

Development of a Self-Guided Tour for El Caño Archaeological Park



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An Interactive Qualifying Project Submitted to the Faculty of WORCESTER POLYTECHNIC INSTITUTE in partial fulfilment of the requirements for the Degree of Bachelor of Science

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Abstract

El Caño Archaeological Park is an archeological site in the Coclé region of Panamá with great historic and cultural significance to the country. The goal of this project is to design a mobile application and a brochure to make the archaeological interpretation of the site accessible to French and English speakers. Our products were delivered in an editable format, along with a manual and training session so that El Caño's staff can update or modify the information as seen fit.

Acknowledgements

This project was significantly influenced by the support and assistance of several individuals whom we would like to acknowledge. We would like to express our gratitude to Fundación El Caño, including Alexa Hancock for her assistance, support, and collaboration throughout the entire project. Mrs. Hancock's complete devotion to the project and trust in our team allowed us to succeed, and we are fortunate we had the chance to work with such a wonderful sponsor. We would also like to thank Dra. Julia Mayo for her helpful feedback and assistance in design iteration. We could not be more pleased with this experience.

We would like to extend further gratitude to our sponsor Ricardo Montanari of Footprint Possibilities for his constant dedication to our project's success. Mr. Montanari's guidance, direction, and resources helped make this project possible. We would like to extend a special thanks to the members of the other A19 IQP team, who also worked at El Caño on a different project, for their collaboration and assistance throughout the term.

We would like to thank our advisor Prof. James Chiarelli from Worcester Polytechnic Institute for all of the hours spent helping us with our report and presentation. His constant guidance, and wisdom helped make our project possible. We would also like to extend our gratitude to Panamá Project Center Director Prof. Aaron Sakulich for his overall efforts in coordination and commitment to the Panamá Project Center.

Lastly, we wish to express our gratitude to Worcester Polytechnic Institute. We are lucky to attend a university that provides opportunities to become global citizens. The knowledge we have gained from this project is something we will take with us in all of our future endeavors.

Executive Summary

Archaeology is an important tool in studying how and why human behavior has evolved over time. The process of analyzing archaeological findings to explain their significance in history is called archaeological interpretation. Without this process, the success and shortcomings of past societies would be a mystery. Through archaeology, a nation's cultural and ethnic identity can be preserved and solidified. Archaeology also promotes tourism and gives a nation a feeling of cultural pride and ancestry. El Caño Archaeological Park is a symbol of patriotism and pride for Panamá. It provides a deep link to the rich historical heritage of the country.

It is essential to preserve archaeological sites and to disseminate the information they contain. Artifacts and burial tombs found at El Caño date back to the Pre-Columbian period, between AD 680 – 1020. (Fundación El Caño, 2017). Currently, information pertaining to the site is only accessible to Spanish speakers (Fundación El Caño, 2017). During operating hours, visitors to El Caño have the ability to take a tour led by a Spanish-speaking guide or to wander the park at their leisure. Visitors can also visit the El Caño museum, where they will find signage in Spanish describing some of the ruins and artifacts found at El Caño, along with a vast historical background of the archaeological site. Presently, there are no guides or other means to communicate this information in English or French, presenting a barrier to the park's English-speaking and French-speaking guests (Fundación El Caño, 2017).

Our goal was to create deliverables to make El Caño more accessible to English and French speakers. This was accomplished through the design and production of a mobile application and a brochure. Our solution was modeled from existing resources. We explored archaeological parks and other sites that have already implemented techniques for increasing

accessibility to archaeological interpretation. We then fit these solutions to El Caño's specific needs and limitations.

A few archaeological parks have used technology to increase accessibility to archaeological interpretation, specifically through the use of mobile applications. Applications are becoming the dominant form of digital interaction. A mobile application carries a multitude of benefits, including the fact that it can reinforce an organization's brand, enhance visibility, and increase accessibility (Patel, 2017). Creating an application for El Caño Archaeological Park cannot only better display the information the park has to share, but can also attract international visitors. Alternatively, distributable materials are not commonly used for archaeological parks, but are more common in other tourist destinations. Many self-guided tours include a map with descriptions of the points of interest within the site. Guests can easily obtain brochures from the entrance to the site. Both of these solutions will be explored for El Caño Archaeological Park.

The first step in creating the deliverables was to collect information about El Caño. To do this, we established a Dropbox with Fundación El Caño to share information about the guided tours that are given at the park and the museum. Another vital aspect of the data collection phase was to visit the park and take the guided tour ourselves. The last significant resource for gathering information was through informal interviews with our sponsor Alexa Hancock.

The design and development of the mobile application involved three steps and resources. First, we analyzed the literature review to create the application's features and aesthetic design. We then used a combination of wireframing software and web code to create initial designs to style the application. Once the initial designs were created, we transformed our web code into a progressive web application using a service worker. We then used a software called Cordova to transform our progressive web application into a native application. A flow

chart detailing each of the steps can be seen in Figure 1 below and each of these steps are thoroughly discussed in the methodology chapter of this paper.

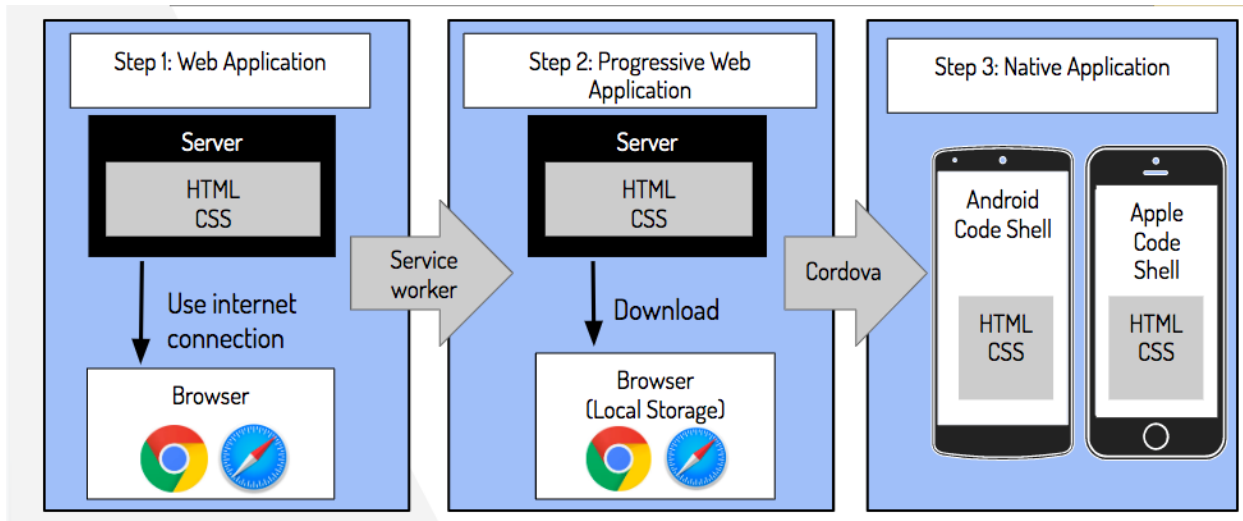


Figure 1: Application Progression Flow Chart

In the development process, there were a couple of aspects that needed testing including: download speed and functionality. During the refinement process, we made many edits to the application, including minimizing file size and therefore decreasing the download time on El Caño’s low-speed internet. By testing the application, we ensured that the application design did not take away from its functionality. The final step in the refinement process was to use third-party testers to get an objective, outside perspective on the application.

After application refinement, we started to distill the information from the tour into the brochure. This brochure is a condensed and informative version of the self-guided tour. The brochure designs were originally created using Adobe XD. This software allowed our team to brainstorm various designs before creating the final product and presenting to Fundación El Caño. The brochure is a tri-fold with information on both the park and museum. The designs parallel the application in fonts, colors, and images. The final product was printed and laminated

to ensure its durability in Panamá's volatile weather conditions and will be stored at the park for visitor use.

There are three deliverables that Fundación El Caño received at the conclusion of this project. The mobile application, the brochure, and the maintenance manual are discussed more in the Findings and Analysis Section. Each deliverable went through extensive revision with feedback from Fundación El Caño and third-party testers. The first deliverable is the mobile application. The mobile application costs one dollar in both the Apple and Android app stores. The main components in the mobile application include the following:

- 1) Language Settings
 - a) English
 - b) French
- 2) Interactive Map
 - a) Clickable Park Map with the list of stops
 - b) Clickable Museum map with the list of stops
- 3) Detailed Stop Information
 - a) 8 locations within the park map
 - b) 15 locations (displays and panels) within the museum
- 4) Sponsors
- 5) Donation link

The second deliverable is the tri-fold style brochure. The main components of the brochure include the following:

- 1) Main Logo, Android Application QR Code, and Park Contact Information
- 2) The Park Map
 - a) Details about each stop
- 3) The Museum
 - a) Brief overview
- 4) Sponsors Section

We designed the application to serve El Caño Archeological Park long after the end of the project. To help Fundación El Caño, we have written a maintenance manual that describes how to update the app, download the software necessary to the application's maintenance, edit the application's contents, and manage the app store listing. The maintenance manual also provides written instructions on how to revert the native application to a Progressive Web Application in case the instructions to update the application become dated or if the foundation is unable to perform the updates.

We hope that these deliverables will increase archaeological interpretation in El Caño so that a broader range of people will enjoy and learn about the historical and cultural significance of this important archaeological site. English and French speaking visitors of all ages will be able to explore the wonders of the park for a small fee of one dollar. El Caño is a key symbol for Panama, and it is a site that should be shared with the world.

