APPLYING DIGITAL ARCHAEOLOGY TO EDUCATION AND HERITAGE MANAGEMENT AT CAHAL PECH, BELIZE

By

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ABSTRACT

APPLYING DIGITAL ARCHAEOLOGY TO EDUCATION AND HERITAGE MANAGEMENT AT CAHAL PECH, BELIZE

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Decades of archaeological excavation and research at Cahal Pech have allowed this site to become a place where locals and tourists can come to learn about Belizean cultural heritage and Maya history. Several past projects at Cahal Pech have created a visitor-friendly tourist destination. These projects have produced a visitor center and conservation work for some of the site's structures. To add to the visitor center and education materials, I examined the use of 3D modeling to create interactive educational items for the site. The models were incorporated into educational materials for use by the site, its visitors, and educational institutions. Over the course of this project, I addressed the separation between archaeological research and how it is distributed to the public. The major goals of this project were to determine how archaeologists can improve their dispersal of archaeological data and information to the public using free and/or inexpensive digital equipment and to promote free public access to archaeological information. The methods used for this project are cost-effective, efficient, and easily replicable. Without these 3D models and educational materials, this information would likely not be accessible to the public, which shows how public education should be a major focus for archaeologists who want public sentiments and actions to be informed by heritage knowledge.

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Chapter 1: Introduction

Cahal Pech is an ancient Maya city site, dating as far back as ca. 1200 B.C., in the upper Belize River Valley of the Cayo District of western Belize. The site core of Cahal Pech is situated on top of a large hill that overlooks the town of San Ignacio and contains most of the site's ceremonial and elite architecture. Cahal Pech was first investigated in 1951 by American archaeologist Linton Satterthwaite, but a full report of his work was never published. Several years later, in 1988, and at the behest of the Belize Tourism Association, Belizean Archaeologist Jaime Awe launched the first long-term research project at the site.

Awe's investigations are still ongoing and operate under the auspices of his Belize Valley Archaeological Reconnaissance (BVAR) Project, which he now co-directs with Dr. Julie Hoggarth of Baylor University and Dr. Claire Ebert of the University of Pittsburgh. Besides investigating the role of Cahal Pech within the political landscape of the Belize Valley, the BVAR Project, in collaboration with the Belize Institute of Archaeology, has expended considerable effort to conserve the site for its educational and tourism potential. The purpose of this research is directly related to BVAR's heritage management goals, particularly with the creation of digital and educational materials for use by local schools and the tourist industry. I wanted to figure out how to make archaeological information more accessible to the public. To figure this out, the questions I focused on during this research are as follows:

1. How can digital applications be used to create educational content for archaeological sites?

2. How can digital media contribute to archaeological education outreach in rural areas?
3. How can learning about archaeological sites be made more interesting to students?

To answer these questions, I conducted a single-person photogrammetry survey at Cahal Pech during the summer of 2024 to create 3-Dimensional (3-D) models of the structures and artifacts at the archaeological site. Working with the Belize Valley Archaeological Reconnaissance (BVAR) project and using their established standards and framework for community collaboration, I created an interactive StoryMap, educational coloring book, and 3-D models for use by schools and the management team at the Cahal Pech Archaeological Reserve. The materials will also be shared and distributed to local institutions and other stakeholders in the neighboring communities.

Study Area

Belize is a small country in Central America. It is bordered by Mexico to its north, by Guatemala to its west and south, and by the Caribbean Sea on its east coast. The country is about 8,867 square miles in area and has around 419,385 people as of January 2025 (World Population Review 2025). It is one of the few countries in Central America that contains ancient Maya sites. Out of the numerous Maya sites located throughout Belize, 14 are featured as tourist destinations on the Belize tourism website (Belize Tourism Board 2025). Cahal Pech is one of several ancient Maya cities in western Belize that has been conserved and developed for tourism purpose.

The Belize River Valley, a subregion of western Belize, is covered by tropical rainforest and has a rainy season spanning from May to November and a dry season from January to April. Cahal Pech is located within this region along with many other major Maya cities and cave sites (see Figure 1). As noted above, several of these sites serve as heritage centers and tourist destinations. Cahal Pech is located within the town of San Ignacio and is accessible to other parts of the country by way of the Western Highway. This highway also serves as a major tourist route that connects Belize to Mexico and Guatemala.

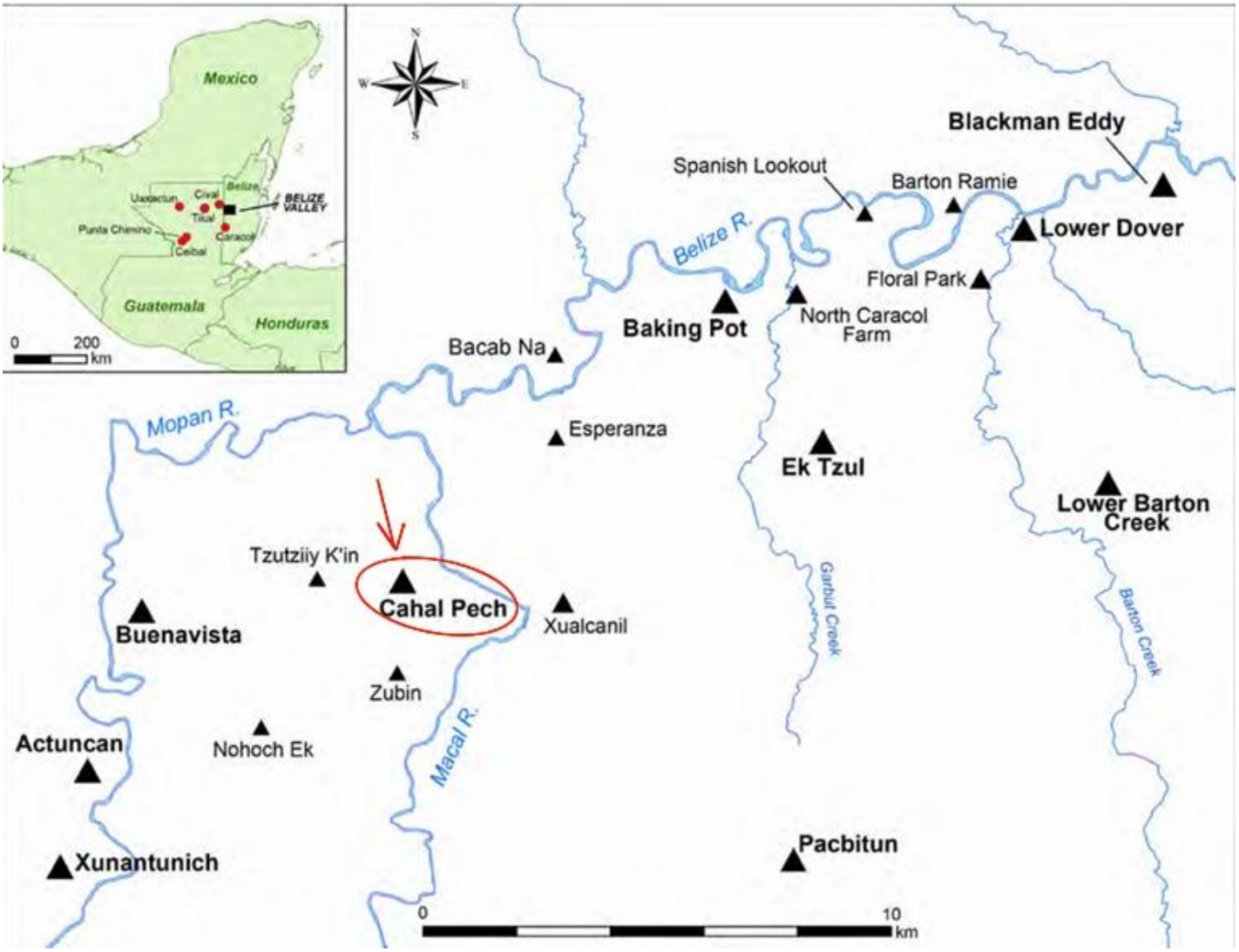

Figure 1 Map pf Belize River Valley. Adapted from a map by Claire Ebert (2018).

Goals of the Project:

Archaeologists tend to write their reports in a scientific and academic way; utilizing words that non archaeologist might not know. This often makes it difficult for people to learn about archaeological sites, and the artifacts, structures, and cultural remains found in them. Taking this into consideration, I incorporated multiple aspects of archaeology to create educational materials for the public. These educational materials include aspects of photogrammetry, 3D modeling, excavation and site data, drawings, maps, and various other types of cultural information.

To complete this task, I decided to create educational materials that could be accessed and used by anyone. The materials I created were digital models of some structures from the site core accompanied by a StoryMap and coloring book, which includes the construction history of the structures and some of the artifacts found throughout the site. I used the photogrammetry application Scaniverse to create the 3D models then uploaded them to an open access website to be viewed and downloaded by the public. The coloring book encompasses Quick Response (QR) codes that take you to the 3D models, making them easily available on any mobile phone or tablet. The StoryMap includes videos and photographs of the 3D models along with QR codes to view other 3D models not included in the StoryMap.

