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Making the Rollins College Archaeology Lab Accessible through Digital Technologies

Ellie Minette
eminette@rollins.edu

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Department of Anthropology
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CHAPTER 1: INTRODUCTION

INTRODUCTION

Archaeology is the study of stuff people left behind. It is the trash, the treasures, and everything in between. Archaeologists' goal is to learn about the people and the cultures that left these items. Most archaeologists work in the field or in museums or academic institutions. They work with the collections that are physically located at their job sites. They conduct research and work to publish their findings. Sometimes these discoveries are widely broadcast, like the recent discovery of footprints in New Mexico (Hunt 2021). However, of all the archaeology being conducted around the world, very little of it makes it to the public eye. Museums work to make archaeological materials accessible to the public, but they can only reach the people that visit the museum. This greatly limits the engagement with the artifacts. Academic institutions rarely display their collections making them almost impossible to interact with. There are millions of artifacts that have the potential to inspire and educate kept away and inaccessible at these institutions.

Archaeologists study the material culture that has survived through time, but this does not ensure that it will last forever. Once a site has been excavated, a piece of it is permanently lost and destroyed. There will always be the records and the recovered artifacts, but those things are not permanent and are easily lost. Online files and databases provide an effective means of safeguarding against such losses. It has been common practice for many years to digitize written records in laboratories. The Rollins College Archaeology Lab has an online database for storing and accessing data from the bag log, the site log, and the inventory lists. It also maintains digital copies of field notes, excavation profile drawings, and topography maps, which are saved locally and backed up to the Cloud. However, until recently, there was no way to properly digitize artifacts themselves. They could be photographed, but conventional photos are unable to capture the full magnitude and three-dimensional detail of an artifact. Now, digital models can help fill this gap.

If an artifact goes missing or is moved to a different lab, school, or museum, an accurate replica can be 3D printed for analysis and research. Artifacts can be printed over and over as well; there is no limit (excluding resources like funding and supplies) to the number of replicas one can make. This allows an entire class or study group to handle the same artifact at the same time. Additionally, students retain information better through tactile learning in the classroom (Means 2017). 3D replicas provide a new avenue of engagement with artifacts.

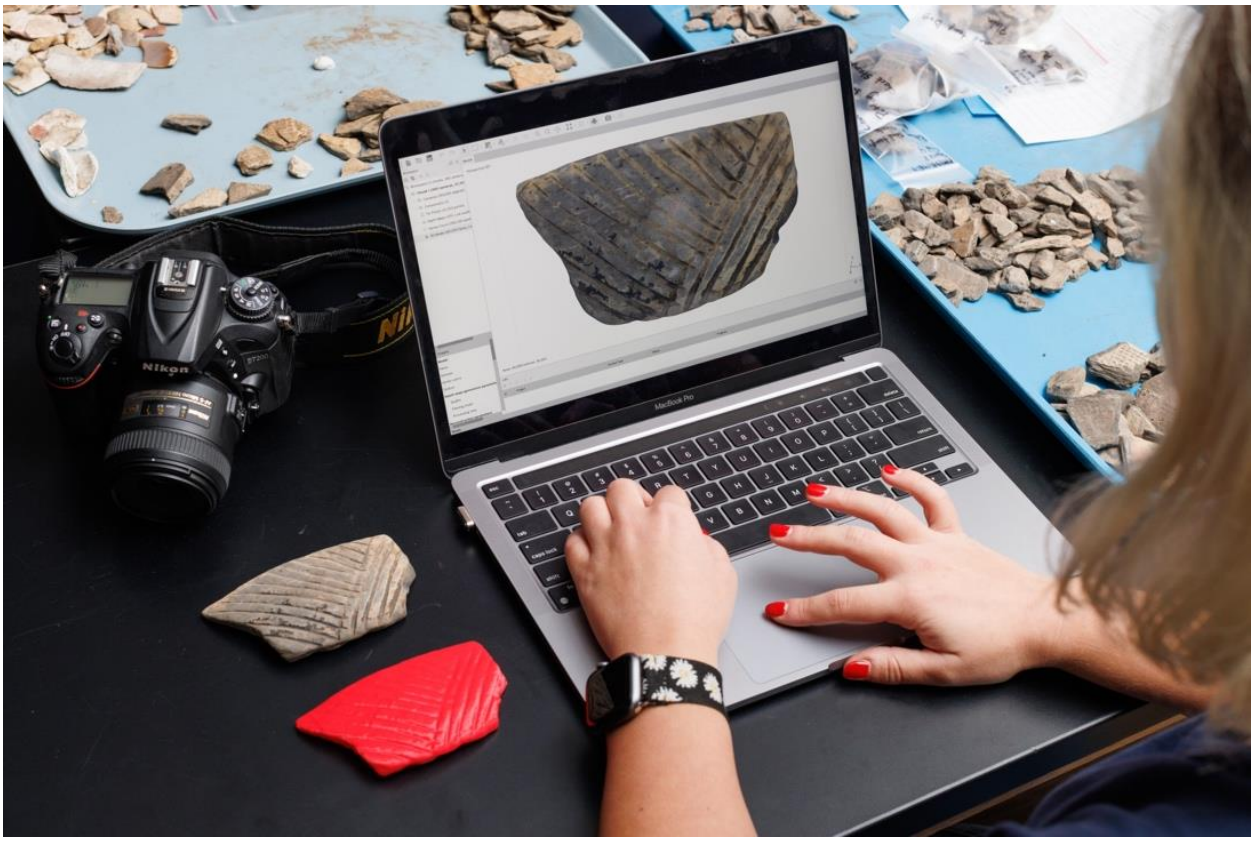


Figure 1: An example of the digital modeling process. (Photograph by Scott Cook.)