Authorship Page

Kayla Baez, Mary Kandaras, Matthew St. Louis, and Jessie White contributed to the creation of this report, including research, writing, and editing. The team worked together to write, structure, and edit the report. The breakdown for each contribution is as follows.

Kayla Baez was one of the primary authors for the Introduction and Background section, including the section on self-guided tours. Ms. Baez was also the primary author for the conclusion section of the methodology chapter, the executive summary, and a secondary author for the brochure and maintenance manual section in Findings and Analysis. Ms. Baez was the creator of the park map and contributed as an editor on the paper as a whole.

Mary Kandaras was one of the primary authors for the Introduction and Background, and section on the archaeological interpretation in El Caño. Ms. Kandaras also wrote the literature review for mobile application and how we applied our findings to our methodology section. Mary Kandaras was the primary creator of the Brochure and all of the sections in the paper relating to the development of the brochure. Ms. Kandaras was also the primary writer of Acknowledgements and Abstract, and the creator of the Museum Map. Ms. Kandaras also contributed as an editor on the paper.

Matthew St. Louis was the primary author for the more technical subsections on the types of application and application design paths. He was likewise the primary author of the maintenance manual. He also conducted most of the research on converting a web application to a progressive web application and on converting a progressive web application to a native application. Mr. St. Louis also contributed as an editor on the paper.

Jessie White was the primary writer of the first 3 sections of the methodology: Gather Information and Informal Interviews, Application Design and Development and Application

Refinement. Ms. White was also the main contributor of the Deliverable 1 section within Finding and Analysis. Ms. White also contributed to parts of the background including the brochure literature review. Ms. White was responsible for editing the HTML files and coding all CSS files which style the application. Ms. White also contributed as an editor on the paper as a whole.

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Chapter 1: Introduction

One of the primary goals of archaeology is to understand how and why human behavior has evolved over time. Archaeologists can explore patterns in significant cultural events, such as the development of new cities, new farming methods, and the rise and collapse of major civilizations for clues as to the processes by which these events occurred. With such findings, archaeologists can better predict a culture's ability to change and adapt to new challenges. Archaeology is also extremely valuable because it provides a more objective account of our past than the historical record alone (Pennsylvania Historical & Museum Commission, 2015). The process of analyzing archaeological findings to explain their significance in history is called archaeological interpretation. The inclusion of archaeological interpretation for visitors at an archaeological site is essential to the overall experience. It requires knowledge of the information presented at the site, the targeted audience, and the best forms of media that can be employed to reach that audience (Grimwade & Carter, 2010).

It is essential to preserve archaeological sites and to disseminate the information they contain. The archaeological site of El Caño is of great importance to understanding the history of Panamá and the ancient societies in the area. Artifacts and burial tombs found here date back to the Pre-Columbian period, between AD 680 – 1020. Currently, information pertaining to the site is only accessible to Spanish speakers (Fundación El Caño, 2017). During operating hours, visitors to El Caño have the ability to take a tour led by a Spanish-speaking guide or to wander the park at their leisure. Patrons can also visit the El Caño museum, where they will find signage in Spanish describing the ruins and artifacts at El Caño, along with a vast historical and cultural background of the archaeological site. Presently, there are no guides or other means to communicate all this information in English or French, presenting a barrier to the park's English-

speaking and French-speaking guests (Fundación El Caño, 2017). The park has natural trails that connect different locations within the park, but no clear route is communicated. (Fundación El Caño, 2017). Limited accessibility to information in the park prevents tourists from fully appreciating El Caño Park and the history presented there.

The problem of accessibility is common in the world of archaeology and has been addressed in sites around the world. Solutions often include the implementation of a self-guided tour, along with various alternative methods. A self-guided tour is an excellent way to immerse visitors in an authentic experience in an archaeological site. Independent-minded tourists can explore at their own leisure, although, it is vital that they are given the means to learn, view, and appreciate the site they are visiting. The tour should be no less informative than a guided tour, for all information displayed in a self-guided tour should ideally mimic the learning experience and ease of navigation demonstrated in a guided tour. There are several different types of self-guided tours, including distributable materials and more technological approaches. Other archaeological parks around the world have adopted these methods which have proven to be successful.

The best solution for any park depends heavily on its individual needs. Unfortunately, formal published studies about accessibility to information in El Caño and other Panamanian archaeological parks are limited. Creating a working solution to El Caño's accessibility problem required examining El Caño's specific needs and designing a method to fit. Any solution must consider El Caño's specific goals, limitations from financial resources, climate conditions, and the target audience to be reached.

The goal of this project is to design a framework that will make archaeological interpretation in El Caño Archaeological Park more accessible to all guests, but more

specifically, to English-speaking and French-speaking guests. We explored and evaluated two different methods: including a technological approach; and distributable materials. We delivered our products in an editable format so that El Caño's staff can update or modify the information as they see fit. We found the most successful designs to implement in the park that meet Fundación El Caño's goals.

Chapter 2: Background and Literature Review



Figure 2: Part of El Caño Archaeological Park

In this chapter, we will introduce El Caño Archaeological Park and its specific needs for accessible archaeological interpretation. We will provide background on El Caño Archaeological Park, as well as the context for the project at hand. We will introduce both sponsors, Fundación El Caño and Footprint Possibilities Inc, along with their current work in Panamá. We will also discuss the background of our two proposed methods of creating a self-guided tour: a mobile application and a brochure. We will conclude by defining the criteria for this project's success.

2.1 El Caño Archaeological Park

The village of El Caño contains one of Panamá's most important archaeological sites. This site has been extremely important for archaeologists in the last century, as they have discovered several pre-Columbian burial sites that are believed to date between A.D. 680 to 1020. The first finding in this archaeological site was in 1926, and the first discovered artifacts of ceramics and sculptures made their way to the Smithsonian for preservation and display. However, a vast majority of ruins remain at the site available for view by locals and tourists

today (Fundación El Caño, 2017). The site was rediscovered in 1973 with the help of Panamanian archaeologist Dr. Reina Torres de Arauz and the site was transformed into an archaeological park in 1979. Upon further excavation of the park, the site was determined to be a cemetery housing large ancient tombs. (Fundación El Caño, 2017). One of the tombs can be seen in Figure 3 below.



Figure 3: El Caño Mound 3 Tombs

These burial sites have become very important to the scientific community as they have helped researchers gain a better understanding of the dynamic system of the hierarchical chiefdom-based societies created by the people who lived in this region of Central America before contact with Europeans. The tombs sit on approximately twenty acres of land and they hold the remnants of the great Coclé society. To this day, excavation at the site has proven to be of immense value to Panamanian culture and history. These discoveries have been instrumental in advancing knowledge of Pre-Columbian society in the region and for informing and educating both the

Panamanian public and foreign visitors. (Williams & Coventry, 2017). See Figure 4 below for the excavation currently in progress at the park.



Figure 4: El Caño Current Excavation Site

Currently, El Caño Archaeological Park and its website are only tailored toward Spanish speakers. During operating hours, the park has Spanish-speaking tour guides on hand, who will accompany visitors through a tour of the park, engaging them with the history of different landmarks. This tour is often unavailable to non-Spanish speakers since there are very limited means to communicate such information in English or French (Fundación El Caño, 2017). Visitors are also able to wander the park at their own leisure, although the language barrier and lack of information provided often discourage tourists who cannot speak Spanish from visiting El Caño. The park has also recently reopened their museum to tourists. Here, an abundance of information can be found about El Caño's vast historical and cultural background. The museum targets only Spanish speakers. (Fundación El Caño, 2017). This lack of support and resources for

the English and French visitors has resulted in the missed opportunities among one of El Caño's main visitor demographic. Therefore, access to this archaeological interpretation is essential to the overall experience of the park.

2.2 Footprint Possibilities, Fundación El Caño, and Project Goals

The major stakeholders in this project are Footprint Possibilities Inc, Fundación El Caño, and Worcester Polytechnic Institute, their logos can be seen below in Figure 5. Footprint Possibilities is the facilitator for this project between Worcester Polytechnic Institute and Fundación El Caño. Each of these organizations has a very specific and important role in the project.



Figure 5: Logos of Fundación El Cano and Footprint Possibilities Inc.

Footprint Possibilities is based in Panamá to help serve as a mediator between US-based student organizations and the needs of local Panamanian communities. With an emphasis on self-sustaining projects, Footprint Possibilities works on events that engage the community with the environment, cultures, health, and education. In essence, its mission is to find and support local community centers and meeting centers with technical support, funding, and coordination for infrastructure improvement in order to enhance general health and provide sustainable platforms

for increased educational and cultural opportunities (Footprint Possibilities, 2018). Footprint will support Fundación El Caño as they work to develop and enhance outreach to visitors of the park.

Fundación El Caño works to fund conservation and research of Panamá's archaeological heritage. There are five major programs on which Fundación El Caño focuses to benefit the park: investigation, conservation, education, community, and diffusion. Archaeological investigation of newly discovered findings is an important aspect of the work done by the Fundación El Caño, as well as the conservation and preservation of recovered artifacts. Visiting scholars and students are welcome at the site, as scientific collaboration and education are valued as well. Additionally, the Fundación El Caño works to inform the community of El Caño about the value of the park and how it can benefit them. Lastly, they aim to educate the public on the investigations and activities to encourage the Panamanian citizens to recognize the importance of their cultural heritage (Fundación El Caño, 2017).

This project with Worcester Polytechnic Institute and Footprint Possibilities will emphasize each of the five programs: self-sustaining projects, environment, culture, health, and education, that Fundación El Caño works to improve upon. Specifically, the programs involving public outreach will be major components of the project, as the project aims to increase the demographics of the target community.