Throughout this project I collaborated with the local park rangers, park staff and communicated with some of the tourists visiting the site. This approach allowed me to incorporate the types of information people would like to see included in the educational

materials and which structures should be included in the 3D models. This approach also complemented the focus of my project which is to create educational materials for use by the local public to help further heritage education in Belize, and for people from around the world to learn more about this part of the Maya world.

Chapter 2: Background

This project is based on the current knowledge of Cahal Pech, particularly on archaeological research conducted at the site by the BVAR Project. Cahal Pech has a deep and rich history, from its establishment as a small Maya village around 1200 BC, to its present situation as a tourist destination and archaeological reserve. There have been several archaeological investigations at the site since it was first reported in the 1950s. Each excavation brings new data to light and further questions about the role of this ancient Maya community. To create educational materials for this site it is important to first understand the history of the excavations and the community outreach that has taken place at Cahal Pech.

Cahal Pech Archaeological Research

The name, Cahal Pech, which means “Place of Ticks” in the Yucatecan Mayan language, was given to the site by Linton Satterthwaite in the 1950s (Awe 1992, 2023). It was given this name because the area used to be a cattle pasture overrun with ticks. L. Satterthwaite briefly investigated the site in 1951 when he conducted preliminary excavations in Plaza B and Plaza C but never published a report of his work (Awe 1988). In 1953-1955 Gordon Willey visited the site while doing a settlement study in the Belize River valley. He did not perform any excavations but did write a brief site description in his report (Awe 1988). Later, in 1969, Peter Schmidt conducted a small salvage operation after his discovery of looting at the site. This operation focused on a tomb in Structure B1, but Schmidt also did not publish a report of his findings. However, Schmidt’s notes and the artifacts he recovered from his excavation are at the Belize Institute of Archaeology

(Awe 1988). From 1970- 1987 there was no archaeological research conducted on the site, and it was looted numerous times.

In 1988, the first long-term and ongoing project began under the direction of Belizean archaeologist Jaime Awe. The Belize Valley Archaeological Reconnaissance (BVAR) Project, presently under the direction of Dr. Awe and his colleagues Drs. Hoggarth and Ebert, conducts all the archaeological work at Cahal Pech. Since 1988 BVAR's projects in western Belize have had two focuses, cultural heritage management and archaeological research (Awe 2020; Hoggarth et al, 2020). A major goal of BVAR's heritage management projects has been to conserve the monumental site core of Cahal Pech in an effort to establish the site as a tourist destination and heritage/educational center for the people of Belize (Awe, *com pers*, 2024). This aspect of the project, especially the conservation of monumental architecture (See Figure 2 below for site map), began in the late 1980s and continued until quite recently. Despite these achievements, the educational and tourism materials for the site have not been recently updated, and most publications have been produced for professional archaeological audiences. See chapter five for more information about the site and the structures located there.

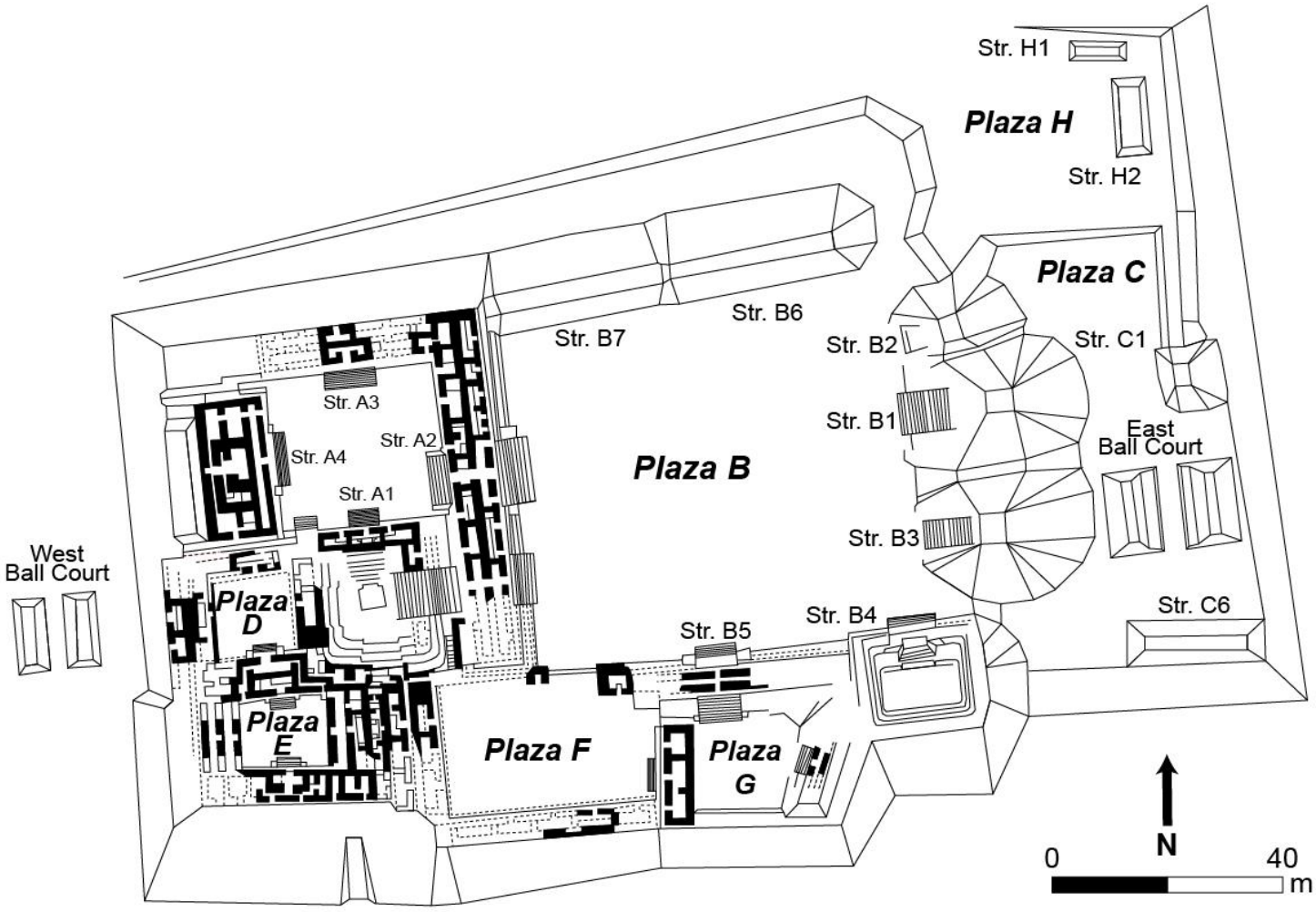

Figure 2 Map of Cahal Pech site core. Map by Claire Ebert (2017).

Literature Review:

With the rise in technology, analog methods are becoming scarcer and have now been replaced by more sophisticated digital applications. These new digital methods are making it easier and faster to document sites with more accuracy. Digital recording is also becoming more popular due to its ability to record archaeological data that may deteriorate over time.

Three-dimensional (3D) models have become a new and improved way to introduce archaeological sites and artifacts into education. This type of digital media allows people to see and interact with a site and its artifacts without having to visit and handle the actual material. “Although digital and printed models remove the authenticity of viewing the original artefact, the replica allows individuals to physically handle and manipulate it for self-directed and personalized learning” (Williams 2019: 2). Since 3D models can be accessed online, it helps teachers and other educational professionals teach about archaeology, a site, and/or artifacts in a more engaging way without needing to visit a museum or archaeological site. “Digital technologies have changed not only how archaeologists embody our craft but also how we imagine past embodiment” (Morgan 2022: 216). This technology allows us to recreate sites to portray how they might have looked at their peak and to reconstruct artifacts that have missing pieces. This gives students a better understanding of what was going on at a site, the importance of it, and viewing artifacts in their original form. This interactive and more technological approach not only allows educators to present sites and artifacts to students but also allows heritage managers to record sites for future generations to observe and enjoy.

The digital technology that is being used by archaeologists can also be applied to making educational materials more accessible to the public. For example, most people today have access to some sort of digital device, be it a computer or a smartphone. These devices allow for the public to view research, or materials archaeologists have created. However, not everyone learns the same way, or they may need other ways of acquiring the information. This project focuses on creating visual and hands on activities for disseminating archaeological knowledge to the public.

The goals of archaeologists are to collect, preserve, and disseminate data of archaeological sites for the public. However, there has been a gap between archaeology and the field of education for much of their existence; with archaeologists primarily focusing on writing and presenting their data to the academic community rather than to the public. To connect local communities to archaeological sites, many heritage managers have turned to archaeo-tourism as a mode for sharing information with diverse stakeholders. Archaeo-tourism develops sites into destinations that local communities as well as tourists can visit to learn about past cultures and of the historic accomplishments of the people that once inhabited the archaeological sites (Diaz-Andreu 2013).

This type of community archaeology is seen as “archaeology by the people for the people” (Thomas 2017: 14). Through community involvement, archaeologists can share information about the site, gain insider knowledge, access local resources, and provide the means for site preservation. This approach allows the community to have hands-on experience with archaeology, to contribute and participate in site

development, and to learn more about their culture and the history of the area they live in.