It is also exceedingly difficult to study material remains, or artifacts, if they are located across the globe. Just like the internet helped the widespread sharing of written information, it can also help us share our material knowledge. It's one thing to write about an artifact; it's another to have an accurate, 3D model of it. These digital models can be downloaded, printed, and analyzed from

anywhere. They allow artifacts to be examined globally without ever leaving your desk. The applications and uses of these models are just starting to be recognized.

Digital modeling helps to solve both the issue of preservation and accessibility. Creating 3D models of artifacts is a unique way to preserve objects because it captures features that 2D photos cannot. There is also the added benefit of being able to print a replica of an artifact from a 3D model. The issue of accessibility is also solved because 3D models can be shared and uploaded digitally to all sorts of platforms. It is now possible to upload 3D models into Microsoft PowerPoint and Word. This addition allows presentations and papers to include a more interactive and engaging feature. There are also plenty of open source, online sites to upload and post these 3D models. Sketchfab is one of the most well-known host sites for digital models ranging from cultural heritage to video game characters. These sites are accessible to anyone with internet connection. An object that was merely sitting on a museum shelf can now be modeled, preserved, and accessed online at any time. Digital models are the compromise between accessibility and preservation.

There are many parties or stakeholders that would benefit from implementing these digital modeling technologies into the cultural heritage sector on a large scale. First and foremost, archaeologists would benefit from the increased preservation of objects and the wider availability to study artifacts around the world. Second, museums would benefit greatly from these technologies. During the COVID-19 pandemic, for example, many museums had to rely on their websites to engage with the public. Three dimensional models of major artifacts would have made the sites more interactive and educational. In the same vein, the general public is a stakeholder in this plan. They are the ones that museums want to engage and interact with. Private collectors also hold a stake in this project because they can make their artifacts accessible to archaeologists without losing their physical collection. This also helps archaeologists to study new material

without having to complete an excavation. There are many stakeholders with many overlapping benefits and interests.

In particular, the Rollins College Archaeology Lab (RCAL) is working to promote its diverse collections. The Rollins College Archaeology Lab houses numerous archaeological collections that vary greatly in terms of size, age, and the types of artifacts that are represented. In total, the RCAL has over 50,000 individual artifacts from over 20 different sites. Many of these artifacts and sites are from Central Florida and were excavated by Rollins students and faculty, but they have not been systematically studied by Rollins archaeologists and virtually all remain under-publicized outside of the college. The RCAL houses predominately pre-Columbian Native American artifacts ranging from ceramics to bone decorations to marine shell tools. These collections offer a great insight into Florida's buried pre-Columbian past. However, they are in desperate need of attention and curation. In the past few years, students have worked to take these collections from old sandwich bags and produce boxes to industry standard 4-mill bags and sturdy plastic boxes. Slowly the RCAL's collections are getting to a place where they can be used for teaching and research projects.

While these advances in cataloging and storage are helpful, the artifacts are still primarily seeing the inside of a box or cabinet. To remedy this, I have begun to compile a series of digital models of various artifacts from the RCAL. By uploading our models to Sketchfab or partnering to 3D print replicas for local museums, there are many opportunities to collaborate with stakeholders to make the RCAL's collections more accessible and visible, all the while preserving them.

From classrooms to museums, and even private collections, these digitized artifacts can pave the way for a more inclusive and accessible future for the field of archaeology. This thesis looks

specifically at how this technology can be used to increase the accessibility and utility of artifact collections housed at the Rollins College Archaeology Lab. It focuses on the question—how can we preserve these collections while also making them more accessible to not only academics and researchers but also the general public? My primary goal is to work with different types of artifacts and with different stakeholders to better understand how RCAL's archaeological collections can be made more accessible through 3D modeling technologies. Ultimately, I want RCAL models to be effective tools for education and engagement in museums, classrooms, and laboratories both at Rollins and beyond.

PROJECT BACKGROUND AND SUMMARY

I became interested and involved with three-dimensional technology through an academic internship with the Florida Public Archaeology Network (FPAN) in January of 2021. They had just begun to digitize a large portion of their collections for public education and use. I had the opportunity to learn photogrammetry from one of FPAN's Public Archaeology Coordinators, Emma Dietrich, as part of my internship. In the twelve months since I started learning, I have created 3D digital models of 40 individual artifacts that are all accessible and downloadable online on a public website called Sketchfab. The models have been viewed over 900 times and downloaded over 75 times. This means artifacts that usually sit in dark boxes are being seen by so many more people now.

At the same time, I was working as an FPAN intern, I was also lucky enough to get involved in the later stages of cataloging RCAL's Shell Island (8OR452) Collection with my research partner Zoe Milburn and Rollins Professor of Archaeology, Dr. Zackary Gilmore. This collection is from a pre-Columbian site in the Wekiva River and includes over 200 bags of artifacts weighing more than 260 pounds total. This collection provides a unique snapshot into the pre-Columbian Indigenous history of the Wekiva River that has not been heavily studied. While working on this

project, we realized that this information needed to be publicized, not just for scholars but for the local public too. This required a strategy that goes beyond publishing a journal article or presenting at a conference, neither of which would reach many people outside of the professional archaeology field. Creating and publishing digital models of unique and important artifacts from Shell Island would be a fast and effective way to put some information out into the world. With that in mind, I modeled fifteen unique artifacts from different time periods and spatial contexts at Shell Island. These models include ceramics, stone and shell tools, and even vertebrate fauna.

