to the age and complexity of the site. Much of the documentation was in different languages and because of various natural and human events over the centuries, there are huge gaps of missing information about this site.

Fortunately, I came across classical archaeological records created when the Tholos was first excavated in 1892 by the French School of Athens. These records involve carefully documented hand-drawn images with measurements. Roughly half of these drawings show "Etat Actuel" or the state of the ruins after that first excavation.

FIGURE 1. View of the Temple to Athena Pronaia looking southeast. Photo taken by author at the Marmaria site in Delphi, Greece, May 2022.

FIGURE 2. Close-up detail of the temple's partial physical reconstruction. The lighter colored stone in the image is new marble used to fill in missing segments of the temple. Photo taken by author at the Marmaria site in Delphi, Greece, May 2022.

The drawings are highly detailed depictions of what this looked like before even the partial physical reconstruction was created. There is a scale at the bottom of each drawing that is hard to decipher and not well labeled. One of the drawings I referenced the most shows the top-down view of the remaining ruins. This drawing was used to help with scale, layout, and alignment of additional details of the temple. Several similar depictions document different pieces of the temple ruins as they were when they were first cataloged. These images assisted in reconstructing the *in situ* ruins. The other half of the drawings from this excavation are reconstructions of the ruins that show what the site was predicted to have looked like. They use measurements taken from the ruins, historical accounts, and comparisons of similar temples to fill in the gaps of what was missing to create a complete depiction (Gottlob, 1925). Their predicted measurements were difficult to read. However, laying out the images in a virtual space and using them as guides for building my model proved vital in recreating this ancient temple.

The excavations of the French School were only able to document what remained of the over 1,500-year-old site. What isn't carefully documented in drawings in the "Etat Actuel" was lost to time long before the French School of Athens came along. Researchers had and have very little information about what, for example, the roof actually looked like, whether it was tiled in terracotta or marble slabs, whether it was domed, flat, or multitiered. The rest of the information on the temple is just as fragmented, but existing reconstructions show only the completed temple with no context. Information about the reconstruction process is not easy to access nor understand for the typical viewer. However, as an important historical site it has a large audience interested in its preservation and how it was reconstructed. My work strives to reveal these processes and asks the viewer to think about why and how ruins are presented the way they are. This work follows typical archaeological processes of comparing site maps, archaeological drawings, and existing theories based on comparable architecture from the same

cultural group and time period to piece together what was ruins, what experts are reasonably certain was there, and most importantly what gaps were filled and how. It then places the model and related information into a format that is easier for a modern viewer to interact with and understand.

EXISTING SOLUTIONS

The initial research process revealed existing projects similar to the ultimate goal of inclusion in an interactive space. One such project from 15 years ago, Ashes2Art, was originally created by Coastal Carolina and Arkansas State Universities and broke ground in using 3D models for a technical archaeological reconstruction of the temple. Most of its information has since been removed from public access but fortunately one of the founders of the program, Dr. Arne Flaten, is coincidentally the current head of the Rueff School of Design at Purdue and was available to provide insight into Ashes2Art and give guidance on this project. Dr. Flaten's paper, *Ashes2Art: A Pedagogical Case Study in Digital Humanities*, was originally presented at the 36th International Conference of *On the Road to Reconstructing the Past.* The paper describes the general process that he and his students used from 2003 to 2009 to create digital reconstructions of various historical sites, including the Tholos of Delphi. His students did explore contrasting theories of the roof of the temple of Delphi while they were executing their models, but this was not the focus of the work published in the open access journal *First Monday* (see https://firstmonday.org/ojs/index.php/fm/article/download/2203/2021) (Flaten, 2008). He also describes several trips taken to these sites, the data collected, and the process his students used to complete this work. Their work focused specifically on how 3D spaces could be used to understand the past. The work was built with detailed measurements to piece together the ruins and provide archaeologists with a complete picture of what the Tholos and similar sites would have looked like. His work was a precursor to many similar projects, like "Rome Reborn," which recreates historical sites in a digital environment. This project allows a viewer to explore historical sites as they might have been and offers group tours through them. They focus on virtual tourism, allowing people to learn about these sites no matter where they are. Users can navigate through places like the Roman Forum on their phones or computers to explore what these sites may have looked like in their prime. Neither of these existing works discusses how the creators built the end result nor do they allow for direct interaction or comparison between ruins and reconstructions. This revealed a space for further exploration that I wanted to pursue. Guided by Dr. Flaten's advice, I narrowed my focus to educating a new audience through highlighting the reconstruction processes rather than virtual tourism or pure archaeological reconstruction.