The ethics of archaeo-toursim and community archaeology, however, remain an issue among archaeologists. In Belize, the increase of tourism has caused an increase in revenue earned by the locals (Diaz-Andreu 2013). Local communities provide much of the labor force at archaeological tourism sites, this includes Cahal Pech. Because of increased visitation, archaeological sites require continuous upkeep and maintenance to ensure that ancient and fragile structures do not deteriorate. The local workers provide visitors with educational story telling via archaeological information and local knowledge, while the visitors get to experience a more personal connection with the site's history and the local community.

Heritage management and public education outreach became more intertwined with archaeology over the past 20 years. Archaeology can help people make connections between the past and present allowing them to see the value and complexity of heritage (Henson 2017). When applying educational outreach with archaeology, there are important ethical obligations we must consider. For example, "archaeological remains are not neutral, but powerful means of creating historical memory and identity" (Diaz-Andreu 2013: 225). In the case of descendant communities, it is important to understand the existing cultural connections that local people have to sites and artifacts. For this reason, it is critical we incorporate local involvement in excavations of sites and to consult with them when creating educational materials. Instead of the archaeologist deciding on what would be best for the community or the site, they should be asking the locals what they see as important and necessary to

include in the educational materials we prepare “[T]here has been a slow seepage of Maya cultural heritage through the proverbial cracks of the post-modern world. Modernization and development, globalization and the forging of national identities, and deep-rooted poverty and socio-cultural marginalization, have all played a part in contributing to extensive loss of historical and cultural heritage” (Ishihara 2008: 307). According to Awe (personal communication, 2025), colonization and conversion to Christianity also led to a major disconnect between descendant communities and their past. The rise of cultural heritage and public education projects such as BVAR and the Maya Area Cultural Heritage Initiative (MACHI), has attempted to address these problems, and to allow communities to learn more about their ancestors and to participate in decisions that affect both the conservation of sites, as well as cultural heritage education.

Cultural Resource & Heritage Management in Belize

Belize has a rich history and diverse cultures that includes cultural traditions that are still flourishing. The government of Belize introduced heritage management systems as early as 1894 and has revised them since, resulting in one of the most comprehensive programs in Central America (Awe 2020). The National Institute of Culture and History (NICH) houses four branches that are responsible for the preservation and promotion of Belizean culture. One of the four branches is the Institute of Archaeology (IOA) which is tasked with inventorying ancient and historical tangible remains, including descriptions of sites, their cultural affiliation, chronological assignment, state of preservation, type of property, and their geographical coordinates

(Awe 2020). The IOA focuses on four major goals, 1. To protect and preserve the archaeological heritage of Belize., 2. To encourage research in temporal, spatial, and topical areas where knowledge and scholarship for the country is lacking., 3. To disseminate knowledge of archaeological heritage to national and international communities, and 4. To integrate archaeology and tourism development in a sustainable manner (Awe 2012). This thesis focuses on the last two goals of the IOA.

Chapter 3: Methods

This project focuses on the creation of educational materials for the public. This type of project exemplifies practical research dissemination instead of the traditional article or book format, allowing for the content to be more accessible and comprehensible to the public. To complete the research, it was split into three phases. The first phase was field work, the second phase was processing the data, and the third phase was creating the educational materials.

Technology and Equipment

This study was produced by using relatively simple and affordable tools. The technology that was used consisted of an iPad, DSLR camera, laptop, and an external hard drive. Drawing and professional modeling software's were easily downloadable on the iPad and photographs were stored on the hard drive. For photographing artifacts two collapsable photo lights and a photography light box were used to limit shadow.

I used a Nikon Coolpix L830 digital single-lens reflex (DSLR) camera, that I already owned, for capturing photographs of the structures and artifacts. The Nikon Coolpix L830 is designed for easy use and is light weight making it a great camera for field work. It has a 16-megapixel sensor, 22.5-765mm optical range, and takes 1080p video. The downside is that it takes AA batteries instead of a battery pack, so I had to always have spare batteries. I purchased an iPad 9th generation to use for creating drawings of the site structures and artifacts for the educational coloring book along with using it to scan the structures and artifacts for digital modeling.

An external hard drive was used to store all the photographs and videos for the 3D images, while also having back up SD cards to keep the original photos on. Over 2,000-4,000 photographs were collected for structure A2 and A3 and 50-100 photographs for each artifact. Other structures were digitized with the use of Scaniverse.

Scaniverse is an application or modeling program that creates three- dimensional models from a series of photographs. It is extremely user friendly and can be downloaded on most mobile devices. To create the models, you must scan the object then press process, and the application does the rest of the work. This can take multiple tries since the software is creating a point cloud using videos that cannot be edited instead of using single over lapping photographs that can be edited.

I also used MeshRoom and MeshLab to create and test some of the models. These are both free applications that can be downloaded to a laptop or desktop computer. Multiple photographs of an item must be uploaded to MeshRoom to create a photo cloud that can then be downloaded and put into MeshLab. Once the photo cloud is in MeshLab a 3D model is created. The models created were uploaded to Sketchfab which is a free site that housed 3D models and Virtual Reality (VR) content.

For the coloring book, I used Procreate which is an art application that can be downloaded on iPads. Once the drawings were created, I used Pages, which is an application that apple offers on all their devices, to create a coloring book. Both applications need a few instructions on how to use them but after learning the basics of the applications they are easy to use and can be taught to anyone. Other applications used during this thesis were Arc StoryMap, Google sites, and Microsoft Word. The

StoryMap was created on the Arc StoryMaps application, Microsoft Word was used to create the site guide, and Google Sites was used to create a webpage to house all of the materials in one place.

Phase 1: Field Work

Phase 1 of this project was conducted at the site of Cahal Pech in Belize for six weeks between June 3rd to July 19th, 2024. The goal of this phase was to photograph and scan the significant structures in the site core. The “significant structures” are structures that have been excavated and conserved and are major points of interest to visitors. The first week I started with having discussions with the park rangers and staff who are all native Belizeans. One of the rangers pointed out that the most beneficial structures to digitize would be the E-group (Structures B1, B2, & B3), Structure A1, and Structure A2. They also said for the StoryMap, I should mention the importance of the structures, where the materials came from, and what was found in the structures.

Once I knew which structures the park rangers wanted me to focus on, I needed to see which were the most feasible to digitize. Accessibility and surrounding foliage were the factors that went into determining this. Accessibility was determined by my own ability to climb and safely navigate the structure. Since I did not have a drone, I was doing all photographs and scans on the ground which can be more difficult when doing photogrammetry since it requires all or most parts of the structure (see Figure 3 for visual representation of photogrammetry process). Most of the structures at Cahal

Pech are stabilized but some do not have clear access to the top. This observation helped determine which structures were fully, partly, or non- accessible for photogrammetry. The structures that had access to the whole structure and the top were fully accessible. Those that had a staircase or were easy to climb but were not fully conserved, meaning they had some overgrown or unstable areas, were deemed partially accessible. Additionally, structures that were not fully excavated and conserved were non-accessible.

After determining which structures were the most feasible to record, Structures A2, A3, A4, F2, H1, and the East Ballcourt, I proceed with photographing and scanning them. The method of photographing the structures required no measurements or tripod, instead, they were taken by holding the camera at approximately the same level from the ground, about 1.5 meters, and about 5 meters from the base of the structure. No reference or control points were used during this process. I did not use the zoom on the camera, if I needed to include a closer photograph, I would reposition myself closer to the structure. This allowed me to not have to fix the photographs once put into the software and kept them consistent. Photographs were taken in succession beginning with an origin point at ground level. To collect the scans and photographs I had to take multiple overlapping photographs of each structure and artifact. Capturing the photographs for the structures, I had to stand in the same place and take three to four photos then take a step to the side and move the camera, when needed, then repeat until the structure was completely photographed. To scan the structures, I slowly walked around the building while using Scaniverse to take a video. The best time to capture the

photographs and scans of the structures was on cloudy days since there were fewer shadows that would interfere with the digital processing.

Once I finished photographing and scanning the structures that were the most feasible, I started photographing some of the artifacts from the site. Since most of the artifacts from Cahal Peach were on a museum tour in the United States, the artifacts that I picked to photograph were ones that were available to me in Belize, mostly pottery. I photographed 13 pottery vessels, one projectile point, three pot stands, and an effigy lid from Cahal Pech. These artifacts were chosen based on their design and if they were whole.

For the artifacts, I used a photography light box and photography lights. I started with the artifacts facing the right way up, spun the artifacts around, and then flipped them upside down. I did this until the whole artifact was captured. The lights and photography light box allowed for the whole artifact to be illuminated in a consistent way. This ensured that photographs and scans did not have to be redone.

Structure A2 required five tries because some of the scans failed to capture all sections of the structure. Each scan took over an hour to complete due to the size and how slow I needed to do the scans. For each artifact I also took scans which did not need to be redone because of their small size. Each of these scans took about a minute to complete.