Learning how to create these 3D models while working to finish the Shell Island collection sparked my research question. How can we preserve these collections while also making them more accessible to not only academics and researchers but also the general public? I addressed this question using multiple related methods. First, I created digital models of artifacts from the Rollins College Archaeology Lab's collections. I selected artifacts from various collections in the RCAL that represent the wide range of history covered. These digital models were uploaded to Sketchfab, a freely accessible website that serves as a hub for digital models. On Sketchfab, anyone is able to view and download our models at no charge. I combined model creation with stakeholder interviews in which I questioned local museum curators, public archaeologists, archivists, and private collectors about the applications and implications of digital models from their particular perspectives. In conducting this research, it was my goal to gain a better understanding of how digital models can be used in the real world to promote accessibility and visibility of artifacts while also contributing to their long-term preservation. I am hopeful that this project will culminate in a plan to use digital models to make the RCAL's collections more public and useful.

CHAPTER 2: LIT REVIEW

LITERATURE REVIEW

Over the past decade, archaeology has seen a dramatic shift in interest toward what Manovich calls "new media" (Manovich 2010). His definition states that this new media is all digital numbers and data on computers. This includes virtual reality, digital simulations, complex computer programs, and digital models. González-Tennant remarks that historical research is mainly academic, that it does not engage with the public often or at all (González-Tennant 2018). He continues and references Manovich by saying that these "new media" are the future of not only research, but public engagement and education as well. Research conducted by González-Tennant through the years reflects that the internet is a tool for disseminating information to the masses. It is also relatively inexpensive and easily accessible. This greatly increases scholarly and community collaboration with researchers. Translating these "old media" (artifacts, paper records, papers) to "new media" (digital models, documentaries, online databases) is the task of future archaeologists (González-Tennant 2018). "New media," especially digital artifact models, "offer researchers new techniques for crafting the way historical knowledge is accessed and interpreted" by other scholars and the general public (González-Tennant 2018, 173).

The term "new media" encompasses many different forms of technology, but I am focusing on digital modeling of artifacts. There are two main ways to create these 3D models. The first is laser scanning, which "[works] by emitting some form of light at a target object and then using a camera to capture the way this light deforms" (Porter 2016, 72). This data is then transformed into an accurate 3D model. There is some evidence that laser scanning can produce more accurate and precise results in some cases, but it is very expensive and there are some drawbacks (Porter 2016). If not done in complete darkness, laser scanning often produces models with warped edges or

surfaces. Having a completely dark space at all times is difficult. Additionally, most laser scanners can only scan small objects. Large buildings or entire sites are out of the question. These are the major drawbacks of laser scanning.

The second is photogrammetry. This is my specialty and the technique I used to conduct all research related to this project. In contrast to laser scanning, photogrammetry is relatively affordable. In total, the entire setup we used to collect photogrammetric data cost approximately $1,176, excluding the camera (see Table 1).

Table 1: Costs of Photogrammetry Equipment

What	**Why**	**Approximate Cost**	**Notes**
Turntable	This turntable connects to your phone and can be set to rotate the exact number of degrees.	$139	
Lightbox	This ensures a clean background with bright and even lighting.	$139	
Extra Lights	This provides additional lighting.	$32	
Turntable Extender	This allows larger objects to be modeled.	$89	
Foldio3 Full Set		$359	This includes everything listed above.
Tripod	This stabilizes the camera and allows for all photos to be taken from a control point.	$29	
Agisoft Metashape (Educational Professional License)	This is the program we use to actually create the digital	$549	There are other licenses that you can get.

	models. The Professional License is installed on the computer in the RCAL.		
Agisoft Metashape (Educational Standard License)	This is the program we use to create the digital models. The Standard License is currently installed on my personal laptop so I can work from anywhere.	$59	
Sketchfab	This is where we upload our models for public access and engagement.	$15 / month	There is a free version, but all of your models must be free to download.

The RCAL primarily digitizes portable objects, so our equipment is a little different than site mapping tools. However, the same principal ideas and methods are used for both tasks. Photogrammetry works by taking a series of hundreds of photographs from different angles. Specialized software is then used to identify data points across individual photographs that can be used to connect them together to create a digital three-dimensional model of the subject (Luhmann 2013).

Photogrammetry can also be conducted almost anywhere. The ideal conditions are a clean, evenly lit lightbox, but those are by no means the only conditions to conduct photogrammetry (Porter 2016). It can also be done in the field, either with a portable lightbox (like the one created by Porter, Roussel, and Soressi), or by simply taking photos of an artifact or object in situ, that can be reconstructed into an accurate 3D model that can be referenced to study and analyze the artifact. This is incredibly useful for artifacts that are large or too delicate to move without breaking. Photogrammetry can also be used to reconstruct entire sites (Gardiner 2019). I do not have first-

hand experience with this, but I have looked at countless castles, churches, forts, landmarks, and city streets that were all reconstructed using photogrammetry. One of the most interesting of these sites is the Ellis Island immigration offices which I will discuss in more detail below (Gardiner 2019). Archaeologists, historians, and preservationists can use this technology to reconstruct excavation projects, sites, and important architecture. When combined, these various applications of photogrammetry give the public a better understanding of the diverse scales at which digital archaeology can be conducted.

One of the most important places that these digital tools can be applied is in the classroom. Teachers and students alike can benefit from the integration of 3D models into everyday classes. Hands-on learning is one of the best kinds of learning (Nancarrow 2016). I think we all felt the ramifications of this during the pandemic when we were all learning and teaching virtually. There is not much research currently published on the digitization of everything during the COVID-19 pandemic. However, I am sure there will be many reports about museums and cultural heritage sites turning to the digital world to stay relevant and afloat. It is very hard to replicate the experience of handling and examining artifacts or objects through Zoom or WebEx. Likewise, it was almost impossible to visit museums or heritage sites. However, with 3D models, it is easy for students and viewers to manipulate and explore models online. On the other hand, it is just as easy for students to handle 3D replicas of artifacts back in the classroom. This allows the artifacts to remain safe and preserved while allowing students to gain tangible experience.