El Caño Archaeological Park has already developed programs for outreach and community involvement. The park currently strives to disseminate information about its archaeological findings to the Panamanian public, and it invites student archaeologists to learn more about the site and to practice their craft (Fundación El Caño, 2017). Local schools also require that the students visit El Caño at least once to learn more about Panamanian history and

culture. These programs only target the Spanish-speaking community, but they are a significant foundation for sharing the information that has been extracted from the site to all visitors.

2.3 Self-Guided Tour Overview

All tourists should have access to the information of the park, whether it be from the park employees or from a self-guided tour. When creating a self-guided tour, it is important to create an adventurous experience that is rewarding for the tourist. A self-guided tour allows visitors the flexibility to customize and optimize their experience. For the creation of a self-guided tour in El Caño Archaeological Park, a variety of site detail and historical information will need attention. The two methods we will be using to present information at the site are the mobile application, and a brochure. Both of these methods will ensure a successful self-guided tour for any visitors or tourists.

2.4 Creating a Solution to Accessibility Issues: Technological Approach

Many archaeological parks have used technology to increase accessibility to archaeological interpretation, specifically through the use of mobile applications. Applications are becoming the dominant form of digital interaction. A mobile application carries a multitude of benefits, including the fact that it can reinforce an organization's brand, enhance visibility, and increase accessibility. The average time spent per day on mobile devices has increased 575% in three years and 80% of the time spent on mobile devices is spent using applications (Patel, 2017). Creating an application for El Caño Archaeological Park cannot only better display the information the park has to share, but can also attract visitors. We will examine mobile applications that have been created in other natural sites around the world.

The interactive application for Yellowstone National Park is a prime example of a fully-functioning application with a variety of features to enhance a visitor's trip through the park. One of the main features is an interactive map which allows users to see their location; find nearby points of interest; investigate the status of roads, campgrounds, lodges, and service locations within the park. In addition, there is a “favorite” section, in which users can plan their visit in advance and research places, topics, tours, and events that interest them. The application will even notify users when they are near to a saved location. There is also a calendar and alert system through which users can access up-to-date information from the National Park Service about what is happening in Yellowstone, including ranger programs and road construction. The application is free for all, and because cellular service within the park is extremely limited, it can be downloaded beforehand without compromising content (National Park Service, 2019).

The San Antonio Missions National Historical Park is a part of a UNESCO World Heritage Site. (National Park Service, 2019). Along with interactive tours, maps, and signage this site was particularly interesting to research by reason of their self-guided audio tour. Visitors have the option of experiencing a self-guided audio tour through the San Antonio Missions Website or simply by calling or texting a number. Due to the fact that there is limited Wi-Fi in the area, it may be difficult for some visitors to access the audio tour through the park's website. Visitors can follow the map to the series of designated checkpoints. At each checkpoint, there is an audio tour sticker which contains a URL that leads directly to the audio message of the checkpoint. In addition, the audio tour sticker has a number in which a visitor may text to receive a full transcript of the audio or may call to receive the audio message (National Parks Service, 2019).

The Grand Canyon National Park also has an interesting application. This park offers a GPS-guided audio tour of Grand Canyon National Park. When the user is approaching the landmark from any direction, the application uses GPS location to share fascinating stories about the magnificent scenery visitors see as it rolls by outside the car window. The audio tour describes the canyon's geology, wildlife, human history, and much more. This application is also well organized with a multitude of tabs containing the rich history of the park and its evolution over time. In addition, there is also a section on the sponsor of the park and the key figures in the development of this historical site (Rider, 2019).

All of the examples examined above are relevant to the creation of our mobile application. We modeled certain features in the application for El Caño after elements in each example. The Yellowstone and San Antonio Missions applications function without network connectivity and they both include interactive maps. In addition, the Grand Canyon tour has a multitude of other features including a sponsors and key figures section that could be incorporated into El Caño's application as well. Overall, analyzing these completed applications helped us to develop a successful solution in El Caño.

2.5 Types of Mobile Applications

There are three distinct types of mobile applications that were considered for El Caño's application: a web application, a native application, and a progressive web application. The relevant differences among them include their internet-independent functionality, cross-platform compatibility, ease of update, and cost. We will discuss the types of applications in this section and the positive and negative features associated with each.

2.5.1 Web Applications

Web applications run in a browser-based environment, so their functionality is dependent on internet connection (Google Developers, 2019). Web applications have incredibly strong cross-platform compatibility. They can run in a web browser on almost any smartphone, laptop, desktop, or tablet. One drawback to web applications is that their interface may be slightly confusing. The interface is usually confined to the browser in which they run, and that interface usually includes a bar at the top of the screen for searching and a bar at the bottom of the screen for navigation (Invisia, 2019).

Maintaining web applications can range from trivial to very complicated. The difficulty associated with maintaining or modifying depends largely on whether they were coded from scratch or made through an intermediate software. Creating web applications from scratch usually requires at least three programming languages: HTML, CSS, and some variant of JavaScript. Additional languages may be necessary, depending on the application's expected functionality. Creating web applications with an intermediate software can take little-to-no coding, with some intermediate software that even offer drag-and-drop tools for buttons and text. Editing a web application would take roughly the same amount of technical knowledge as creating it. However, web applications would likely only need to be updated to add features or to change their content (Invisia, 2019; Google Developers, 2019).

The monetary cost of maintaining a web application comes from the method used to create it. A web application coded from scratch only requires fees for the domain name and hosting. Basic domain name and hosting services cost about five dollars a month. A web application created through an intermediate software would incur the cost of using that

intermediate software. This cost is usually significantly more expensive than the domain name and hosting services (Low, 2019; Invisia, 2019).

The web application has some strong attributes that are conducive to El Caño's current needs. They are not expensive for the non-profit to produce and maintain, and the web languages are easy to learn. However, the park's lack of Wi-Fi cannot support the web application.

2.5.2 Native Application

Native applications are created specifically for smartphones, tablets, or other devices. Users must download native applications through a store specific to their device. Because native applications are downloaded at purchase, they can run largely independent of internet connection (Invisia, 2019).

Cross-platform support is one of the native applications' greatest weaknesses. Native apps run almost entirely on the operating system of the device where they are installed. Because of this, native applications must be written in a different programming language for each operating system they expect to run on. This means that for every target platform, the developer must essentially create a separate application (Invisia, 2019). There exists some intermediate software that could potentially create a native application in one language and convert it into different languages for multiple mobile operating systems. These could potentially make cross-platform support more viable (Google Developers, 2019).

The fragmentation of platforms makes maintaining a native application difficult. Since each platform-specific version of the application has its own source code, each must be updated individually when the developer wants to change the application. These updates can be especially cumbersome when a smartphone updates the operating system itself, as the corresponding version of the application might have to change the syntax or format of its source

code. Developing the application through an intermediate software rather than coding from scratch may help automate rewriting code, but each platform's version of the application would still need to be updated individually. These updates would then need to be sent to each platform's respective store (Invisia, 2019).

Deploying a native application usually requires a license for each store on which it will be hosted. A developer's license for the Android app store is a one-time \$25 purchase (Developer.android.com, 2019). A developer's license for the Apple app store is an annual \$99 fee (Developer.apple.com, 2019). Any intermediate software used to improve cross-platform compatibility will add to the developer's costs.

While native applications require a larger investment for licensing, they can also be monetized. The ability to monetize the application would help the foundation fund the costs associated with developing the native application. The native application is usable offline which is a necessity at El Caño as there is limited internet connection, which is only available at the park's museum. While the native application has weak cross-platform support, visitors to El Caño would be most familiar with downloading and operating a native application.

2.5.3 Progressive Web Application

Progressive web applications are a powerful combination of native apps and web applications. Progressive web applications are at their core a website, but their appearance and functionality can resemble a native application. Unlike a web application, progressive web applications can be downloaded for offline use. This allows progressive web applications to store a reasonable, but finite, amount of data independent of internet connection (Google Developers, 2019).

Similar to a web application, progressive web applications run in a web browser-based environment. This lets them run on almost any smartphone, laptop, desktop, or tablet using the same source code, giving them strong cross-platform compatibility (Google Developers, 2019).

Maintaining a progressive web application is similar to maintaining a web application. The difficulty of maintenance depends on whether the application was coded from scratch or assembled with an intermediate software. Coding from scratch requires the same languages as web applications (HTML, CSS, and some version of JavaScript). Intermediate software is likely to use drag-and-drop interfaces rather than code (Aboulhosn, 2019; Google Developers, 2019).

Similar to maintaining a web application, the monetary cost of maintaining a progressive web application comes from the method of its creation. A progressive web application coded from scratch only requires fees for the domain name and hosting (a rough minimum of five dollars a month). A progressive web application created through an intermediate software would incur the cost of using that intermediate software. This cost is usually significantly more expensive than the domain name and hosting services (Aboulhosn, 2019; Google Developers, 2019).

Progressive web applications are only getting more powerful as their popularity grows. Certain software can produce native application code from a progressive web application, allowing them to be hosted on smartphone application stores (Google Developers, 2019). This would entail the associated fees of developers' licenses.

Progressive web applications have many ideal characteristics for El Caño. They can be used offline and are inexpensive to develop and maintain. However, the progressive web application can be slightly confusing to visitors in El Caño and cannot be monetized.

2.6 Mobile Application Design Paths

The end goal for the application is to create a native application because it is most familiar to users and can be monetized. There are a few development paths that can be used to get roughly the same end product. The relevant differences between these paths are how easy it is for a beginner to learn the path, how flexible the path is (what types of application the path can produce), and how simple the path makes the application's maintenance.