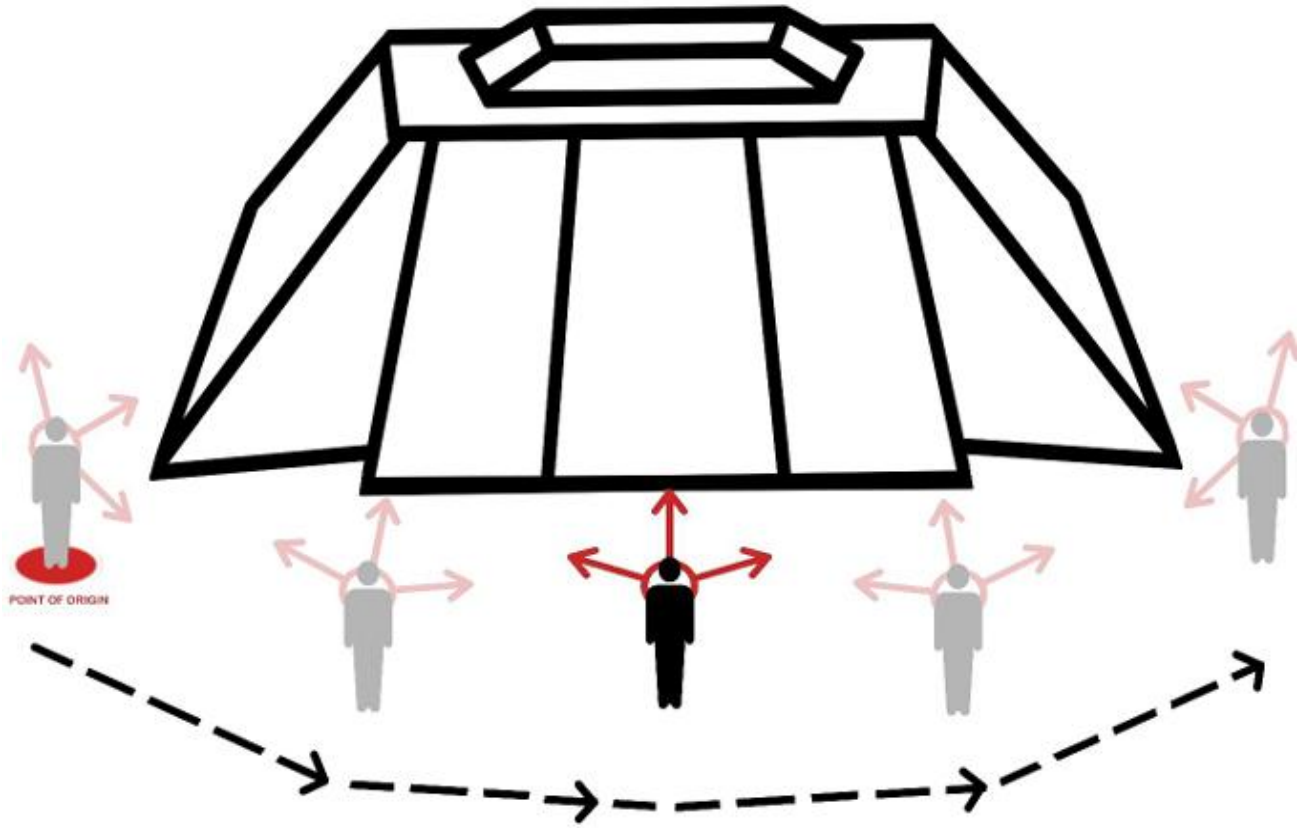

Figure 3 Visual representation of photogrammetry method. Figure by Kelly Baer (2024).

Phase 2: Refining Models

Phase 2 focused on editing and refining the 3D models of each structure and artifact. To determine if any structures needed to be re-photographed, test models were created via Meshroom and Scaniverse. Meshroom is mostly self-regulated and can perform tasks without interference from the user. By recognizing the overlap in the photographs, MeshRoom creates a cloud of the object. The mesh cloud is then put into MeshLab to create the 3D models. Depending on the number of photographs, the processing can take an hour to eight hours to complete using Meshroom and MeshLab.

This process was done overnight or when I was not at site due to rain. Scaniverse processed the scans in one to two minutes after capturing the video scans of the structures or artifacts.

Once all the models were created, I sorted them into categories based on appearance. Appearance was based on the presence of holes or gaps in the images, lack of texture, shape, and if anything was distorted. Models with 85% or higher visual representation were considered successful, models with 70-84% were partially successful, and models 69% or less were unsuccessful. The models that were successful moved on to the editing stage, whereas the other models required photograph retakes and then reprocessing.

After the scans were processed, they were uploaded to Sketchfab, which is a free platform that allows people to view, upload, and download 3D and VR content. I uploaded my models on public mode so they could be accessed by anyone searching for models of “Cahal Pech.” This project is meant to make content easily accessible for educational purposes and should be accessible for anyone wanting to learn about the site and its history. Once on Sketchfab, I edited the sharpness and grain so the models would look less pixelated and turned the background off so the model could be uploaded and added more easily to the educational materials.

Phase 3: Developing the Educational Materials

Phase 3 focused on the creation of educational materials, the StoryMap, educational coloring book, and site guide. Data were gathered from publications and reports of past excavations at Cahal Pech. The reports include the 1988-1994 and

2010-2023 BVAR project seasonal reports, along with some unpublished theses and dissertations related to the BVAR project. The data included information about the architectural features of each structure, their construction history, and their significance. It also includes facts about the artifacts excavated; what they might have been used for, what they were made of, their relative date, and their significance to the Maya culture. This information was narrowed down into short informational facts that describe the history and importance of each structure and artifact. Since the StoryMap is designed for middle school students, the facts that accompany the digital models contain more in-depth information than that of the coloring book which is for a younger audience. The site guide contains the most information since it is intended for older students and adults.

To create the StoryMap I used a website called StoryMaps, that can be downloaded on mobile devices. This application allows anyone to create and share their maps or other information in the form of narrative text and other media content (Kandhari 2023). It helps individuals learn by presenting information in a visual and interactive way that catches the viewers' attention. I started with a blank template and added maps, photographs and videos of the 3D models, and information textboxes. To add maps there is an express map option that drops the map into your desired location. You are then able to edit the location on the map, add layers, and create points and polygons. Test blurbs can be added to maps to add information about a certain place. The informational text boxes can be added to the photographs and videos that go along with the facts. Once I was done adding all information, maps, and 3D models, I edited

the text boxes to make them look more presentable. The process of creating this material was relatively easy and could be taught to any adult or older student.

Creating the coloring book took multiple steps. First, I needed to obtain photographs of the structures and artifacts that would be included in the coloring book. I used photographs of the 3D Models that I took of the structures and some of the artifacts. For some of the more eccentric artifacts that were on the museum tour, I received copies of photographs that Dr. Jaime Awe had of the artifacts. Once I had photographs, the second step was to trace them. I used an application called Procreate to do the tracings. This application allows the user to add in a photograph of the item they want to draw then add other layers on top so they can trace the item. Changing the transparency of the photograph enables the illustrator to see the tracing that they are doing on top of the original photograph. After the structures and artifacts were drawn the last step was to place them into the coloring book. For this step I used Pages, an application that comes with apple mobile devices. It has templates for books, reports, letters, resumes, flyers, etc. I used a landscape book template named “Story” to create the coloring book. This template lets you add photos and has small text boxes for information. I added all the drawings that were created in Procreate then added the facts about each drawing. I also added information about what an archaeologist is and what they study for those that do not know.

For the site guide I used Microsoft Word where I wrote up a document explaining each structure and area of the site. I added photographs of the structures and some artifacts to go with their information. I then created a website using Google Sites, which anyone that has a Gmail account can use, to house all of the educational materials. The

website allows anyone to access the materials and download the coloring book and site guide. It also contains QR codes and links to the StoryMap and all of the 3D models created for this thesis.

Chapter 4: Results

The purpose of this project was to develop interactive materials on Cahal Pech archaeological site for public education purposes and that could be replicated at other sites in Belize. As part of the project, I recorded the successes and failures of the various processes, along with material requirements and costs so that others wanting to replicate it could have an idea of the challenges involved with preparing these materials. Below, I present the results of the various processes and requirements needed to conduct the project.

Modeling Results

While photographing and scanning the structures, I realized I could not capture all of structures B1, B2, and B3, (the E-group) and structure A1 due to their size, because of tree cover, and because I did not have a drone. With use of a drone some of the structures could have been more easily modeled even though tree cover would have posed a challenge to do so. In spite of the latter, I was able to scan and photograph seven other structures: Structures A2, A3, and A4, the East ballcourt in Plaza C, Structure F2, a room in Plaza E, and the H1 tomb. Most of these structures were modeled using Scaniverse since they were relatively small. I photographed Structure A2 in four days and scanned it over three days on Scaniverse. For the other structures each took a day to two days to scan depending on if the scan needed to be redone. Most structures had to be scanned multiple times. The scan of Structure A2 and A3 did not turn out good on Scaniverse, most likely due to the vegetation, angle of the scans, and shadows. The photographs of A2 that were processed through MeshLab

turned out to be better than the Scaniverse model. The other structures that were scanned had a good turnout rate after being rescanned.

I was able to photograph and scan 18 artifacts, mostly pottery vessels, which were excavated from different areas of Cahal Pech. Each vessel took 5-10 minutes to photograph then one to two minutes to scan. Some of the artifact scans had to be redone due to me moving too fast and the model turning out unsatisfactory.