One example of this is a project conducted by the National Parks Service in partnership with the National Council for Preservation Education (Gardiner 2019). Their goal was to create a series of lesson plans and resources for teachers to use when discussing certain sites or events in history. They built most of the lesson plans around existing digital resources like artifact models

or site tours. The purpose of these lessons was to incorporate digital resources into regular classroom learning to engage students with sites they could not visit or objects they could not handle in person. Gardiner's (2019) paper focuses on two specific lessons and how they were created, utilized, and received. The first of these was a lesson on the Civil War. Originally, the lesson plan's goal was to teach about the archaeology of the site and how the research and excavations were conducted. However, the digital resources did not support this learning outcome. The authors changed course based on the digital resource they had available — a 3D model of a canteen turned into a shovel — and instead designed a lesson plan about how soldiers in the Civil War modified the landscape to their benefit. In other words, the authors of these lesson plans took what artifacts were already digitized and created a learning environment around them. The VCU Virtual Curation Laboratory had already created and uploaded a digital model of the canteen shovel to Sketchfab, so it was free to access and view at any time by anyone. The National Park Service took advantage of this resource and created a lesson plan for teachers to use that incorporated digital models. This exposes more people to the world of digital archaeology and cultural heritage. Students were able to actually manipulate the model in three dimensions instead of just looking at a textbook photograph. This helps them to retain the information because it is presented to them in a unique way. To further the students' understanding and engagement with this history lesson, a 3D print of the canteen-shovel would have been a very useful addition. They would have been able to physically hold the object and possibly even try to use it as a shovel. This sort of replication and interaction also aids in learning and retention (Nancarrow 2016).

In addition to digital objects, the National Park Service also created lesson plans centered on digital reconstructions of entire sites, such as the Immigration Station at Ellis Island and the Pu'uhonua o Honaunau National Historic Park (Gardiner 2019). Gardiner details how the virtual

tour at Ellis Island was created and how the lesson plans explain the history of the site. The virtual tour of Ellis Island was created by "the NPS Historic American Building Survey, Historic American Engineering Record, and the Historic American Landscapes Survey (HABS/HAER/HALS)". Many students learn about Ellis Island; it is an integral part of American history. However, it is difficult for the vast majority of students in the United States to physically visit Ellis Island and see the Immigration Station, especially the parts of it that are not restored. This virtual tour allows students from across the country to "visit" and explore the Island and its buildings. There is no need to schedule a tour, book a trip, or even leave the classroom. The virtual tour allows students to visit each room of the complex and examine the details and history. Using this technology, students are able to explore the Immigration Station at Ellis Island that they learned so much about in a new and exciting way. This was especially helpful during a pandemic when most students were learning virtually. It is interesting to note that the virtual tour did exist prior to the National Park Service's lesson plan and that teachers could have used it before. However, it is vital that large institutions, like the NPS, start using these resources and promoting their usefulness. Gardiner remarks, "Along with these lesson plans, the project resulted in … a list of considerations for anyone looking to create cultural resource education materials utilizing digital technology" (Gardiner 2019, 15). The possibilities of these digital resources for education and engagement are seemingly endless.

Another case study worth noting is the use of physically printed 3D models of artifacts, specifically "two Pictish cross slabs" (Nancarrow 2016, 71). The University of Western Australia used two smaller scale replicas of these cross slabs to help teach undergraduate students about the Pictish iconography (Nancarrow 2016). They also used photos, the digital models, and displayed the actual measurements of the slabs in addition to the prints. The benefit of this study is that the

researchers surveyed the students to see which methods of study worked best. Many students reported that they appreciated the replicas, but wished they were to scale. This is an issue of printer size and availability. It is much easier and cheaper to print smaller objects or to scale down objects. However, there are obvious advantages to having a life-sized replica. When asked about having nothing versus a smaller version of the slabs, the students responded that they would rather have the scaled down versions than none at all. This is direct evidence that 3D replicas do have an important place in the classroom. Many students also noted that the tactile handling of the artifacts helped them remember the information better (Nancarrow 2016).

Digitizing models is also a great assignment for students in class to gain a more hands on approach to curation. Having students model the artifacts themselves greatly increases the number of artifacts digitized online. No matter the quality of the model, a model still exists. There are tons of applications for students to create and use the digital models of artifacts. One class can make the models for future students to study. It is also an incredibly useful skill to add to a resume. The Art History Department at California State University took this approach to digitizing different pieces of art (Nancarrow 2016). Students were told to create "two 3-D printed models: (a) a copy of an object from the Wriston art collection and (b) an experimental model that blurred the distinction between "copies" and objects that are indistinguishable from the originals" (Nancarrow 2016, 73). This taught students the difference in form and function. The first print was simply a replica of the original, while the second print had a different purpose entirely. It might have looked the same or similar, but the object was inherently different (Nancarrow 2016). This comparison is a useful lesson when teaching about representation and replication in cultural heritage or art history.

However, not all applications of 3D technology in the field of cultural heritage and archaeology are free from problems. One example of this is the exhibit of Star Carr headdresses at the Museum of Archaeology and Anthropology at Cambridge (Cooper 2019). The Star Carr headdresses are a collection of artifacts that are very fragile and located in multiple locations. The creation of digital models of these artifacts was a brilliant idea. This ensures preservation in some form and allows the models to be examined together as a collection in one place. Cambridge decided that they should be viewed together in person, though the originals were too fragile and valuable to display. Their solution was to create 3D models of these intricate and detailed artifacts and display them instead. The exhibit would still contain all of the relevant information and analysis and would have a disclaimer that the objects are replicas. However, these plastic replicas were kept at a distance away from the viewer, so that one would think that the artifacts were authentic (Cooper 2019). The irony of protecting the replicas instead of letting the public engage with them was not lost on Cooper. This exhibit was an ideal opportunity for the Museum of Archaeology and Anthropology to let visitors get up close and personal with these "artifacts" because they were simply plastic replicas. Additionally, because the Museum already had the digital models, they could have printed a replacement if anything were to happen to one of the replicas.