2.6.1 Native Application from Native Languages

One way to build a native application is in the native language directly. A native language is the programming language that a mobile operating system uses to run applications on the phone. Each mobile operating system (e.g. iOS for Apple, Android for Google, Samsung, and LG) has its own unique native language (Android Developer, n.d.; Apple Developer, n.d.).

A single native language has a relatively steep learning curve: A new developer needs to learn how to use an Integrated Development Environment program specific to the native language on top of the native language itself before they can see any of their progress. Additionally, the developer would need a relatively large vocabulary of code snippets and file structures that essentially amount to incantations to get anything to run (Android Developer, n.d.; Apple Developer, n.d.).

Because each mobile operating system has its own unique native language, this development path is inflexible. To update the app, a developer would need to make changes to each language's source code independently. Additionally, the native code cannot be used to write a progressive web application or a web application. When Apple or Google released their annual major operating system updates, each language's source code would need to be updated to fit the

new standards, making this development path very hard to maintain (Android Developer, n.d.; Apple Developer, n.d.).

This development path would require the personnel with no coding background to learn multiple complicated coding languages. The complexity of using native languages will be an obstacle for El Caño's staff to keep the application functioning after the completion of this project (Android Developer, n.d.; Apple Developer, n.d.).

2.6.2 Native Application from a Common Languages

One level of abstraction that developers can use to distance themselves from pure native code is to write an application through an intermediate software. One example of this is Unity. Unity is a video game engine, but it can be used for a series of text pages. Unity programs are written in the language C# (pronounced see-sharp). From this C# code, Unity writes a different native application for each supported language that the developer requests. Other intermediate software could provide a similar level of abstraction to Unity's (Unity, n.d.a; Unity, n.d.b).

The learning curve on an intermediate language is considerably less steep than that of native languages, but can still prove challenging for beginners. On top of the language itself, a developer would need to learn how to use the intermediate software to convert the intermediate language into native languages.

This path is slightly more flexible than using native languages. It allows one code base to produce applications for different mobile operating systems, but only native applications can be created.

The annual maintenance to catch up with mobile operating software updates, however, would be fairly minimal. Any competent intermediate software for writing native applications will release annual updates in tandem with mobile operating systems to remain relevant. A

developer would only need to wait for one of these updates, then recompile a new version of the native code, rather than rewriting the code in the intermediate language (Unity, n.d.a; Unity, n.d.b).

The common languages can be difficult to learn for the inexperienced El Caño staff. The common languages have cross-platform support but they lack the simplicity El Caño is looking for.

2.6.3 Native Application from Website Code

A third way to make a native application is to start from web languages. Like the common language approach, this development path only requires one code base for multiple versions of the native application. However, unlike the common language approach, the web language development path can start with a gentler learning curve. Web languages such as HTML and CSS are generally easier to learn than other intermediate languages, especially because of the abundance of free online tutorials and because of the ease of viewing progress in making web pages along the way.

There are a few options within the development path of using web languages. One option is to use low-level web languages (such as HTML and CSS), and the other is to use high-level web languages (such as Angular or React). High-level web languages provide an easier interface for using the constructs in low-level web languages, but they are generally harder to learn and harder to find where to learn than low-level web languages.

A web language development path would be by far the most flexible option. Software like Cordova can convert web language into native code, but web code can also be hosted as a web application or as a progressive web application (Cordova, n.d.).

The maintenance of a web language development path depends on where it ends. Maintaining a native application written from web code would require that the developer reuse intermediate software to recompile the web code into native code annually. If the web code were instead available as a web application or a progressive web application, no maintenance would be required, assuming domain name and hosting services are upkept.

The goal for El Caño's application is to find the least complicated development and maintenance path. The web languages are relatively easy to learn and allow for the foundation to create both a progressive web application and a native application. These languages are easy to work with and create the most flexibility for the foundation.

2.7 Creating a Solution to Accessibility Issues: Brochure

Distributable materials are not commonly used for archaeological parks, but they have been used in many other tourist attractions. Many self-guided tours include a map with descriptions of the points of interest within the site. We will refer to this as a brochure throughout this section.

The Freedom Trail in downtown Boston has a self-guided tour. The document contains a large map that labels each important stop along the trail. Each numbered site has a corresponding description on the following pages that explains the historical significance of each site. This document also explains the current relevance of each site to the city (Boston.com, n.d.).

Another example of a brochure used in the tourist site is Castillo de San Marcos located in St. Augustine, Florida. The first page displays a condensed map which shows the layout of the fortress that remains at this site. Many locations on the map are marked by symbols that correspond with the ledger on the right side; each symbol indicates a time period. The second page contains descriptions of the historical context and significance. Each description is labeled

with one or more symbols indicating the relevant time period. This brochure guides the visitors through the fortress and gives them a picture of the attraction through the timeline of its existence (National Park Service, 2018).

Both of these examples show the ease with which these brochures can be used. Guests can easily obtain brochures from the entrance to the site. These materials are straightforward and guests can use them at their convenience. Many complications can also arise when designing a brochure. For example, multi-paged documents can be difficult to transport throughout the park, there must be a good ratio between pictures and text, site descriptions must be easy to read, and the material must also be weather resistant. Analyzing these documents and taking into consideration these complications can help us develop a brochure that will be successful in El Caño.

2.8 Criteria for Success

Our solution to El Caño's accessibility issue includes a mobile application, a distributable brochure, and a maintenance manual. These materials convey all of the information that Fundación El Caño wanted to include. The maintenance manual also aims to educate the staff of El Caño Archeological Park on how to edit and update these materials as their needs change and as updates are needed. A successful project will be one that makes the most important aspects of the park accessible to English and French-speakers so that they can experience the enrichment that the park has to offer.

Chapter 3: Methodology

The goal of our project is to increase accessibility to archaeological interpretation through a self-guided tour with a mobile application and a distributable document, specifically for English and French speakers, in El Caño Archaeological Park so that all visitors can grasp the historical significance of the site. To accomplish this, we set out to achieve the following objectives:

1. Gather information on El Caño
2. Application Design and Application Development Process
3. Application Refinement
4. Brochure Development
5. Maintenance Manual

In this chapter, we will discuss the methods we developed in order to obtain these objectives, why the methods were effective, and why we chose them.

3.1 Gather Information and Informal Interviews

The first step in creating the deliverables was to collect information about El Caño. Fundación El Caño was instrumental in this process. A Dropbox was established to share information about the guided tours that are given for the park and the museum. All the information on each tour stop was provided in English, along with photographs. There are 8 stops total on the guided tour. One of these stops is the museum, which holds many artifacts and information panels explaining the theories behind the findings at the park. Each artifact is described in the Dropbox, and the English translation of each of the seven panels was included. Some pictures of the displays and panels were also in the Dropbox.

The Dropbox allowed us to review nearly everything the park has to offer, but there were still missing pieces. Another vital aspect of the data collection period was to visit the park and take the guided tour ourselves. Taking the tour helped solidify our understanding of the park and the cultural significance that the site has to Panamá. The last significant resource for gathering information was through an informal interview with our sponsor Alexa Hancock. We were able to ask her lingering questions about the park's history and staff, future plans for the foundation and the park itself, and some miscellaneous questions that were essential to the development of products. The informal interview questions are included in Appendix A.

The mobile application was developed in both English and French and was originally translated from Spanish. Our sponsor from Fundación El Caño, Alexa Hancock, provided the entire English translation of the application. The French translation was provided by François Poilly, who is a friend of our sponsor Rick Montanari from Footprint Possibilities. An excerpt of the translation from English to French is shown in Appendix D.

3.2 Application Design and Development

The design and development of the mobile application involved three steps and resources. First, we analyzed the literature review to create the application's content. We then used a combination of wireframing software and web code to create initial designs to style the application. Once we had the designs, we transformed our web code into a progressive web application, and then a native application. Each of these steps will be discussed below.

3.2.1 Literature Review Resources

Each example from our literature review provided information that was essential in the creation of the application. Due to the fact that Wi-Fi and cellular coverage are extremely limited

in the El Caño region, the mobile application must function without internet connection, similar to the case of Yellowstone National Park. In order to use the application while in El Caño Archaeological Park, the application must be downloaded either before arriving at the park or in the museum, where Wi-Fi coverage is present but limited.

The main feature of the application is an interactive digital map of the park and museum. This map highlights the eight landmarks of the site numbered in the order of the guided tour. When a user clicks on a location, they are directed to a page containing information and a photo. This system is similar to interactive maps included in the Yellowstone National Park application and San Antonio Missions application (National Park Service, 2019). In addition, there is also a few secondary features including a section describing the sponsors of the project. This feature is replicated after Grand Canyon's system and features tab (Rider, 2019).

3.2.2 Designing the Mobile Application

After reviewing other applications in the literature review section, we began to design El Caño's own application. There were many aspects to take into consideration before the coding process began. These included colors, fonts, and overall layout of the pages, as well as the application's navigation. To begin the design process, we used Adobe XD. This program allowed us to holistically design each page and evaluate the aesthetic aspects of the application with ease. We were able to make changes using this simple software rather than exploring these changes with our code.