Educational Materials Results

For the StoryMap and archaeological coloring book it took time to figure out how to work the applications, but once I knew how to work them the process went smoothly. While tracing the structures and artifacts for the coloring book, I noticed that some did not look as good drawn as others, so they were not placed in the coloring book. The coloring book has information on the structures and artifacts along with other information about what archaeology is and what archaeologists do since not all students will know this information (see Figure 4 for coloring book layout). It also has some QR codes that people can scan to view the 3D model of the structure or artifact they are coloring. Some of the artifacts do not have a 3D model created because I did not have access to the artifact.

The StoryMap contains location maps of Belize and Cahal Pech, videos and 3-D photos of artifacts and structures, as well as information that goes along with each. There are QR codes that people can scan to view the other artifacts and unsuccessful

3-D models I decided to not include in the StoryMap. They can also access a PDF of the coloring book through a QR code at the end of the StoryMap.

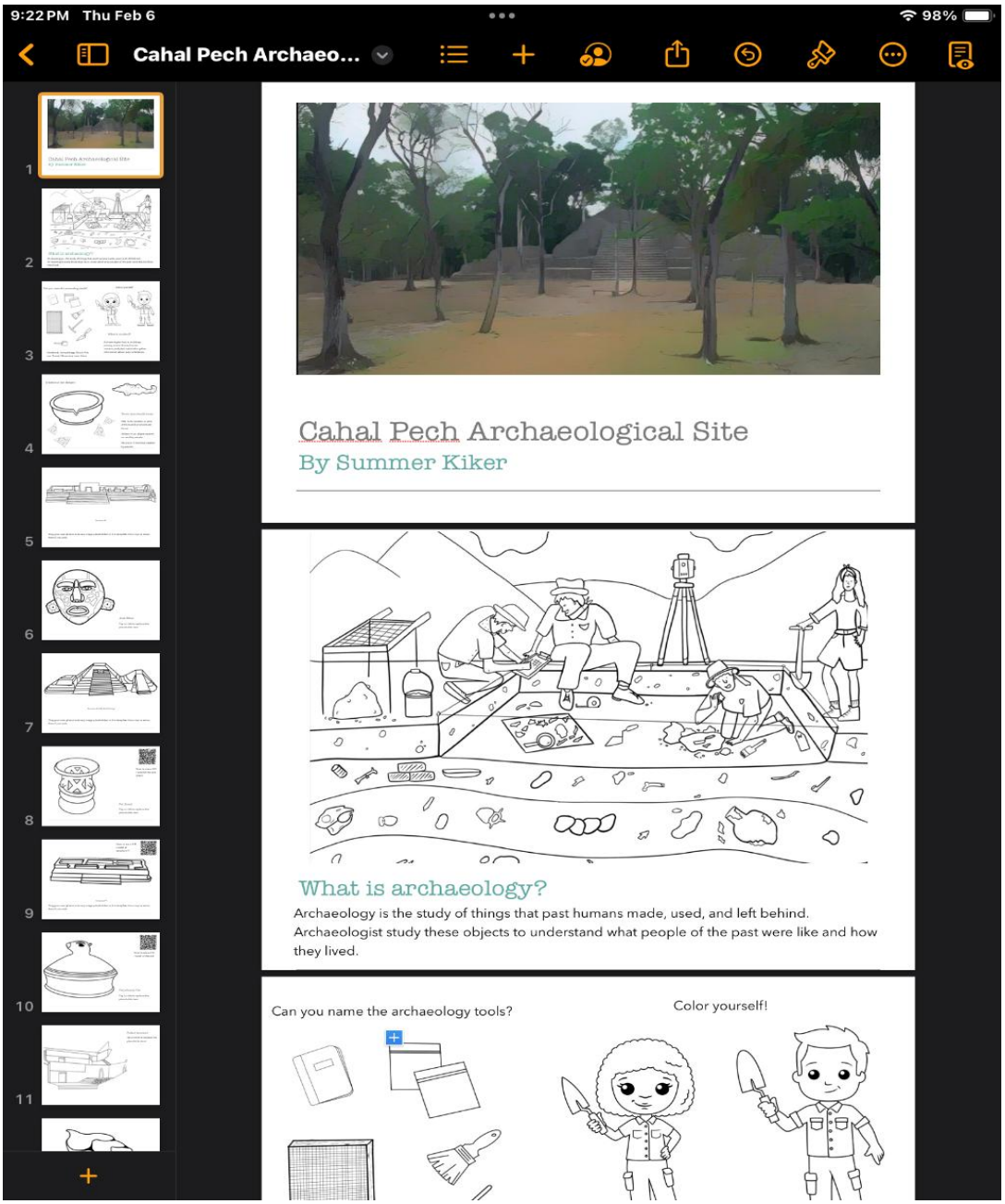

Figure 4 Coloring book process. Created by author.

Time Commitment and Physical Requirements

The first phase of this project required five of the six weeks I had estimated for being in the field. I took the first week to talk with park rangers and staff and to rank structures by priority. During this week I also tested the equipment to see what methods would work best for documenting the structures. The rangers and staff gave me information on the structures and the site and gave me suggestions on which structures to model.

For modeling the structures, the time varied depending on the day and which structure I was photographing and scanning. Some of the days that I was photographing structures the site had school groups visiting so I had to stop photographing the structures to not be in their way. I averaged five hours a day over three weeks photographing and scanning the structures, minus the days I could not photograph due to rain. About one hour per day spent in the field was spent sorting photographs and compiling them onto the external hard drive. The models were rendering during the night and took two to eight hours to complete, depending on size.

Modeling the artifacts took one week to complete all the photographs and scans. Each artifact took 30 minutes to an hour to set up then photograph and scan. Some of the vessels had two parts which took longer to photograph, since I took scans and pictures of the vessel with the lid and base together then each part separately. I was able to complete an average of five artifacts each day.

During the second phase of the project, about 50 hours were dedicated to editing and exporting the successful models. This time frame included the time used to process

and review models for successfulness and reprocessing when needed. In the last phase, I spent over 200 hours researching information and writing the facts for the educational materials. This time also included the time it took to draw the structures and artifacts for the coloring book and the time it took to create images and videos for the StoryMap.

The physical requirements for conducting the field component were moderate. The person conducting the research must be able to climb large structures, stand in one place for short periods of time, and walk for several hours. They must take the climate into consideration as well. Summers in Belize are hot and humid with lots of bugs and animals, so one must be able to work in that condition. Most photos were taken on ground level or by climbing the structure to capture different angles of the buildings. Most of the structures at this site have steep stairs or slopes and do not have rails to help, so you must be knowable of climbing without gear. Some of the structures like B1, B2, and B3 do not have stairs going all the way to the summit so they must be climbed carefully to capture images from the top. The second and third phases required little physical activity but did require sitting for extended periods of time to edit, research, write summaries, and to create the materials.

Cost of Equipment

The cost of the equipment and software used totaled around $920 USD. The camera, iPad and laptop used for this project were personal ones that I already had, so I used the current price of them to calculate the cost. Different equipment can be used for better quality. The Nikon Coolpix L83 camera currently can be bought for around

$100 USD. I did not use any extra lens attachments. I used an iPad 9th generation which runs at about $400 USD and an ASUS Vivobook laptop that runs for around $300 USD. The external hard drive, extra memory cards, and AA batteries cost about $110 USD all together with the external hard costing the most at $75 USD. Software costs were the lowest since most of it was free. The only application that cost money was Procreate at $12 USD and is a onetime fee. Pages, MeshLab, and Scaniverse were all free.

Chapter 5: A Brief Guide to Cahal Pech Archaeological Site

This is a guide to be used by educational and tourist institutions to have a more in-depth explanation of the site, its structures, and some artifacts. Parts of the text in this chapter were used in the educational materials created for the site, the StoryMap and coloring book.

Cahal Pech is a middle-sized ancient Maya center located in western Belize that is situated atop a steep hill overlooking the Belize River Valley. It is about 2 km south of where the Macal and Mopan tributaries of the Belize River meet and has a commanding view of the Maya Mountains to the south (Awe 1992; Healy et al. 2004). Cahal Pech was first settled around 1200-1100 BCE and abandoned around AD 800-900. It was one of the first permanently occupied sites in the Maya Lowlands (Awe 1992). What we see today is but a small percentage of the city's extent during its peak in the Classic period (300-800 AD). This site has produced an abundance of valuable information on early Maya settlers in western Belize. The cultural remains discovered suggest the early settlers were highly sophisticated. They built large platforms for ritual purposes, carved symbols into pottery, imported jade and obsidian, created figurines resembling women, and produced beads made from conch shells (Awe 2006). Cahal Pech likely became one of the most important cities in the Belize River Valley during the Late Preclassic (300 BC-AD 250) and continued to grow during the Classic Period (AD 300-800) before it was abandoned during the ninth century.

Archaeological Work

During the 1950s Dr. Linton Satterthwaite, from the University Museum of Pennsylvania, was the first to report Cahal Pech (Awe 2006). Between 1953-1955 Gordon Willey, from Harvard University, visited the site and wrote a description of the site core. In 1969 Peter Schmidt, the Belize Archaeological Commissioner, conducted salvage operations after observing that looting occurred at the site. During Schmidt's salvage operations he focused on a tomb in Structure B1 where he discovered the remains of a Late Classic (AD 600-700) ruler. The tomb also included several artifacts encompassing jade objects, obsidian blades, shell and bone ornaments, and several ceramic vessels. A jade and shell mosaic mask that would likely have been used as a center piece on a belt worn by the noble was also found in this tomb. Between 1970-185 the site was looted multiple times which led Jaime Awe to start investigating the site. Extensive excavations at Cahal Pech began in 1988, initiated by Dr. Jaime Awe and his team (BVAR) with support from the Belize Tourism Industry Association (BTIA) and UNESCO. From its onset, the focus of Awe's project was to preserve Maya history and turn Cahal Pech into a national archaeological reserve (Awe 1992).