Another issue with 3D models and physical replicas is cultural significance and heritage getting lost or misinterpreted. If a culturally significant or sacred artifact is digitized, is that file also sacred? If the digital model is printed out, is that object also sacred because it represents a sacred object? Or is the replica simply a piece of plastic with no cultural or religious value?

The other issue with digital content is ownership. Who has control or say over what is digitized or publicized? This goes back to a larger issue of museum ownership and who has a say

in museum politics. It is often the minority populations that are excluded from these discussions. However, making archaeology more accessible to these populations through digital outreach is one way to get their voices back into the picture. On the flip side of that, there is the issue of copyrights and licenses of the digital files. Do they belong to whoever owns the original artifact or possibly whoever made the model? Do they belong to no one and everyone at the same time, like a world heritage site? It is unclear at this point as everything is on a case-by-case basis.

These digital files can be stored on any computer and uploaded to most modern websites. Sketchfab.com/rollins_archaeology is the website where all of the RCAL digital models can be found online. Sketchfab is an incredibly useful site that hosts thousands of digital models, including everything from a pair of shoes to a shrimp to a cathedral to video game furniture. Sketchfab hosts a large variety of users and viewers. However, one of the growing sectors is Cultural Heritage institutions. They have an entire page dedicated to Sketchfab's Cultural Heritage partners. There are hundreds of museums that have accounts and models uploaded. The British Museum is the most followed museum on the site with over 1.7 million views and almost twenty thousand followers. They only have 273 models, but I am sure that more will continue to be published.

Another interesting fact about the British Museum's Sketchfab is that some of the models' captions include, " © The Trustees of the British Museum. Shared under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) licence" ("Tablet" 2021). This copyright notice states that the models are owned by the British Museum. After researching the objects on the British Museum's website, the artifacts themselves are also copyrighted under "The Trustees of the British Museum" ("Tablet" n.d.). Other models on their profile simply have the Sketchfab note "License: CC Attribution-NonCommercial-ShareAlikeCC

Attribution-NonCommercial-ShareAlike" ("Sculpted" 2018). The RCAL's models have Sketchfab's "License: CC Attribution" ("St." 2021). While I won't go into the minutia of copyright laws, there is a larger ownership issue that is becoming more and more prevalent — digital models of human remains and digital repatriation. Digital repatriation is giving objects of cultural importance back to their original communities in a digital format (Nash 2020). In addition, there is the reverse situation, where the original objects are repatriated to their communities and the archaeologists are left with the digital models and data (Meloche 2021). There are countless benefits and ethical issues associated with this process though. First are the benefits of digital modeling of sensitive objects. Spake describes five major benefits of digitizing specifically human remains: "(1) data collection in the field, (2) data preservation and reanalysis, (3) reduced handling, (4) expedited repatriation and reburial, and (5) knowledge transmission" (Meloche 2021, 209). In terms of data collection in the field, photogrammetry of artifacts in situ is incredibly useful to digitize and record an entire grave or site. It allows the site to be studied as a whole after the excavation. Preservation and analysis are very important for the field of archaeology. Preserving and learning from the past is the duty of this field. Often, human remains are very delicate and should not be handled any more than is absolutely necessary. By creating a digital model and printed 3D copy, researchers are able to handle delicate objects without fear of damaging them. Spake also argues that by creating these digital models of sensitive materials the artifacts or remains themselves can be repatriated to their descendants in rapid time. This action itself is very ethical and the right thing to do. However, it must be decided that the repatriated objects can be digitized first. "Knowledge transmission" is the last benefit that Spake discusses. This idea ties into my argument for accessibility and public engagement. By creating replicas of important

objects or artifacts, they can be widely spread and studied but not without considering the question of ethics.

Spake also goes into detail on the ethical issues of digitizing human remains. Her main arguments are in terms of collaboration, ownership, and repatriation. First, Spake argues that collaborating is an important part of any archaeological project involving existing populations. This is an argument for "decolonizing anthropology," or making it less exclusive to academia. (Alonso 2019). By taking others seriously, researchers are more likely to gain permissions to digitize sensitive artifacts. Second, Spake discusses ownership of the digital files, specifically models. Under international copyright law, 3D models made from photographs are owned by their creator. By this logic, I own all of the models I have made for Rollins. This seems problematic, however, given that I own none of the actual artifacts. I will discuss this issue more in my interviews with stakeholders. However, it can be agreed upon, through collaboration, that the models belong to the descendent communities just like the physical artifacts themselves. Lastly, repatriation is a huge issue in archaeology, but more specifically in the digital realm as well. Some communities believe that the digital scans or models of their artifacts should be repatriated along with the physical objects. These issues are ongoing and will continue to be studied and argued about for many years.

There are limitations to digital modeling outside of the ethical ones. First and foremost, there is the fact that technology is constantly evolving. Whatever we think is cutting edge today will be outdated in ten years. An example of this is González-Tennant's Rosewood digital recreation. He designed an entire digital reconstruction of Rosewood but did not update it for years. This neglect led to the site becoming outdated and less useful than it was worth. Digital modeling

may fall into this trap as well, but as long as archaeologists and digitizers keep up with the latest technology, I do not believe this will be an issue.