MODELING METHODOLOGIES

As the archaeological base was established, I also worked with my supervisor, George Takahashi, at the virtual reality lab on campus to discuss different methods to present my ideas and what technology and processes to use to create an exciting educational experience. With guidance from a collage of interdisciplinary mentors, I determined the most effective method of exploring the research question was to place models of the Tholos as it is, as a reconstruction, and with different depictions of unknown portions into a virtual space that a user can investigate using a virtual reality headset. The user can then mix and match different theories to learn about how and why each was posited to facilitate comparisons. The ultimate goal is that through exploration of what is left and what might have been, users will better understand that what they are presented in museums is often an accumulation of historical and archaeological evidence used to fill in gaps in physical knowledge rather than exact parts fitting together. Extensive research and review is used to piece together what these sites probably looked like, but this work is rarely seen by the viewer. Through this project I aimed to highlight this intensive study and make it accessible to a broad audience. Furthermore, because this work is presented in a virtual format it avoids the typical costs and limitations of constructing physical models. The user can easily switch through and explore the representation, and the project can be updated with new information just as easily.

The actual building process worked in pipelines and programs typically used in the virtual production industries. The original site documentation was laid out into a 3D modeling space to use as reference. The reference was then used to construct a wireframe of what experts are

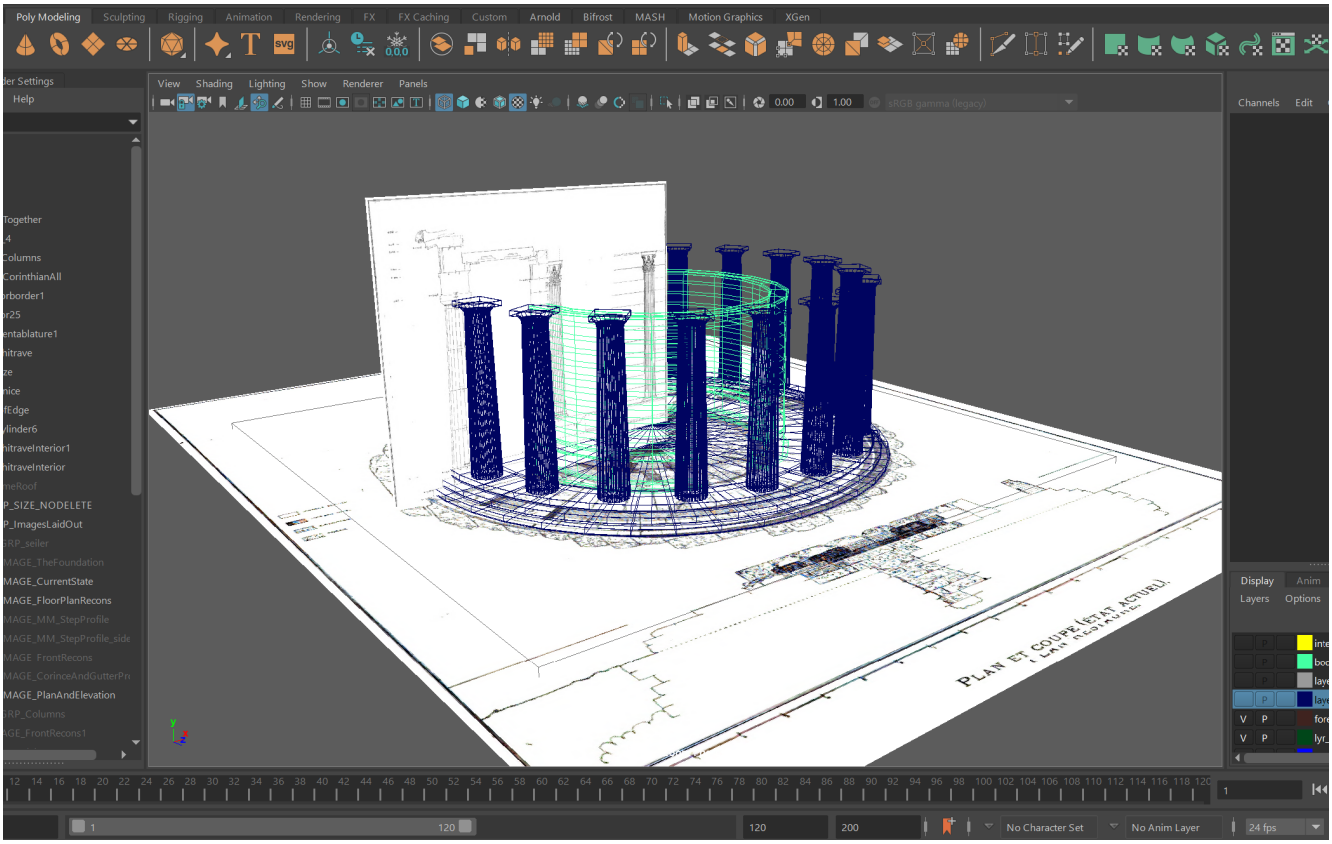

FIGURE 3. Reconstruction wireframe. Digital model by author, 2023. French School of Athens site drawings were used to create a wireframe of the temple.