Site Core Description

Cahal Pech's site core overlooks the modern town of San Ignacio. The site core is about 1.5 hectares in size and has 34 defined structures with the tallest being 24 meters high (Str. A1). The site core consists of a western side with elite residential architecture and an eastern side with ritual and civic structures. The site core has seven plazas, several large temples, an acropolis palace complex, administrative structures,

two ball courts, reservoirs, a sweat bath, and numerous tombs (see Figure 5 for map of structures discussed in this thesis).

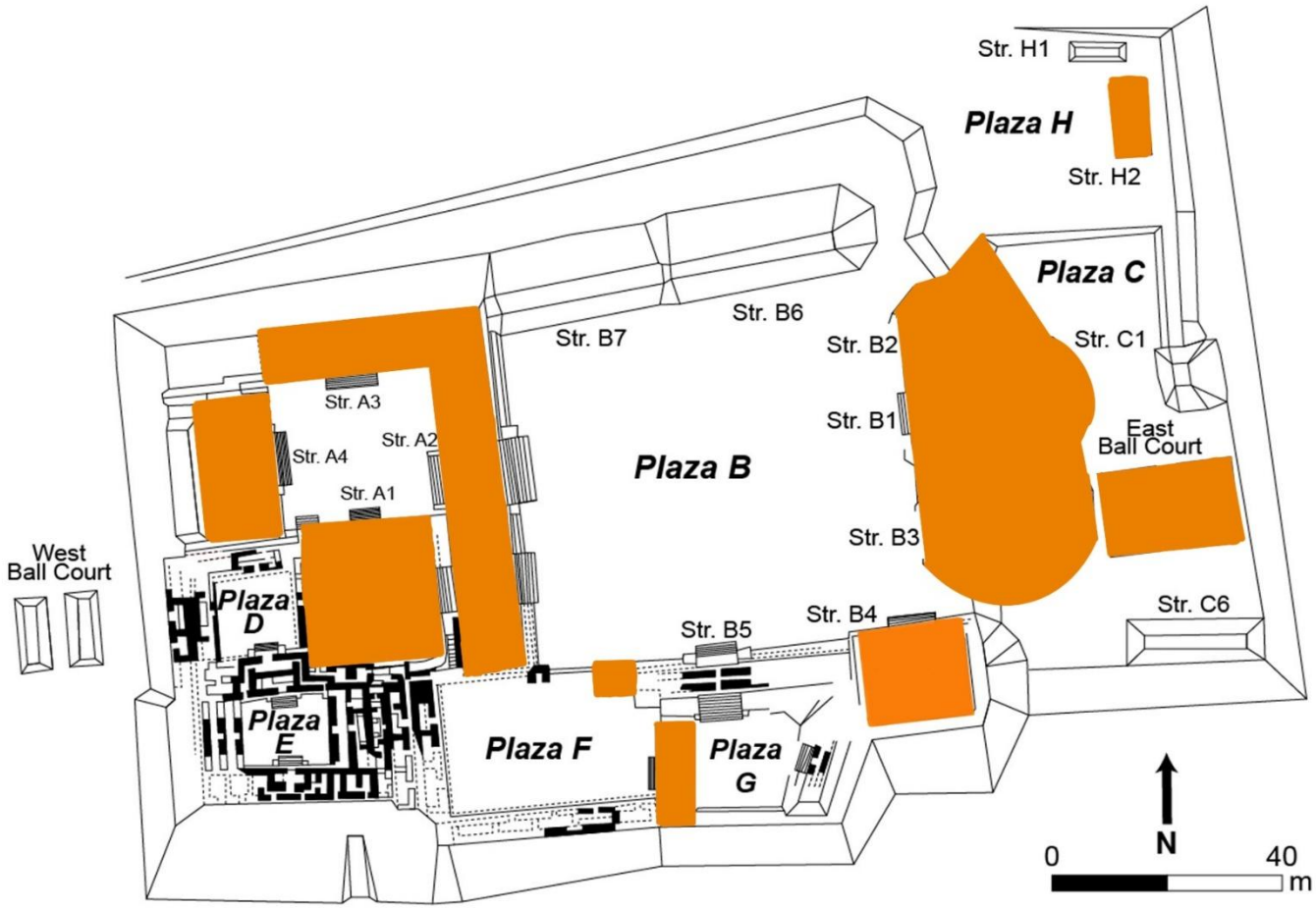

Figure 5 Map of Cahal Pech site structures discussed in educational materials. Map by Claire Ebert (2017). Adapted by author.

Plaza A

Plaza A is a small plaza enclosed by palaces, administrative buildings, and the tallest temple (str. A1). Passages through Structures A2 and A3 and small hallways between each of the structures allow restricted access into the plaza. Access into this plaza would have been exclusively for elites.

Structure A1

Standing 24 meters tall, or about 79 feet in height, Structure A1 is a multi-tiered pyramid and is the tallest structure in the site core. Midway to the summit of the Classic period temple there is at least one chamber that Awe (1992) identified as a “throne room”. The rear wall of the throne room was originally decorated with hieroglyphic texts that referred to one of the Classic period rulers of the site (Awe 1992). Buried within the Classic period temple is an earlier Late Preclassic (ca 100 BCE – 100 AD) structure that also may have served as the private shrine of Cahal Pech’s early ruling family. Prior to Awe’s investigation of Structure A1, the mound had been looted, and it appears that vandals may have uncovered a tomb within the structure. These vandals were later apprehended by police who confiscated a large ceramic vase in possession of the looters. The vase likely came from the looted tomb in Structure A1.

Structure A2

Structure A2, which is located on the west side of Plaza B and/or the east side of Plaza A, separates the two largest courtyards at the site. With its 13 doorways facing Plaza B to the east, Structure A2 likely functioned as an “Audiencia”, an administrative building that was used by the site’s elite to meet and greet important visitors to the site (Awe 2008). The structure seen today is the third construction phase, the first phase being a Preclassic platform buried beneath the present building. See Figure 6 for 3D photograph of Str. A2.

Figure 6 3-dimensional picture of Structure A2. Model by ChoroPhronesis research unit at Pennsylvania State University.

Structure A3

Structure A3 is connected to Structure A2 and is located on the north side of Plaza A. Structure A3 features several rooms above a long platform with a central stairway. Given its location and connection to the Audiencia (Structure A2), it is likely that this building may have also served administrative purposes. During excavation of the central room in Structure A3, Awe (2008) uncovered a small intrusive burial that contained the remains of a child accompanied by an assemblage of Terminal Classic (800-900 AD) period artifacts. The intrusive nature of the burial indicated that it was placed within Structure A3 around the time of abandonment of the site.

Structure A4

Structure A4 is on the west side of Plaza A. It is a multi-roomed structure and like Structures A2 and A3 would have probably been used for administrative purposes. (See Figure 7 for 3D photograph of Str. A4.)

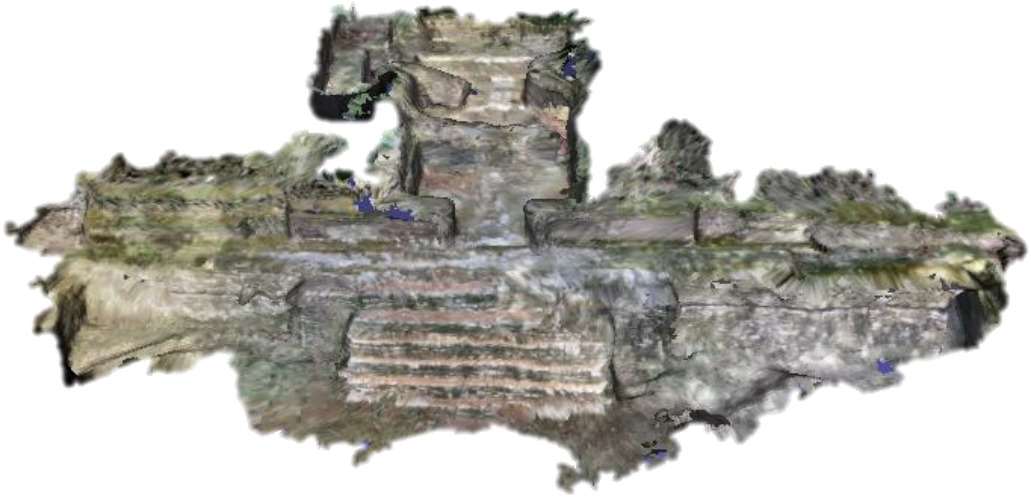

Figure 73-dimensional picture of Structure A4. Model created by author.

Plaza B

Plaza B is the largest plaza at Cahal Pech. This area was likely used for public activities such as markets and ceremonies and is surrounded by several administrative buildings and temples. To the east is the Eastern Triadic Shrine or E-Group (strs. B1, B2, B3), to the southeast is a temple (str. B4), to the southwest is a sweat bath (str. B5), to the west is the primary administrative building (str. A2), and to the north there are more administrative buildings that have been partially restored (strs. B6 & B7).