CHAPTER 3: DIGITAL MODELING

DIGITAL MODELING

Digital artifact models are the foundation of my thesis, but what exactly does that mean? Digital models are three dimensional, manipulatable replicas of artifacts. It is a virtual copy of the artifact that can be accessed online or on a computer. Any material thing can be digitized into a model—from artifacts to buildings to human beings. Digital models can also be manually created for things that do not exist in the physical world the same way that tangible objects do, like video game furniture or a human heart. These models can be uploaded online or stored on local hard drives and can be used for research, entertainment, and education.

Digital models of artifacts are unique because they are a replication of a real physical object. These digital copies are very accurate in size, color, and shape. They can also be viewed from any direction, meaning the model can be spun and flipped so all surfaces can be examined. This makes a model more useful in many respects than a photograph, which can only capture a single viewpoint. These digital models can also be printed on a 3D printer. This allows an artifact to enter back into the tangible space without fear of damage or deterioration of the original.

I have already established that digital models can be made of almost anything, so how did I choose which artifacts to digitize? I had thousands of artifacts at my fingertips and access to even more just an email away. What makes the fifty artifacts I chose special? In short, they are all uncommon or rare finds, or they possess information that is key to the understanding of a site. I have chosen artifacts that represent a variety of materials and contexts, with an emphasis on pre-Columbian artifacts in the RCAL. I also focused on artifacts that are fragile, too delicate to handle frequently, and/or are more visually interesting to a wider audience. I targeted different kinds of repositories and collections, including the Rollins College Archaeology Lab, the Rollins Museum of Art, the Orange County Regional History Center, and a local collector. Through my work with

these institutions and individuals, I was able to identify communities of people that represented important groups of stakeholders in the growing realm of digitization. These diverse communities demonstrate the vast possibilities that digital artifact models have.

ARTIFACT DESCRIPTION	REPOSITORY	VIEWS	LIKES
St. Johns Incised Pottery, Orange County, FL	RCAL	68	2
Chert Biface, Volusia County, Florida	RCAL	19	2
Pre-Columbian Shell Cup, Seminole County, FL	RCAL	27	4
St. Johns Pottery Base, Orange County, Florida	RCAL	25	5
Orange Incised Pottery, Orange County, Florida	RCAL	35	4
Carved Bone Artifact, Seminole County, FL	RCAL	21	2
Orange Incised Pottery, Orange County, Florida	OCRHC	30	3
Shell Adze, Orange County, Florida	RCAL	25	1
St. Johns Plain Pot, Orange County, Florida	OCRHC	126	8
Bone with Embedded Stone Projectile Point	OCRHC	61	1
Modified Bear Tooth, Seminole County, Florida	RCAL	6	1
Fort Walton Ceramic Vessel (BM95)	RMA	1	1

Fort Walton Ceramic Vessel (BM90)	RMA	1	1
Fort Walton Ceramic Vessel (BM89)	RMA	3	1
Fort Walton Ceramic Vessel (BM88)	RMA	6	1
St. Johns Plain Rim	RCAL	3	1
Shell Plummet, Orange County, Florida	RCAL	10	1
Shell Island Knife	RCAL	4	1
Archaic Stemmed Point	RCAL	7	1
Hernando Point	RCAL	10	1
Bone Point	RCAL	8	2
Brown Knife	RCAL	4	1
Shell Plummet, Orange County, Florida	OCRHC	10	1
Shell Adze, Orange County, Florida (2)	RCAL	47	2
Bone Pin, Orange County, Florida	OCRHC	16	1
Ceramic Vessel (RCA15)	RCAL	9	1
Fort Walton Ceramic Vessel (BM 91)	RMA	5	1
Fort Walton Ceramic Vessel (BM 87)	RMA	4	1
Fort Walton Ceramic Vessel (BM 92)	RMA	3	1
Fort Walton Ceramic Vessel (BM 93)	RMA	8	1
Fort Walton Ceramic Vessel (BM 94)	RMA	13	2
Fort Walton Ceramic Vessel (BM 96)	RMA	5	1
Egyptian Ceramic Pendant	RMA	41	3
Egyptian Scarab	RMA	169	7
Cuneiform Tablet	RMA	72	2
Cow Jaw	RCAL	32	2
Egyptian False Beard	RMA	10	1
Egyptian Scarab	RMA	25	1
Ceramic Scarab	RMA	47	2
Cuneiform Cone	RMA	14	3

Votive Cone	RMA	12	2
Small Egyptian Horus Statuette	RMA	25	2
Cuneiform Tablet (BM8)	RMA	8	1
Cuneiform Tablet (BM4)	RMA	10	1
Greenstone Celt	Private Collection	2	1
Red Painted Pottery	RCAL	1	1
Bone Dagger	Private Collection	2	1

As noted, I used photogrammetry to make all the models included in this project. To summarize my discussion in Chapter 2, photogrammetry is a technique that uses a combination of photography and computer software to create a 3-D digital model of an object or place. I chose photogrammetry because it is relatively inexpensive, portable, and user friendly. The entire setup needed to create photogrammetric models costs a little over a thousand dollars total (excluding the additional cost of a camera and computer). Because photogrammetric models are created using simple 2-D photographs, the necessary artifact images can be obtained almost anywhere: in the field, in the lab, in a museum, etc. Photogrammetry is also easier to learn than many comparable techniques. With clear instructions, I was able to create my own models within a week of being introduced to the technology. The RCAL uses the Agisoft/Metashape software to create our models. There are other options, such as Reality Capture, but Agisoft/Metashape is the most widely used and accepted. Below are brief step-by-step technical instructions of how I create the models:

1. Select an artifact that has educational value and potential public interest.
2. Place the artifact onto the automated turntable.
3. Position the camera at a head-on angle.
4. Take a photo of the artifact every 15 degrees (about 24 photos total).
5. Flip the artifact to capture the other side.
6. Repeat Step 4.
7. Move the camera position to angle down at the object.