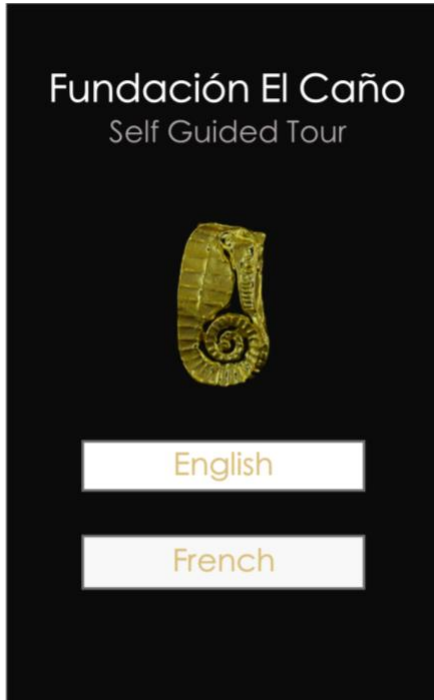


Figure 6: Adobe XD First Page Original Design



Figure 7: Adobe XD Second Page Original Design

After our first designs were complete, we chose the design we liked best, as displayed in the figures above, and began the coding process. The two languages we used were HTML and CSS. These coding languages serve two different functions. The text and images that are displayed within the mobile application are coded into the HTML files. The HTML files were also used to link different pages together. The CSS code is what styles the words, images, and links that are in the HTML files with different fonts, colors, borders, backgrounds, and locations on the page. The final designs are coded in these pages before moving on to the next steps.

3.2.3 Web Application to PWA to Native Application

After the basic HTML and CSS files were created, it is essential that these files are accompanied by other files and supplemented by other programs and software in order to produce each step in the process. These steps are the Web Application, the Progressive Web Application, and finally the Native Application.

The first step was the Web Application. The HTML and CSS files were first hosted on GitHub Pages with the URL “<https://fundacionelcano.github.io/tour/>”. This website can be added to the home screen of any phone and viewed like an application when the pages are hosted. The pages were taken down at the conclusion of this project for monetizing purposes. In order to use this application, the user must have an internet connection.

The next step was the Progressive Web Application. A service worker file was created in JavaScript to accompany the HTML and CSS files. The purpose of the service worker file is to create the browser cache that allows all the files to be downloaded into the local storage of a browser. The service worker source file is also hosted on GitHub Pages alongside our HTML and CSS files, and it installs itself in the browser as a service worker. When the pages are hosted, users can access the progressive web application with the QR code, which opens the application in the browser. The progressive web application’s final size was about eleven megabytes, and users must wait for all components to download before it is usable. On El Caño’s museum’s Wi-Fi, which has an average download speed of about a quarter megabyte a second, this would take about a minute. From there, the application can be used without internet connection. The ability to download the files into local storage is essential because the internet connection is poor throughout the park.

The final step was the Native Application. In order to produce a native application, we used Cordova. Cordova is a free, open-source software that allows cross-platform development of applications from standard web languages. The software writes native code shells around the HTML and CSS files to make a native application that can run on native operating systems. Ultimately, this software allows the user to avoid coding in the native language of each mobile platform. We used Cordova in order to develop the native application for both Apple and

Android. After creating the native application, it was imperative to obtain the developer’s licenses for both platforms. These licenses allowed the application to be hosted in the app stores and downloaded by the general public with a simple search. The application is monetized in both app stores for one dollar and can be downloaded in the United States, Canada, or Panamá.

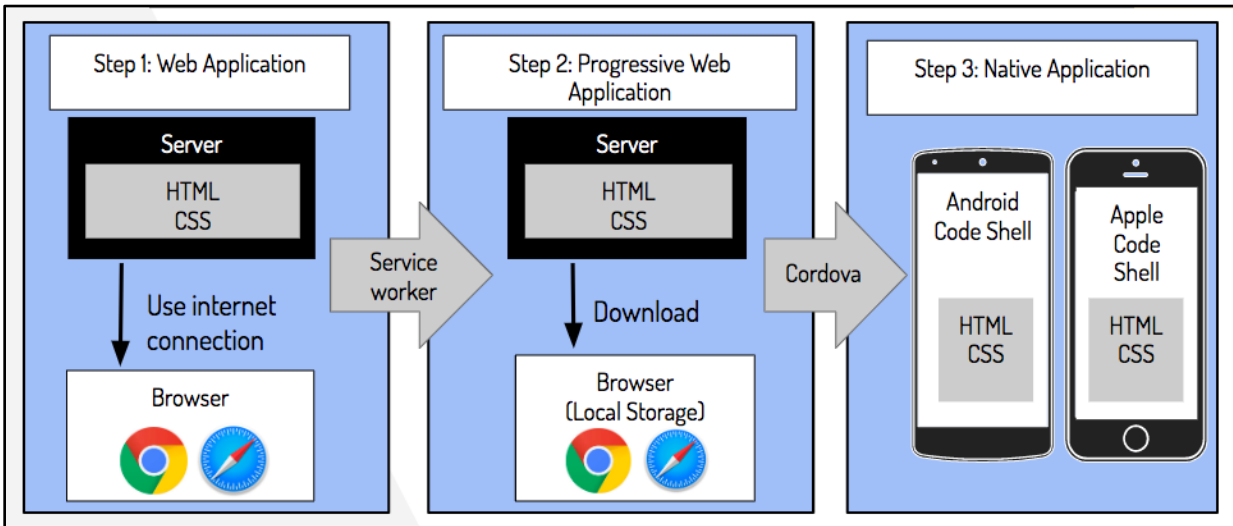


Figure 8: Application Progression Flow Chart

We chose to complete this progression from web application to progressive web application to native application for several reasons. First, the languages used to code the original files are relatively simple to learn and manipulate. However, we needed a solution to El Caño’s poor internet connection and cell service. The progressive web application allowed the application to be used independent of a Wi-Fi connection and it can be used on any mobile platform. Finally, we created the native application because searching and downloading the application from an app store is more familiar and intuitive for most tourists and the native application can be monetized. The native application requires updates about once a year as software updates become available under each platform. If necessary, the foundation has the ability to revert back to the progressive web application if there are complications with the native

application updates. This progression from web application to progressive web application to native application provides the most reliable solution to El Caño.

3.3 Application Refinement

In the development process, there were several aspects that needed testing. The download speed is an essential aspect of the progressive web application. The application must completely download on the landing page before navigating through the app. The poor connectivity at El Caño had to be accounted for in the process of downloading the content, and testing the speed at which the application downloaded at the park was imperative. We tested the downloading speed with several different phones connected to the Wi-Fi at the museum. Multiple versions of the application were used in this testing process.

The native application is hosted in the Android and Apple app store, and users do not need to wait on the landing page for the application to download. Users can see the progression of the download and will only be able to access the application once the download has completely finished. While testing the native application at El Caño and after reducing the file size greatly, we determined it to take about 40 seconds to download completely.

Testing the functionality of the application within the park ourselves was also an important step in application refinement. Acting as tourists, we downloaded the application in the museum where Wi-Fi was accessible. Then, we disconnected cellular data and Wi-Fi connection and used the application to tour the park's sites. This testing process helped to ensure the application worked properly, and it helped us identify any aspects of the application that needed improvements.

Using third-party testers was essential during the refinement process. Five IQP students and two English-speaking guests downloaded the application onto their phones, then

disconnected from cellular data and Wi-Fi. We asked them to take the tour without any assistance. Afterward, we held an informal interview with the testers and asked for feedback and recommendations. These informal interview questions are listed in Appendix B.

3.4 Brochure Development

After application refinement, we started to distill the information from the tour into the brochure. This brochure contains a condensed and yet informative account of the information from the self-guided tour. Each example from our literature review provided the background information required to design the brochure. The main aspects of our design were modeled after the Freedom Trail Walking Tour brochure. In the Freedom Trail tour the first page displays a map of the area in which all points of interest were labeled with a number. Included in the remaining pages are the descriptions and historical significance of each specific site. The document has a simple background and is legible (O'Rourke, Ewell, & Ballard Historical Society, 2015; Boston.com, n.d.). Keeping fonts, backgrounds, and colors simple in order to ensure the legibility of our document was vital in our design.

The brochure designs were originally created using Adobe XD. This software allowed our team to brainstorm various designs before creating the final product. These designs were presented to Fundación El Caño. The final design, with all text, images and logos, was created on Microsoft Word. The brochure is a tri-fold with information on both the park and museum. The designs parallel the application in fonts, colors, and images. The final product was printed and laminated to ensure its durability in Panamá's volatile weather conditions and will be stored in the park for visitor use.

3.5 Maintenance Manual Development

The creation of the maintenance manual was the last step in our methods. In order for the application to continue to help tourists learn about El Caño Archaeological Park, the staff of El Caño need to understand the application's inner workings to update and maintain it. The maintenance manual was written in Google Docs. It is comprised of ten sections that include detailed descriptions and screenshots that walk the reader through different functions. These include downloading software, updating the native application, editing the application, reverting back to the progressive web application, and managing the app store listing. In addition, the manual provides numerous external links for more information on almost every topic it covers. These links include websites like W3Schools, which has an immense amount of information about how to code in HTML and CSS. We also included various tutorials on how to use the command line which is necessary for updating the android app. Another notable set of resources linked are a variety of links to the documentation of the various software we used, including Cordova, Android Studio (Android's application writer), and XCode (Apple's application writer). This maintenance manual is an engaging document that helps the reader learn about how to maintain our application.

3.6 Conclusion

We created an application, which displays information found all throughout the park, allowing visitors to tour at their own leisure. Alongside this application, we also created a brochure, for those without smartphones. This brochure is a byproduct of the application created and is available in print for visitors to carry during their self-guided tour. The staff will also have access to an O&M Manual so that they have the technical capability to modify the mobile application and the brochure as they see fit. Each step of this process was necessary in the

creation of these three deliverables. The five steps of our methods allowed us to create the most suitable and sustainable products for El Caño's specific needs.

Chapter 4: Findings and Analysis

There are three deliverables that Fundación El Caño received at the conclusion of this project. The mobile application, the brochure, and the maintenance manual, all of which are discussed in this section. Each deliverable went through extensive revision with feedback from Fundación El Caño and third-party testers.