Structures B1, B2, B3 (E-Group or Eastern Shrine)

Structures B1, B2, and B3 make up what is referred to as an Eastern Triadic Assemblage (E-Group). An E-Group is three freestanding structures that are on the eastern side of a plaza, where the central structure is taller than the two on the northern and southern sides. E-Groups are usually associated with the solstices and equinoxes, where the pyramids will align with the sunrise on these special days. These structures usually have their own construction history (Awe et al. 2017). At Cahal Pech, the earliest phases of the E-group date to the Middle Preclassic. Excavations of the structures indicate that they later became an elite mortuary shrine starting in the Late Preclassic period and continuing into the Terminal Classic. Thirteen royal burials were deposited in Structure B1, and six other burials were found in Str. B2 and Str. B3 (Awe 2013, Ebert et al. 2021). (See Figure 8 for 3D photograph of Strs. B1, B2, and B3).

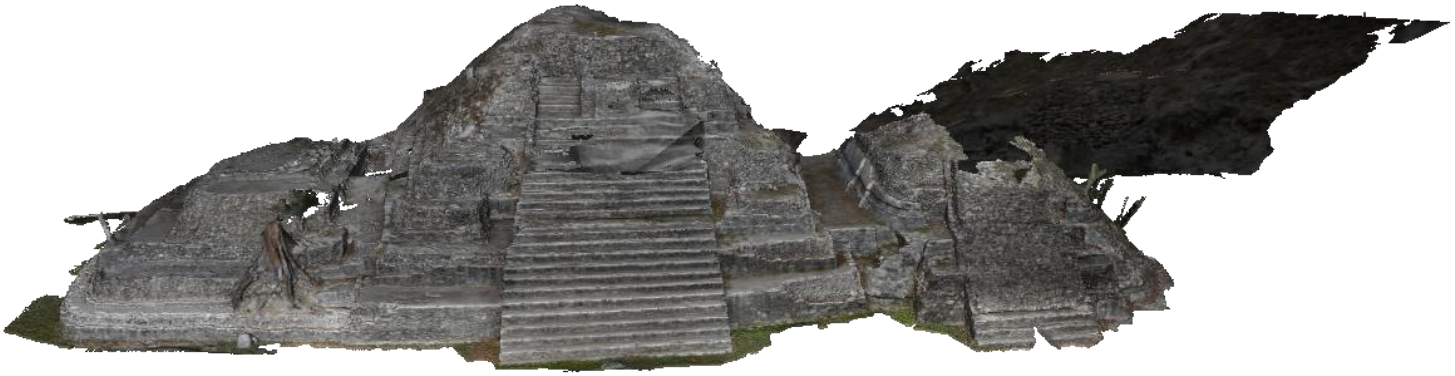

Figure 8 3- dimensional picture of Structures B1, B2, and B3. Model created by ChoroPhronesis research unit at Pennsylvania State University.

Structure B4

Structure B4 is one of the most important structures at Cahal Pech. With 13 construction phases, it has the longest construction sequence at the site (Awe 1992). The earliest phase of construction dates from the Early Preclassic (ca. 1200-1000 BC) and the last phase dates from the early Late Classic (Beardall 2017). The last two phases (B4/11th and B4/12th) were removed in 1991 leaving what we see today, phase B4/10th, which was constructed in the Late Preclassic between 250 BC- AD 150.

Structure B5 (Sweat bath)

Structure B5 is a sweat bath. A sweat bath is a structure used for both ritual and mundane purposes. They are highly gendered spaces since they are associated with gestation and the goddesses of fertility. Childbirth would commonly take place in sweat baths and is still practiced in some areas today (Tejeda-Barillas 2024). They were also used for healing purposes. “The healing that occurs in sweat baths can depend on a variety of factors such as size, shape, acoustics, and location” (Tejeda-Barillas 2024). Cahal Pech’s sweat bath was determined to be a public healing center due to its

location within the site core and its rectangular, large, shape (Tejeda-Barillas 2024). (See Figure 9 for 3D photograph of the Sweat bath).

Figure 9 3-dimensional picture of the sweat bath. Model created by Lilian Tejeda-Barillas (2024).

East Ballcourt

Ball courts are an important architectural feature of major sites in the Maya world. They were not only used for a fun ball game against friends but can also be tied to politics and religious rituals. The ballgame and the courts have been symbolically linked to the movement of the sun and moon and their relation to seasonal agriculture. A game could also be played to dispute political disagreements, to mark boundaries or be a substitute for war. In 1995, the center of the eastern ball court at Cahal Pech was excavated and a cache (a collection of items deposited as an offering) of marine shell, chert flakes, five obsidian eccentrics, and the skeletal remains of two children were

found (Fergusson et al. 1996). Analysis of the artifacts found that the ball court had been built in the Late Classic period (AD 700-900) (Santasilia 2013). (See Figure 10 for a 3D photograph of the East Ballcourt).

Figure 10 3-dimensional picture of the East Ballcourt. Model created by author.

Plaza F and G

Plazas F and G are less restricted areas with less monumental structures. These plazas and structures likely served as residential areas for craft specialists and lesser elite. Plaza F is a semi-restricted courtyard with several low platforms on its southern flank that may have supported perishable, pole and thatch, buildings. On its western side, the courtyard is bounded by a three-story high palace.

Structure F2

Structure F2 is located on the east side of Plaza F. F2 has three masonry rooms on top of a large platform, with each room having their own central doorway entrances. Discovery of potsherds with incised scenes suggest that Structure F2 could have been the house of a scribe or artist (Awe 2006). (See Figure 11 for 3D photograph of Str. F2).

Figure 11 3-dimensional picture of Structure F2. Model created by author.

Structure H1

Plaza H is located on the northeast corner of Cahal Pech's site core. Because the courtyard contains only small platforms compared to the monumental architecture of the other plazas in the site core, it is generally overlooked by visitors to the site. Investigations done in 2006 discovered a tomb (Burial H1-1), in Plaza H, that dates to the Terminal Classic period. It is a subterranean crypt made from limestone blocks and was created by remodeling a Late Classic platform. This tomb contained a high-status burial with 13 ceramic vessels and other items such as effigy censers, several bone tubes, obsidian blades, a carved jade pendant representing the maize god, and the remains of a small feline (Awe 2013; Douglas & Brown 2015). (See Figure 12 for 3D

photograph of Str. H1). Like the child burial in Structure A3, the H1 tomb was constructed at the time of abandonment of the site (Awe et al. 2020).

Figure 12 3-dimensional picture of Structure H1. Model created by author.

Plaza E

Plaza E is the most restricted plaza at Cahal Pech. It is surrounded by elite residential structures and forms the southwest corner of the site core. There are three structures around the plaza and could have only been accessed by going through the structures surrounding it.

Structure E1

Structure E1 is the most notable structure in Plaza E. It would have been the palace for the royal family and has two entryways; one is an entrance from Plaza E and the other is a twisting stairway from the east side of Plaza F. One of the rooms in Structure E1 contains a bench with red paint which would have decorated the room (see Figure 13).

Figure 13 3-dimensional picture of Structure E1 room. Model created by author.

Artifacts

Cahal Pech has an abundance of artifacts ranging from ceramics to eccentrics. Most of these artifacts were found in tombs throughout the site (See Figure 14 for

examples of artifacts found at Cahal Pech). In figure 14 from left to right; (Top Line) Cabrito cream polychrome vessel found in Structure H1 tomb 1, Pot stand with coca pods found in Structure B1 burial 10, Zacatal Cream Polychrome dish with peccary lid found in Structure B1 tomb, Polychrome dish with depiction of ancestor found in Structure B1, (Bottom Line) Jade mask made of jade and shell found in Structure B1 tomb, Ink pot made from a conch shell found in Structure B1, Stingray effigy found in Structure B1.

Figure 14 Cahal Pech artifacts. Photographs by Jaime Awe and author

Peccary Vessel

This Early Classic (ca. AD450-600) Peccary Vessel was discovered in Structure B1. It is a Zacatal Cream Polychrome Dish with depictions of captives around the base. The lid depicts Maze Gods under a peccary head (Zender et al. 2017).

Jade mask

This jade mask was discovered in Structure B1 in a tomb. It is made of jade and shell and would have been worn as a belt piece by an elite royal. The jade would have come from Guatemala, and the shell would have come from the coast showing the wide trade routes Cahal Pech had.

Ink Pot

This Late classic (ca. Ad 600-700) conch shell was excavated from a tomb in structure B1. It would have been used to hold ink for an expert scribe and still has preserved residue of blue, red, and black ink that would have been used in three of the four ink wells (Zender et al. 2017).

Chapter 6: Discussion

When writing up archaeological research, it is important to use language that is more suitable for people outside the academic setting. Archaeology is meant to uncover the truths of the past and gain information about past cultures and people. The discoveries are about people's ancestors and should be made available for anyone to read and understand. If there is sensitive information in the discoveries, then that information should be kept confidential, but the other information should be made available for others to learn about. Educational materials of unsensitive sites and information should be made available to the public so they can learn more about the past, gain more information about their heritage, and have a better understanding of what archaeologists do.