8. Repeat Step 4.
9. Repeat Step 5.
10. Repeat Step 4.
11. Move the camera position to angle up at the object.
12. Repeat Step 4.
13. Repeat Step 5.
14. Repeat Step 4.
15. This results in roughly 150 photos. If the object is simple, like a shell plummet, this will be enough. However, if the artifact is larger or more complex, like a vessel or statuette, more photos for different angles should be taken.
16. Once all the photos have been taken, the artifact can be returned to its original location.
17. Upload the photos to a computer.
18. Import them into the Agisoft/Metashape software.
19. Align the photos. This results in a point cloud.
20. Clean up the point cloud through camera optimization and general selection tools.
21. Build a Dense Cloud.

22. Clean up the Dense Cloud manually.

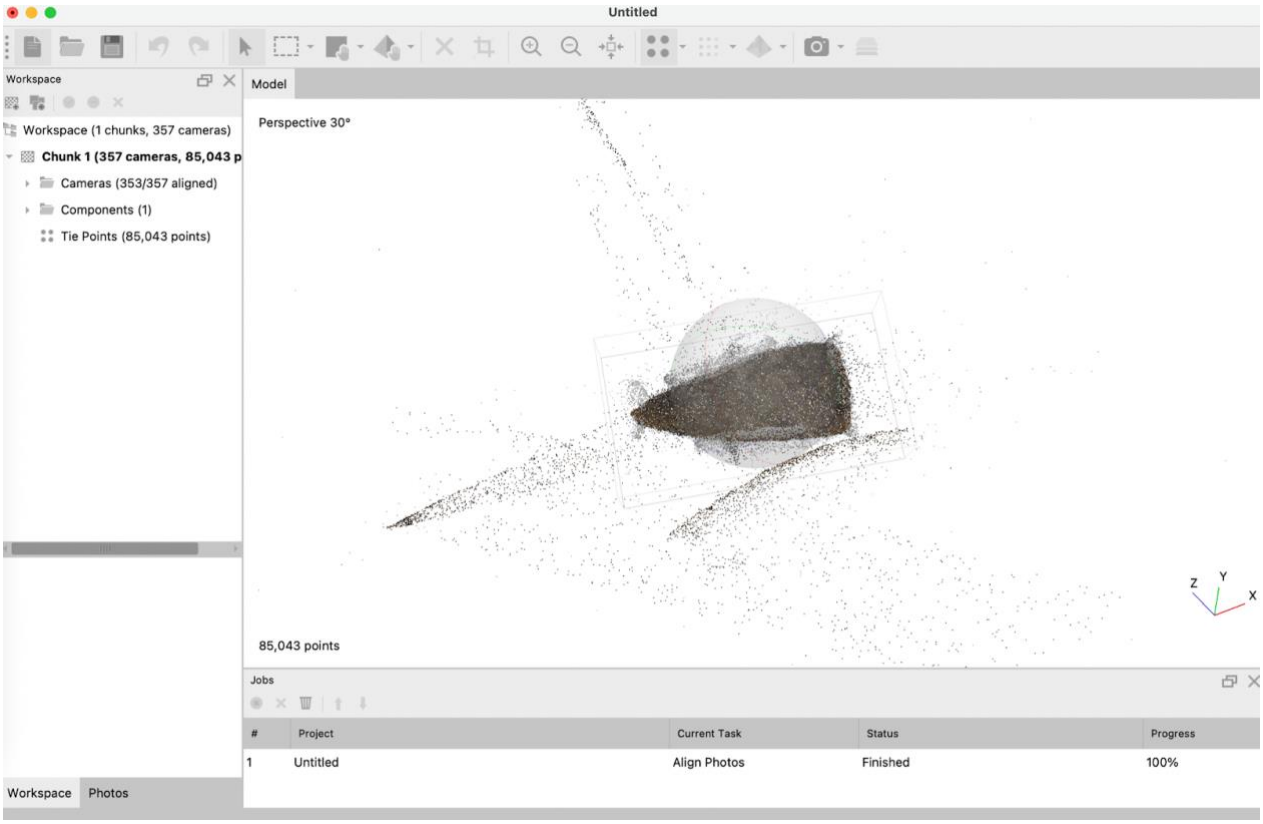


Figure 2: An example of the dense could in Agisoft/Metashape

23. Build the Model and the Texture. This will result in a fully formed and finished model.
24. Upload the Model to RCAL's Sketchfab.
25. Save the file to the computer as a PSX file. This saves the Agisoft copy.
26. Export the file to the computer as an OBJ file. This saves a copy of the file that can be exported to print later or uploaded to other locations (ex: websites and PowerPoints).
27. Edit the Sketchfab settings to include the RCAL background and a short informational description of the artifact.
28. Publish the Model publicly and allow free downloads.

This process takes approximately five hours to complete. The more complicated an object, the more time it can take to photograph and process. Below is a brief technical description of how I print the models in the RCAL using a MakerBot Replicator printer:

29. Turn on the 3D Printer and begin pre-heating it.
30. Check to ensure that the printer has filament and that the build plate is clear.
31. Upload the saved Model (the OBJ file) to MeshMixer, another 3D software.
32. Inspect the Model for holes.
33. Repair all holes.
34. Export the Model back onto the computer as an OBJ file.
35. Import the Model into the MakerBot Replicator software. This is connected to the printer itself.
36. Position the Model onto the digital build plate and manage the printer settings.
37. Begin the printing process and check back occasionally to make sure everything is printing successfully.