reasonably certain stood at the site, which includes the steps and base, and the exterior, as pictured in Figure 3 and Figure 4, and the interior columns. This provided a base framework with the correct measurements that could then be used in conjunction with photographs from the inspiring trip to Greece to reconstruct the ruins. These two models provided a solid base for depictions of different theories about extraneous details. Each step in the process was based on research that had been confirmed by archaeologists, site documentation, historical texts, or photos from the actual site.

The modeling process and ensuring accurate adherence of the model to real-life measurements presented unique challenges. There are inherent errors and biases that come with translation of data into new forms despite efforts to be precise. For one, getting the original site documentation, most of which is in languages I don't speak, into a usable digital format took careful calculation. Additionally, many of the drawings were difficult to read because of their age, pre-digital sources, and ambiguity around the units used. In some cases, educated guesses needed to be made for the sake of this project, which comes with its own risk of error and bias. Another challenge was acquiring accurate information, not only because of the age of the site but also the levels of detail necessary for this project. A future question this project will continue to explore is how detailed must a model be to be useful for the professional but not distracting for the novice? Further refining and cross-examination of detail aims to draw in the professionals while explorations into what interactions with the model would best convey the ideas behind this work reach toward the untrained audiences.

Modeling varying constructions of the roof, as seen in Figure 5, was the specific focus of this work because there are several theories that are easy to visually compare to explore the different methods researchers used to fill in missing pieces. Ashes2Art explored two of the predicted roofs, a single and multitiered roof configuration. Additionally, more recent research in April 2022 by