4.1 Deliverable 1: Mobile Application

The first deliverable is the mobile application. The main components in the mobile application include the following:

- 1) Language Settings
 - a) English
 - b) French
- 2) Interactive Map
 - a) Clickable Park Map with the list of stops
 - b) Clickable Museum map with the list of stops
- 3) Detailed Stop Information
 - a) 8 locations within the park map
 - b) 15 locations (displays and panels) within the museum
- 4) Sponsors
- 5) Donation link

One of the most important features of the application is the language settings. A large number of El Caño's foreign visitors speak either English or French, therefore it is important to build an application suitable for their needs. The application is offered in two primary languages,

English and French, as seen in Figure 9 below. The landing page of the application allows the user to pick their preferred language before navigating through the rest of the application.



Figure 9: Language Settings Page; Language Landing Page in French and English

The main component of this application is the two interactive digital maps of the park and museum. The park map features eight locations that are focal points of the guided tour, as seen in Figure 10. When a user arrives at the location they can tap on the numbered landmark or tap on the landmarks name in the list of pages underneath the map. The application directs the user to a page that contains a photo of the site and information pertaining to that sites background and purpose. These pages aim to explain what is available to the tourists in the park and the significance behind each site. Similarly, when a user is touring the museum, they can tap on the numbered landmark that correlates with a display case or wall panel, or they may tap on the landmarks name in the list of pages underneath the map, as seen below in Figure 10. The application directs the user to a page that contains the translated content that is displayed in the museum, as well as any additional information that is typically given through a tour guide.



Figure 10: Interactive Maps

There are secondary features included in the application as well, and can be seen below in Figure 11. Found within the language dependent landing page, the “Sponsors” page provides information about each of the three key contributors to the creation of the application. The sponsors, Worcester Polytechnic Institute, Footprint Possibilities, and Fundación El Caño, are described on this page of the application. The logos of other associated organizations are also included. Another feature also found within the home page, is the donations link. This button directs the user out of the application, and to the Global Giving webpage run by Fundación El Caño. This gives users the opportunity to donate to the organization so that the efforts in exploring, excavating, and running the park can continue. The user must have an internet connection to access the global giving website. Preferably users will complete the self-guided tour of the park, then either make their way to the museum for Wi-Fi or return to the application when a connection is established to donate to a worthy cause.

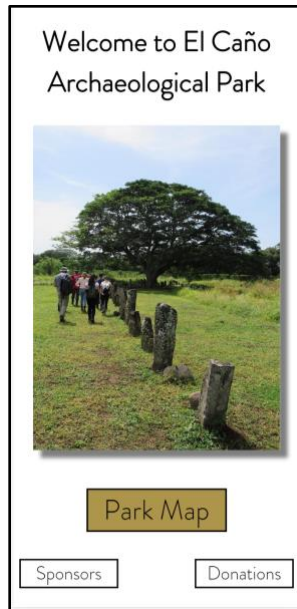


Figure 11: Secondary Features

The process of revising and editing the application can be seen through the three stable versions of the progressive web application that were created throughout the project. A stable version refers to a fully progressive version that was hosted on GitHub Pages and readily available to download. Each version was sent to Fundación El Caño for feedback and each version was tested by either our team or third-party testers. Major changes in both aesthetic features and content were made between each stable version.

The first stable version was an elementary adaptation of all the information that was gathered. It had pictures and simple text with different color schemes. The maps were not yet created in this version and therefore were not included. The designs from Adobe XD with black background and white buttons were recreated for the language settings page and the language specific landing page in the first stable version. Edits to this version created the more polished second stable version. In this version the black background and white text was uniform throughout the application, the newly created maps were inserted, and additional pictures were

added. The final stable version looks very different from the first two. The color scheme was changed to a white background with black text. The font type was changed, the photos and content were finalized, and the maps became interactive in this version. The progression of the application design can be seen in Figures 12 and 13 below.



Figure 12: Stable Version Progression Language Dependent Landing Page

Park Map

List of Pages

- [Home](#)
- [Background](#)
- [Introduction](#)
- [Area 1 Excavation](#)
- [Information Panels](#)
- [Mound 3](#)
- [River Rock Causeway](#)
- [Row of Monoliths](#)
- [Museum Antesala Wall](#)
- [Museum Panels](#)
- [Museum Principle Room](#)

Stable 1

Park Map

Park Pages

1. Ticket Booth
2. Museum
3. Mound 3
4. Row of Monoliths
5. River Rock Causeway
6. Sacrificial Area
7. Area 1 Excavation
8. Information Panels

Stable 2

Park Map

Park Pages

1. Ticketbooth	5. River Rock Causeway
2. Museum	6. Sacrificial Area
3. Mound 3	7. Area 1 Excavation
4. Row of Monoliths	8. Information Panels

Stable 3

Figure 13: Stable Version Progression Park Map Page

4.2 Deliverable 2: Brochure

The second deliverable is a tri-fold style brochure. This brochure is available in both English and French. The main components of the brochure include the following:

- 1) Main Logo, QR Code, and Park Contact Information
- 2) The Park Map
 - a) Details about each stop
- 3) The Museum
 - a) Brief overview
- 4) Sponsors Section

The first page contains the park name as well as the park logo, contact information, and a QR code that links to the location of the Android and Apple native applications in their respective app stores. Our main goal for putting the QR code on the brochure is to provide access to the full self-guided tour. The brochure is a condensed version of the tour built for those who do not have access to a smartphone. It is recommended that users download the self-guided tour application “El Caño Archaeological Park” for the full experience that the park has to offer. The front page can be seen below in Figure 14 and Figure 15.

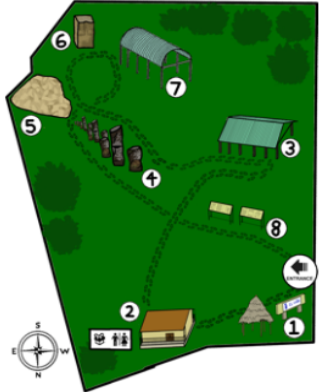


Figure 14: First Panel in English



Figure 15: First Panel in French

The three inside panels contain the park information. Similar to the app, the same park map is included. The corresponding number on the brochure will give the reader a short summary of that stop. These panels are shown below in Figure 16 and Figure 17.



1 Ticket Booth

- El Caño represents the culmination of a long process of economic, political, social, and religious development that spanned from 500-1000 A.D.
- Segregation of rich and poor tombs highlight great social inequalities within the El Caño society.
- Abandonment of the necropolis around 1000 A.D. suggests an exhausted political model and the beginning of a new period.

2 Museum

- The El Caño Museum contains the artifacts discovered in some of the tombs within the park.

3 Mound 3

- When Mound 3 was first excavated it was a small hill, similar to the one to the right of it
- Two different types of burials were found here

- Primary burials: person buried in extended or laid out position.
- Secondary burials: bones were gathered after decomposition and buried in bundles or urns.

The skeletons displayed demonstrate the different types of burials.

4 Row of Monoliths

The ceremonial area of the necropolis is composed of: Alignment of 67 columnar basalt formations, alignment of 14 similar columns, 26 stone figures, 2 alters, 2 basaltic columns with carved reliefs and 37 sculptures in tuff and basalt.

5 River Rock Causeway

- Cobblestone causeway that is believed to have connected to the Rio Grande River which is approximately 450 meters from the necropolis.
- Funeral parties arrived in the necropolis via the river and causeway.

6 Sacrificial Area

- It is believed this area was used to behead prisoners before they were buried with the chief.
- Other household members were honored to sacrifice themselves by drinking poison and be buried with their chief.

7 Area 1 Excavation

This area is only available for viewing when the archaeological team is working

- Dr. Julia Mayo and the El Caño Foundation team have been excavating the area since 2008 during the dry season of every year.
- 7 tombs dating to 680 A.D.- 1000 A.D. have been discovered here

8 Information Panels

- Contains background information about the park.
- Details and pictures of the first two tombs discovered in Area 1.

Figure 16: Brochure Three Inside Panels in English



1 Guichet de vente de billets

- El Caño représente l'aboutissement d'un long processus de développement économique, politique, social et religieux qui s'est déroulé entre 500 et 1000 ap.
- La ségrégation des tombeaux riches et pauvres met en évidence de grandes inégalités sociales au sein de la société El Caño.
- L'abandon de la nécropole vers l'an 1000 de notre ère suggère un modèle politique épuisé et le début d'une nouvelle période.

2 Musée

- Le musée El Caño contient les artefacts découverts dans certaines tombes du parc.

3 Monticule 3

- Lorsque le monticule 3 a été fouillé pour la première fois, il s'agissait d'une petite colline, semblable à celle située à sa droite.
- Deux types différents d'enterrements ont été trouvés ici

- Inhumation primaire; personne enterrée en position allongée ou allongée.
- Enterrements secondaires; les ossements ont été recueillis après décomposition et enfouis dans des bottes ou des urnes.

Les squelettes exposés montrent les différents types d'enterrements.

4 Ronde de Monolithes

La zone cérémoniale de la nécropole est composée de : Alignement de 67 formations basaltiques en colonnes, alignement de 14 colonnes similaires, 26 figures en pierre, 2 autels, 2 colonnes basaltiques avec reliefs sculptés et 37 sculptures en tuf et basalte.

5 River Rock Causeway

- Chaussée de galets qui aurait été reliée à la rivière Rio Grande qui se trouve à environ 450 mètres de la nécropole.
- Les funérailles sont arrivées dans la nécropole par la rivière et le pont-jetée.