The purpose of this research was to analyze and create educational materials for public use and to see the role digital technology plays in creating these materials. Throughout this project many factors were considered, including community collaboration with archaeological research and technological efficiency in the field. This project focuses on creating materials for the local community and other educational institutions, to show how archaeological information can be transformed into engaging materials for students. It also shows what can be created when archaeologists collaborate with local communities and make the communities' interest a priority.

This project had several successes but also had some shortcomings. The major shortcoming was the digitization of the structures. Some of the structures could not be photographed because of size while some structures did get scans and photographs that did not turn out the way I wanted them to. I focused on photographing the

structures in a way that could be repeated by anyone without special equipment or training. This made me rely on the software's ability to calculate the camera's location and distance from the structure which is what caused problems in creating the 3-dimensional models.

A few of the models also had overlap from surrounding foliage which created gaps in the final model. Additionally, Structures B1, B2, and B3 either did not have access to their summits or had foliage covering parts of them. There are vegetation and large trees on the south side of B3. Structure B2 has a large tree stump on the west side of it and Structure B1 did not have access to the top. The vegetation and shadows made those parts of the structure unrecognizable to the software which created holes in the models resulting in me not continuing with the modeling of the structure.

Structures A2 and A3 were modeled but the models were unsuccessful due to vegetation and shadows. The north and south side of Str. A2 has vegetation and Str. A3 has vegetation on the east and west sides that cover some of the structures and create splotchy shadows on the structures. Structure A2 faces east which means the front receives direct sunlight in the morning and the back is in shadows for most of the day. The shadows confuse the modeling software since shadows are what it uses to determine shape and distance of the object.

Modeling Structure A4, the H1 tomb, and the east ball court had similar issues with vegetation. The east ball court is surrounded by trees and is entirely shaded throughout the day and H1 is a tomb with a modern pole and thatch structure covering it to keep it protected, but this made it dark and hard to model. The splotchy lighting on the east ball court did not affect the modeling too much. It did, however, require me to

scan the structure a few times due to some holes in the model. Once I scanned it during an overcast sky, the model turned out successful. Tomb H1 caused the software more confusion since it was essentially a dark hole in the ground. The darkness inside the tomb, and the light outside of it, confused the software resulting in holes in the model. To fix this, I used a flashlight inside the tomb to allow the camera to see the inside and create a full model of it.

Terrestrial photogrammetry requires the photographer to climb and navigate the whole exterior of the structure. Structure A1's size and some vegetation cover made it difficult to photograph it entirely. Details of the structure would have been lost in the model and only a partial image would have been created for the structure. Having a time constraint and the fact that the model detail would be greatly affected, I decided it was not practical to attempt a model of Str. A1.

These weaknesses warrant future analysis of the methods used in this project so changes can be made. However, these restrictions do not diminish the overall accomplishments of this project. The results of this project show that there is promise in developing better methods and approaches that can be applied to other sites. The community collaboration aspect of the project, and the use of digital techniques to create educational materials for an archaeological site were also relatively successful. This indicates that the methods used can be replicated and used at other sites or modified slightly for better results at the same site. The shortcomings described above revealed strategies that can be built upon or modified by other researchers conducting similar projects.

Answering Research Questions

1. How can digital applications be used to create educational content for archaeological sites?

The use of different digital applications was used throughout this whole project process. I focused on using applications that can be easily accessed and used by grade school students and other people without experience. Even though photogrammetry sounds like a difficult technique, the approach I took was simplified so anyone can replicate it. The programs used in the project also allowed me to easily create 3-D models, a coloring book, and a story map that anyone can use.

Digital applications create educational materials that can be used and accessed anywhere in the world. This allows archaeological sites and unclassified site information to be viewed and learned by a wide range of people. Simple digital applications permit anyone to create materials for sites. Not only does this allow the archaeologists to simply document the site digitally but they also allow students and staff at archaeological sites to create 3-D models and educational materials for the site without needing previous experience working with the applications.

I was able to complete the field work and create the materials of this project with little difficulty using digital techniques. Most of the applications I used were easily downloaded onto an iPad which limited the supplies needed. I used Scaniverse to create 3-D models, Procreate to produce drawings of the structures and artifacts for the coloring book, Pages to design the coloring book, and a website, StoryMap, to create the story map. All the applications used were easy to use, free, or of low cost, and all,

except the StoryMap website, can be used offline, making them accessible to use in the field.

2. How can digital media contribute to archaeological education outreach in rural areas?

Digital media allows archaeological information to be more accessible to those who might not be able to visit sites due to physical constraints, distance, or other challenging factors. Rural areas might not have the resources to visit an archaeological site, but they may have access to a computer or mobile device. Having archaeological information and sites digitized allows these communities to learn about the site and what archaeology is without requiring too many resources.

Creating digital open access archaeological materials allows for lower income schools in rural areas to access more information for their students. This helps students learn more about archaeology and other subjects. The story map, 3D models, and digital coloring book created in this project can be accessed for free and via the internet by a simple search.

3. How can learning about archaeological sites be made more interesting to students?

Creating interesting educational materials for archaeological sites can be changeling since most of the information for sites is written for academic audiences with vocabulary and technical jargon that most people do not know or understand. By creating interactive and engaging materials with simplified vocabulary this gap can be lessened.

The 3D models create an image and/or video of artifacts and structures that students can view remotely. They can flip the object, zoom in on certain parts or see the whole thing in the palm of their hand. Sound can be added to describe the object and read the information aloud to accommodate people with visual impairments. Three-D models can also be printed to allow people to physically hold a down-scale version of the object.

StoryMaps create an immersive learning experience for people viewing them. Maps, pictures, sound, videos, and other digital media can also be added to attract the attention of the viewer. This allows “boring” information to be displayed in a more engaging way, helping people learn the information without realizing it. These story maps can be accessed through scanning a QR code or by searching the web on any device allowing for easy access and viewing.

The coloring book, created on digital applications, can be printed, or viewed digitally via PDF. It is targeted for a younger audience so they can learn about the site and what it means to be an archaeologist while coloring what they are learning about.

Recommendations for the Future

This project had many successes and showed that expensive applications are not needed to create digital educational materials for archaeological sites. It demonstrated that Scaniverse, a free 3D model application, could be used to create detailed models of ancient structures and artifacts. It also showed that free websites like StoryMap can be used to create interactive educational materials, and that cheap applications can be used to create informational coloring books.

For future projects looking to create 3D models, I would recommend using drones and photogrammetric targets to capture larger structures for more detailed models. Targets would help the software in differentiating features and points of interest within the pictures taken, making the models more complete in shape and not having holes in the final model. Adding more educational materials, like a brochure or informational signs to the site would also help the guest visiting the site understand what each structure is and the history of the site.

To better understand if these digital methods are effective in teaching about archaeological sites, more research will need to be conducted by visiting schools or institutions using the materials and receiving feedback from the people using them.

Chapter 7: Conclusion

This research project sought to contribute to the relationship between education and archaeology and to address the gap between the two. The project also brings attention to the need for making archaeology more accessible to the public through education outreach and community engagement. These components are necessary for archaeological excavations to continue since much of the funding comes from private individuals that have a love for history.

The models and educational materials produced by this project are meant to be used for educational purposes to teach about Maya archaeology in western Belize. They will allow people to view artifacts recovered at Cahal Pech without handling them and to see the structures at the park without visiting the site. This creates a more accessible alternative for learning about and viewing Cahal Pech while also preserving the structures and artifacts. To achieve these goals, I created an interactive StoryMap and educational coloring book of Cahal Pech Archaeological Site that can be used by local schools, the general public, and visitors to the park. The StoryMap will allow students to go through the site via 3 dimensional models and learn about the site's history, giving a more immersive learning experience. I also created an informational archaeological coloring book of some structures at Cahal Pech, and of some of the artifacts found during excavations. This will allow younger students to learn about the site while coloring the structures or artifacts they are reading about.

While creating these materials I intended for them to have different education levels. The educational coloring book has simple explanations of the structures,

artifacts, and what archaeology is, it is intended for early childhood education around 3rd- 6th grade. The coloring book can be incorporated into lesion plans about archaeology or history on the Maya Empire. The StoryMap has more information about Cahla Pech and is intended to be used by middle school students, around 6th- 9th grade. It can be added to lesson plans about the Maya or Mesoamerica. The last educational material includes the site guide, which can be found in my thesis and on the website I created. The latter has the most in-depth information about the site and explains areas of the center not mentioned in the other materials. The site guide is intended to be used by older students and tour guides to learn more about Cahal Pech and its importance in the Maya world.

While the project focused on only one Maya site, the methods I used can be applied globally. These methods and applications can not only create educational materials but can also be used to help record archaeological site information. The 3D models can be used in both K-12 educational institutions and for research purposes. Using 3D models, researchers can observe the paint details on ceramic artifacts, preserve structures or paint that will erode over time, and analyze artifacts that cannot be touched or brought out of the country.

There are endless opportunities to create archaeological educational materials using digital techniques that are open access. My research represents a small step in bridging the gap between archaeology and public education. The results of this thesis show that recording archaeological sites and creating educational materials for the public is possible with cost effective equipment.

Appendix: Reference Codes

Figure 16 Web Page QR

Figure 15 3D models QR

Figure 17 Story Map QR

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