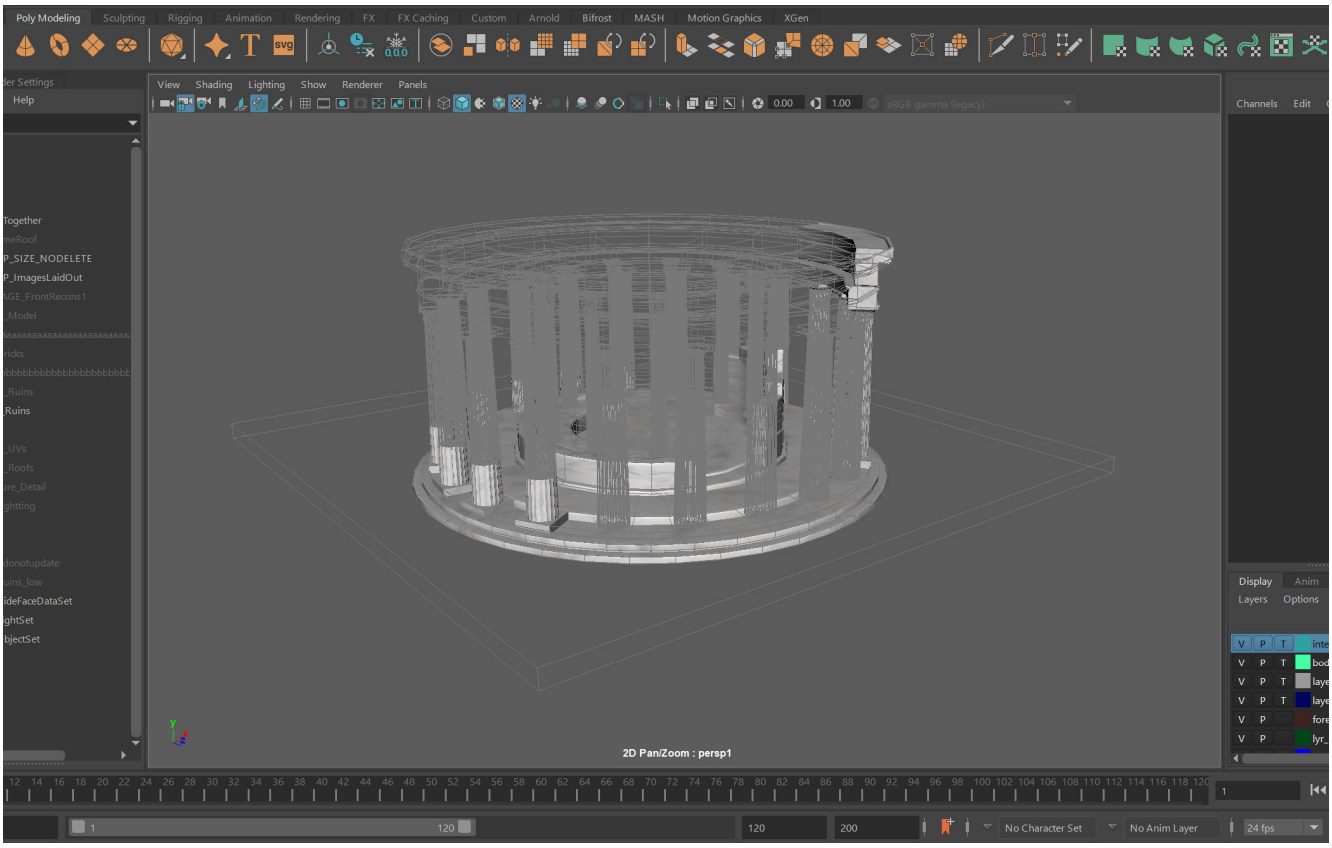

FIGURE 4. A replication of the ruins of the temple to Athena Pronaia using a wireframe. Digital model by author, 2023.

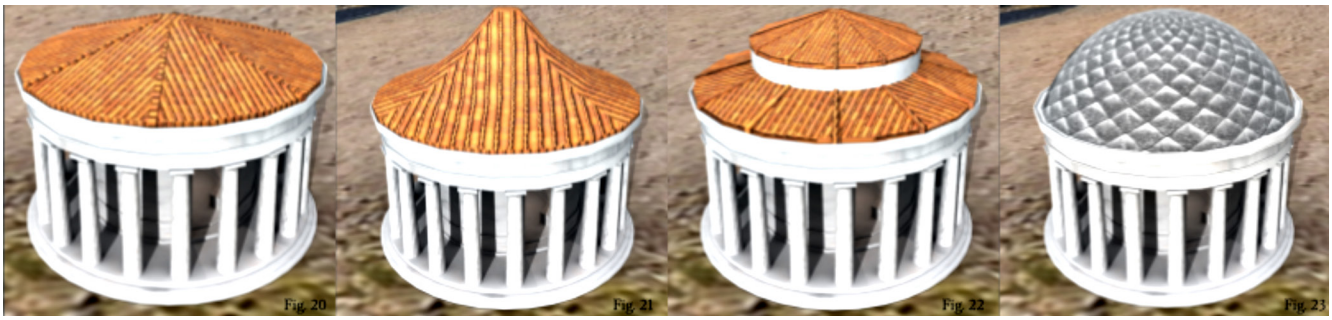

FIGURE 5. An intermediate depiction of the temple roof reconstruction theories before the models were placed in VR. Digital models by author, 2023.

archaeologists in Italy and Denmark, who were studying dome roofs, stereotomy, and compression in ancient Greece, posited an additional theory that the roof was actually rotund and made of stone slabs rather than flat and tiled in terracotta, which had been the prevailing prediction to this point. A fourth version of the roof was a taller, sloped roof crowned with a detailed statue; this was posited during the first French School of Athens excavation (Gottlob, 1925). The Italian and Danish study contained mathematical figures and proofs of the measurement of the roof to help prove their theory of the roof being a stone dome (Pizzigoni et al., 2022). This was very beneficial to my work as I could pull their direct measurements and equations to build my model. However, more detailed research and documentation around the older theories were especially difficult to find. There, I relied on predicted dimensions where possible and visual acuity when necessary. It is also unknown how the roof would have been supported as any possible wood supports have been lost to time. Each aspect

presented a challenge in the reconstruction process that I, like so many others, would not have known about without doing this project. After I reconstructed the temple and surrounding theories, then came the transition of placing the model into virtual reality.