6 Sacrificiel

- On pense que cette zone a été utilisée pour décapiter des prisonniers avant qu'ils ne soient enterrés avec le chef.
- D'autres membres de la famille ont été honorés de se sacrifier en buvant du poison et d'être enterrés avec leur chef.

7 Zone 1 Excavation

*Cette zone ne peut être visitée que lorsque l'équipe archéologique travaille.

- Julia Mayo et l'équipe de la Fondation El Caño creusent la zone depuis 2008 pendant la saison sèche de chaque année.
- 7 tombes datant de 680 à 1000 après J.C. ont été découvertes ici.

8 Panneaux d'information

- Contient des renseignements généraux sur le parc.
- Détails et photos des deux premières tombes découvertes dans la zone 1.

Figure 17: Brochure Three Inside Panels in French

The final two panels include a picture of the museum along with background information for both the park and the museum. This section also mentions the many different types of artifacts displayed at El Caño. In addition, logos of the five sponsors are included on these pages, including Fundación El Caño, Footprint Possibilities, Worcester Polytechnic Institute, SENACYT, Ciudad del Saber, and INAC. Featuring the main contributors to the park allows the foundation to show their gratitude, and remind park visitors the importance of donations for the upkeep and further exploration of El Caño Archaeological Park. The Museum panels and sponsor logos can be seen below in Figure 18 and Figure 19.

Museum (1)	Museum (2)
	<ul style="list-style-type: none"> • The society buried its dead with artifacts for the head, ears, nose, neck, chest, waist, arms and legs, and also with tools and weapons. They were not simple adornments, but elements that symbolically represented the person's identity and social role in life. • As seen in many artifacts, artists represented the people of Coclé with different zoomorphic or hybrid forms that metaphorically expressed their qualities. • The exhibition seeks to show the life and death of the Coclé, their social structure, and funerary customs. Many questions may arise. We encourage you to see it not as the final presentation of a research on El Caño but just the beginning of many others.
<ul style="list-style-type: none"> • The necropolis of El Caño is a complex composed of a cemetery and a ceremonial center. • The cemetery is organized in two sectors, one for the burial of low status persons and the other for high status persons. The tombs vary based on the different rituals conducted after death. • The El Caño Museum contains artifacts discovered in some tombs within the park. Artifacts include jewelry, masks, vessels, tools, bowls, belts, and pectorals made up of gold, ceramics, and emeralds. 	
	

Figure 18: Museum Panels and Sponsors in English

Musée (1)	Musée (2)
	<ul style="list-style-type: none"> • La société enterrait ses morts avec des artefacts pour la tête, les oreilles, le nez, le cou, la poitrine, la taille, les bras et les jambes, ainsi que des outils et des armes. Il ne s'agissait pas de simples ornements, mais d'éléments qui représentaient symboliquement l'identité de la personne et son rôle social dans la vie. • Comme on peut le voir dans de nombreux artefacts, les artistes ont représenté les habitants de Coclé sous différentes formes zoomorphes ou hybrides qui exprimaient métaphoriquement leurs qualités. • L'exposition cherche à montrer la vie et la mort des Coclé, leur structure sociale et leurs coutumes funéraires. De nombreuses questions peuvent se poser. Nous vous encourageons à ne pas y voir la présentation finale d'une recherche sur El Caño, mais seulement le début de beaucoup d'autres.
<ul style="list-style-type: none"> • La nécropole d'El Caño est un complexe composé d'un cimetière et d'un centre cérémoniel. • Le cimetière est organisé en deux secteurs, l'un pour l'inhumation des personnes de statut inférieur et l'autre pour les personnes de statut supérieur. Les tombes varient en fonction des différents rituels pratiqués après la mort. • Le musée El Caño contient des artefacts découverts dans certaines tombes du parc. Ces types d'artefacts comprennent des bijoux, des masques, des récipients, des outils, des bols, des ceintures et des pectoraux faits d'or, de céramique et d'émeraudes. 	

Figure 19: Museum Panels and Sponsors in French

The revision of the brochure took into account feedback from the sponsor only. Changes in content, pictures, logos and some design aspects were made during the developmental process. The condensed content required extensive revision in order to give the user the best experience with only a standard sheet of paper. Some content revisions sent by the sponsors are shown below in Figure 20.

Museum




- The necropolis of El Caño is a complex composed of a cemetery and a ceremonial center.
- The cemetery is organized in two sectors, one for the burial of low status persons and the other for high status persons. ~~The tombs are very different due to the differential treatment of received after death, therefore containing very different artifacts.~~
- Some magnificent funerals were organized in El Caño. When an important person of the society died, his relatives built for him a great tomb in the area of the necropolis reserved to the elite. His body was buried covered with riches and surrounded by companions of his household.

- The El Caño Museum contains artifacts discovered in the tombs within the park. These types of artifacts include jewelry, masks, vessels, tools, bowls, belts, and pectorals made up of gold, ceramics, and emeralds.
- The society buried its dead with artifacts for the head, ears, nose, neck, chest, waist, arms and legs, and also with tools and weapons. They were not simple adornments, but elements that symbolically represented the person's identity and social role in life.
- As seen in many artifacts, artists represented the people of Coclé with different zoomorphic or hybrid forms that expressed metaphorically their qualities.
- The exhibition seeks to show the life and death of the Coclé, their social structure, and funerary customs. Many questions may arise. We encourage you to see it not as the final presentation of a research on El Caño but just the beginning of many others.

El Caño Archaeological
Park Brochure




El Caño Coclé
info@fundacionelcano.org



Scan QR Code for Access to Self-Guided Tour!



5



6

1

Figure 20: Sponsor Brochure Revisions

4.3 Deliverable 3: Maintenance Manual

We want this application to serve El Caño Archeological Park long after the end of the project; to do this, we created a maintenance manual to guide Fundación El Caño through any problems or questions they may have regarding the application. The application's greatest obstacle was the major updates to mobile operating systems that are released annually by Apple and Android. All applications must update to conform to the new standard. We are confident that we chose a design path that would make this process as easy as possible, but the process of updating will still take some technical knowledge and a lot of specialized software. To help Fundación El Caño update the app, we have written a maintenance manual that describes how to update the application, download the software necessary to the application's maintenance, and edit the application's contents. We also wrote instructions on how to revert the native application

to a progressive web application in case the instructions to update the application become dated or if the foundation cannot update or maintain the application.

The main components of the maintenance manual include the following:

- 1) Introduction/ What the O&M manual talks about
- 2) Unzipping the Application Contents
- 3) Using the Command Line
- 4) Software Preparation
- 5) Before you Update
- 6) Updating the Native App
- 7) Modifying the App
- 8) Directing People to the App
- 9) Managing App Store Listing
- 10) Reverting to a Progressive Web App

To help the foundation through any questions they may have concerning the manual, we held a training workshop. In this workshop, we walked through the steps to update the application on a laptop with two members of the foundation. We used this workshop to push the application's final update to the app store within the project.

Along with the manual, we organized the files we used in the application's final version, including source code, the Cordova project, uncropped images, a transcript of the application's text for easy translation, and other various pieces, into a specific file system that we reference in the manual. We zipped the contents of the outermost folder to hand over to the foundation. In addition to the application contents, we included shell scripts to help automate some of the more

technical parts of the update process. A shell script is an executable program that enters commands into the command line. We have included an example shell script as Appendix C.

The intent of this maintenance manual is to simplify and explain the process of updating the application so that it can function for years to come. An essential part of this project was to ensure that our products were a sustainable solution for El Caño.

Chapter 5: Recommendations and Conclusions

5.1 Archaeological Interpretation

One of archaeology's most important qualities is that it provides historical information on past societies from which there are no written documents. Without archaeological interpretation and investigation, the history of past societies would be a mystery. Through archaeology, a nation's cultural and ethnic identity can be preserved and solidified. Archaeology also promotes tourism and provides people with feelings of pride and a sense of history and ancestry. El Caño Archaeological Park is vitally important as a symbol of cultural identity and pride for Panamá. Archaeology gives us a lens into the past so that we can learn from the mistakes of the societies before us. Archaeological interpretation can provide new insights on the past and can reshape our understanding of history to become more aware and involved citizens.

5.2 Application Development Process

The application development process involved three different types of mobile applications: web application, progressive web application, and native application. A web application is essentially a website; a progressive web application is a web application that can be downloaded into local storage on a mobile device; and a native application is an application written in native code unique to each mobile platform and can be downloaded from an app store. We chose to produce a native application because it works offline, it is most familiar to users, and can be monetized.

We considered three options for the native application: native languages, a common language, and website languages. When you build with native languages one must use a different programming language for every platform on which the application would run on (e.g. Apple,

Android). Another option was to build the application using a common language. This would mean using one language to code the application on all platforms. The last option was to build the application using website languages. Using just a few programming languages, a website can be built, which could then be converted into a progressive web application or a native application. We decided to use the third design path because it would give the foundation the option to revert back to the progressive web application if they cannot maintain a native app. The website languages are also the easiest to learn if the foundation decides to edit the application later.

We first coded our application in three web languages: HTML, CSS, and JavaScript. The web application requires a Wi-Fi connection, which is not accessible within the park beyond the museum. In order to accommodate the lack of Wi-Fi, we used HTML, CSS, and JavaScript files to create a progressive web application that would work offline within the park on any mobile platform. However, the downloading process can be confusing for users who are unfamiliar with progressive web apps: the user must wait an extended period of time for the application to fully download, and the application does not notify the user when it finishes, leaving the user to guess when the download is complete. The final step was to convert the progressive web application into the native application for both Apple and Android. The native applications can be found in the Apple and Android app stores respectively.