INTO VR

In order for a project to run well in VR, there are set parameters for the amount of data to allow for an optimal VR experience. If mishandled, the experience would lag and be uncomfortable for a user to interact with. This required careful attention as I ran through the modeling process. One way to work around such limitations was limiting the amount of physical modeling I did and "baking" detail onto the model using appropriate digital texturing techniques; essentially, the computer is told to paint appropriate details onto the surface of the model without being forced to use additional computational power to actually build the details. This is very similar to how a photo of a brick wall takes up a lot less space than the wall itself. This allows for depictions of detail without slowing the computer down and causing lag, which in turn could break the immersive nature for the viewer. As I explored how to make this mode appropriate for VR, I came across a challenging line between how to make an immersive and interactive experience while also being honest about the limitations of this model.

The transition into virtual reality is when transparency around fact and fiction becomes an issue. A common debate in photography and film centers around verisimilitude or the line between truth and the appearance of truth. This debate extends into VR as its entire goal is to present a "reality" in a virtual space. It, however, is virtual, not reality. Figure 6 and Figure 7 show the model as it can be seen in VR. The realistic textures, details, and the creation of a surrounding environment were designed to make use of the virtual space to allow the viewer to get a sense of the full historical site. Each addition that adds to the realism makes the VR program more immersive, but is also a step closer toward misleading the viewer because the realistic textures risk being accidentally taken as fact. This model is not fact. This model is a student project focused on educating about the reconstruction process and, as such, is lacking several details that would have been on the original temple: decorative reliefs around the base of the roof with small lion head sculptures that are believed to have directed rainwater, and sculptures that are believed to have been situated on the roof itself. Furthermore, the texture of the roof tiles do not exactly match the theory of what experts think they looked like, and the metope—relief sculptures around the rings of stonework just below the roof—would have been brightly painted and each one would have been unique. My aim with these additional details was not to mislead, but to help others get a better sense of this site. To help remind the viewer that this is in fact only a model, there is a disclaimer set up in the virtual space to express the limitations of this project. The interactions within the space are also centered around visible buttons as a stark reminder that this is not reality but a model. The interactions within this space center around toggling between different versions of the temple's roof to allow for direct comparison between the different theories. This allows for a very visual

FIGURE 6. A reconstruction of the temple with a multitiered roof laid out in an environment that can be explored with a VR headset. Digital model by author, May 2023.

FIGURE 7. A reconstruction of the temple with a domed roof laid out in an environment that can be explored with a VR headset. Digital model by author, May 2023.

and direct comparison by even the newest of viewers. As this project continues, it will add annotations and information on the reconstruction process to further deepen the educational nature of the project.

CONCLUSION

In the future this research will continue to explore conveying the process of reconstructing a historical site and actuating study of the past through engaging audiences. From here the goal is to further add to the educational and immersive aspect of the program. Additions of annotations in the space would further push the educational nature, and further fleshing out of the scene surrounding the environment creates a more immersive project. As of now, an archaeological and research-based framework cements this work in the real world with quantifiable data. Methodologies from the computer graphics industry make this project engaging for the education of a larger community. All three of these disciplines combined make this project truly innovative. Emergent technology is being used in a reputable field to educate users about a complex and difficult to understand process.

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Mentor

Dr. Katie Jarriel received her PhD in Classical Archaeology from Cornell University in 2017. She joined the John Martinson Honors College as a Clinical Assistant Professor in fall 2018. Dr. Jarriel's research combines archaeology and computer modeling to explore how people living in the Mediterranean during the Bronze Age created communities based on a shared sense of place. She is a co-founder of the Computational Archaeology and Seafaring Theory community of practice, which brings together interdisciplinary scholars from around the world to examine how humans move through and interact with maritime spaces. As an undergraduate, Dr. Jarriel attended the Honors College at the University of South Carolina, where she received her BA in Anthropology. She currently teaches courses such as "Technobodies," "World-Building," and "The Human Epoch: Life on the Coast."