Over the span of the project, we made several designs for the app. When a version of the application was finalized, we hosted it on GitHub Pages as a progressive web application for our sponsors to download and test. They then provided us with feedback. We either incorporated these suggestions into the next draft or recommended against them with an explanation of how it

would hurt the functionality of the application. We iterated this process across three versions until our sponsors were completely satisfied with the design.

5.3 Brochure Development Process

The first step in developing a brochure was creating several designs on Adobe XD. Once a design was chosen amongst the team, the design was presented to El Caño for comments and approval. After the design was finalized, the team created a brochure using Microsoft Word. The brochure was presented in a tri-fold format, and contained the park map as well as condensed versions of information for each stop of the tour. In addition, park contact information, QR codes linking to the Apple and Android applications, and sponsors are mentioned in the brochure. The brochure design was edited and approved by El Caño, and the final product was printed and laminated. The brochure is available in both English and French.

5.4 Deliverables

There were three deliverables that Fundación El Caño received at the conclusion of this project. Each of these deliverables is explained in detail.

5.4.1 Mobile Application

Once the native application was placed in the app store, all of the files were handed over to the foundation. We organized a file system for the app, its HTML and CSS source code, raw images and assets, and other files necessary to the application's maintenance. We compressed the folder into a zip file, which we delivered to the foundation.

We also created a GitHub account for the foundation to host the progressive web application version if needed. This gives the foundation more flexibility in how they wish to deliver the content we created for tourists.

We gathered the links for the native application in the app store and for the progressive web application. We provided these links and their corresponding QR codes to the foundation to include on their website. This will allow the foundation to direct prospective visitors to the application.

5.4.2 Brochure

The availability of the brochure at El Caño is important for those who do not have a smartphone. With this brochure, visitors are able to take a brief version of the self-guided tour, and gain some knowledge and background about El Caño. We recommend that Fundación El Caño laminate the brochure and keep roughly 10-15 copies on hand at all times to ensure that there are enough for any large groups that may visit. The foundation may edit the brochure as they see fit.

5.4.3 Maintenance Manual

Native applications are not self-sustaining; they require maintenance every time a platform comes out with a new Operating System. This happens roughly once a year. To keep the application running after the end of the project, a manual was written for the staff of Fundación El Caño to explain how to update the app. The manual explains the background knowledge needed to accomplish this, such as how to use the command line with Bash and how to download the software necessary for updating the application. In addition, we included sections on how to manage payouts from the app store, how to modify the application's contents, and how to revert the native application back into a progressive web application. We believe it is crucial that El Caño be able to adapt the application to their changing needs, such as adding more information, languages, and being able to revert the native application back into a progressive

web application in the event that something goes wrong with updates or if the manual becomes dated.

In the manual, we also highlighted certain tasks we thought might be important. This includes demonetizing the application and changing the link for the donations page. We filled the manual with enough detail to teach someone with no coding experience to edit the application. We did not want members of the foundation to have to read through all of this detail before they could accomplish these relatively small tasks. These small, focused sections of the manual will help the foundation edit these specific aspects of the application.

5.5 Conclusion

El Caño has had an immense impact on Panamá's community, including nearby schools and local families. El Caño's archaeological findings have provided a deep tie to the cultural heritage of Panamá as well as a strong feeling of patriotism and pride for the Panamanian people. The deliverables created in this project, including a weatherproof brochure and mobile application, will allow El Caño to share this pride with a larger demographic of people. These deliverables will provide greater access to archaeological interpretation within the park for visitors, specifically English and French speakers. We hope that Fundación El Caño will be able to continue to expand their outreach and disseminate the historical and cultural significance to visitors interested in Panamá's heritage.

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Appendix A

Discussion Guidelines

In the initial stages of our project, we used informal interviews with Alexa Hancock (with her consent) to collect vital information about El Caño. Some sample questions that might be asked during these conversations are listed below.

Q1 What aspects of El Caño do you think are most vital to communicate to visitors?

Q2 What aspects do you think El Caño could improve in its visitor experience?

Q3 During what months of the year do you get the most visitors? What times throughout the day do most visitors tour the park?

Q4 What are the visitor rates of the park?

Q5 What are the weather conditions like at different points in the year and how do they affect the visitor experience?

Q6 What are your Wi-Fi speeds and where in the park is the Wi-Fi connection the strongest?

Q7 What funding does the park receive?

Appendix B

Discussion Guidelines for Informal Interviews with Third Party Testers

While designing the application, we had third party testers including other IQP students and other visitors. These questions were used to collect feedback anonymously to improve our application.

Q1 What is your favorite aspect of visiting El Caño?

Q2 Do you feel like you learned more about El Caño from our application?

Q3 What aspects of El Caño would you like to learn more about?

Q4 How did you like using our application? Is it intuitive?

Q5 What features of the application did you find useful/ not useful?

Q6 Are there any aesthetic changes you would make to the overall appearance of the application?

Appendix C

An Early Version of a Shell Scripts to Update the Native Application

```
#!/bin/bash

#####
# Move Necessary Files #
#####

cd ~/ElCañoApp/
echo "Copying Source Files"
cp -a ./EditingFolder/* ./El\ Caño\ Tour/www/
echo "Copying Shelf Data"
cp Shelf/config.xml ./El\ Caño\ Tour/

#####
# Android Builds #
#####

echo "Entering Cordova Project Directory"
cd ~/ElCañoApp/El\ Caño\ Tour/

#Update the android platform
#For help, visit
https://cordova.apache.org/docs/en/latest/guide/platforms/android/upgr
ade.html
#If that link is broken, look for how to update android on
https://cordova.apache.org/
echo "Updating Android Platform"
cordova platform remove android
cordova platform add android > ../Logs/androidAdd.txt

#Log which platforms are added
echo "Logging Available Platforms"
cordova platform ls > ../Logs/platforms.txt
```

```

#Try to get gradle to cooperate. It may just not. See manual for
troubleshooting.
echo "Exporting Gradle Version"
export ORG_GRADLE_PROJECT_cdvMinSdkVersion=20
echo "Building Android Project"
cordova build android -- --gradleArg=-PcdvMinSdkVersion=20 >
../Logs/androidBuild.txt

#####
# iOS Builds #
#####

#Navigate to the right place
echo "Entering Cordova Project Directory"
cd ~/ElCañoApp/El\ Caño\ Tour/

#Update the iOS Platform
#For help, visit
https://cordova.apache.org/docs/en/latest/guide/platforms/ios/upgrade.
html
#If that link is broken, look for how to update iOS on
https://cordova.apache.org/
echo "Updating iOS Platform"
cordova platform remove ios
cordova platform add ios > ../Logs/iosAdd.txt

#Log which platforms are added
echo "Logging Available Platforms"
cordova build ios > ../Logs/iosBuild.txt

```

Appendix D

English and French Excerpts from Our Application

English Excerpt

1. Ticket Booth

Traditionally, it had been thought that the societies of the Isthmus of Panama, as well as others of the Intermediate Area or Lower Central America, were egalitarian or moderately hierarchical societies, i.e. groups that lived a simple village life, harvesting the land and complementing their diet with hunting and fishing. However, a decade of research in El Caño has provided strong evidence of complexity and led to questioning of these traditional views.

The Necropolis of El Caño represents a traditional Coclé society. The creation of El Caño is the culmination of a long process of economic, political, social and religious development that began in the region around 500 A.D. The site was built in 700 A.D. and abandoned in 1000 A.D.

The organization of the mortuary space based on status (i.e. the segregation of rich and poor within the cemetery) and the presence of rich tombs of infants, highlights that El Caño was a society with great social inequalities. The practice of human sacrifices in the funerary rituals of their political and religious leaders also demonstrates the great factual and social power their rulers had and the particular historical moment they were going through. Finally, the abandonment of the necropolis suggests an exhausted political model in crisis around 1000 A.D. and the beginning of a new period.

French Excerpt

1. Guichet de vente de billets

Autrefois, on croyait que les sociétés situées à l'isthme de Panamá, ainsi que d'autres sociétés de la zone intermédiaire ou la Basse-Amérique centrale, étaient des sociétés égalitaires ou modérément hiérarchisées, c'est-à-dire des groupes qui menaient une vie villageoise et simple, récoltant la terre et complétant leur alimentation par la chasse et la pêche. Cependant, une décennie de recherche dans la région nous permet de remettre en question ces perspectives anciennement crues, grâce à une découverte de preuves concrètes démontrant la complexité de la société d'El Caño.

La nécropole d'El Caño représente l'aboutissement d'un long processus de développement économique, politique, social et religieux qui a commencé dans la région vers l'an 500 après J.-C. Son développement s'est étendu sur plusieurs siècles (700 à 1 000 après JC) grâce à une stricte et rigoureuse organisation des travaux.

L'organisation de l'emplacement des tombeaux funéraires en fonction de statut sociale (c'est-à-dire la ségrégation des riches et des pauvres dans le cimetière) ainsi que la présence de tombes d'enfants riches, souligne qu'El Caño était une société constituée de fortes inégalités sociales. La pratique des sacrifices humains dans les rituels funéraires de leurs dirigeants politiques et religieux démontre aussi la grande puissance factuelle et sociale de leurs dirigeants et le moment historique particulier que ces derniers étaient en train de traverser. La pratique des sacrifices humains dans les rituels funéraires orchestrés par leurs chefs politiques et religieux démontre également la grande puissance factuelle et sociale de leurs dirigeants ainsi que la

particularité de l'époque dont ils régnaient. Enfin, l'abandon de la nécropole suggère un modèle politique épuisé en crise vers l'an 1000 et le début d'une nouvelle ère.