The printing process can take anywhere from thirty minutes to over thirty hours depending on the size and density of the model. The RCAL is currently in the process of printing many more models.

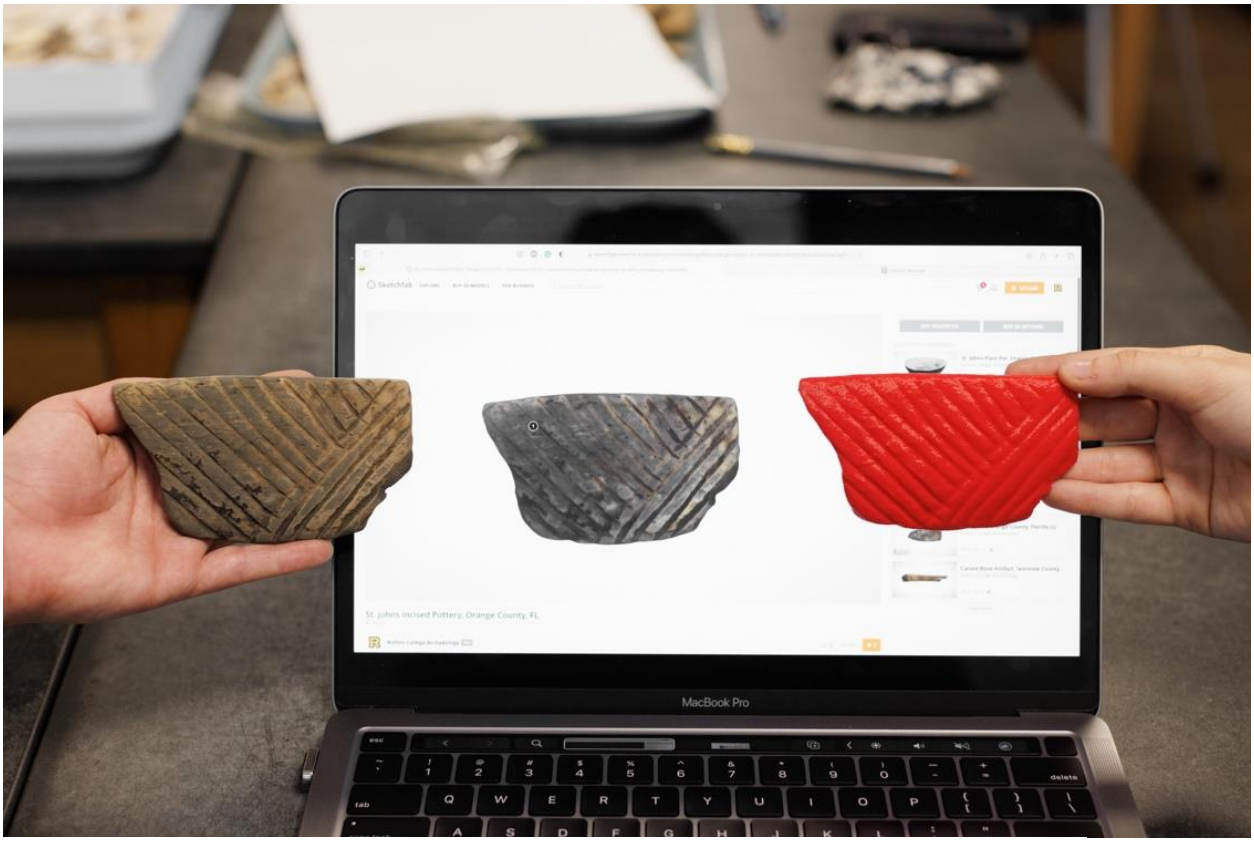


Figure 3: Original artifact (left), digital model (center), and 3D print (right). (Photograph by Scott Cook.)

For example, I took a series of 200 photos of a pottery sherd from different, overlapping angles. I then uploaded these photos into Agisoft/Metashape, a program that constructs the 3D models. It aligns the photos, then I go back in and edit the point cloud that it produces. It generates this cloud by connecting tie points from the photos it analyzes. The next step is to create the dense point cloud. This takes into account the edits I made on the original point cloud as well as a more careful examination of the photos. When the dense point cloud renders, it also needs to be edited and the extra "noise," or unnecessary points, removed. After this, the program builds a solid model and paints the texture and colors onto it. From just 200 photos of an object, there is now an accurate

and precise 3D digital replication available for anyone in the world to see. To print this pottery sherd, I uploaded it to MeshMixer and inspected it for holes. I repaired the holes and exported the new, patched model. I then import that model into the MakerBot software. Once the object is situated on the printer's build plate in an appropriate fashion, I click print. A few hours later, I have a plastic replica of a pottery sherd.

The primary goal of these artifact models is to promote engagement and education among as many diverse stakeholders as possible. The Rollins College Archaeology Lab is where I began photographing and digitizing artifacts. The RCAL collections consist primarily of pre-Columbian artifacts, including pottery, stone tools, animal bone, and other remains from sites around Central Florida. In total, there are over 50,000 individual artifacts from over 20 different sites in the Central Florida area. The largest of these collections is from Shell Island (8OR452), a site where dozens of Rollins students, myself included, have done extensive excavations. This is where I began my selection of artifacts. While there are thousands of artifacts in RCAL's collections, many of them are the same type, so I chose to model the artifacts that stood out from the rest of the collection. For example, in the Shell Island collection, I did not model one of several thousand sherds of St. Johns plain pottery. However, I did model the intact St. Johns plain vessel. In total, I digitized 17 artifacts from the RCAL, 15 of them from Shell Island specifically. These artifacts represent a variety of material types, including bone, shell, stone, and pottery. I chose to model these specific artifacts because they were unique in shape, material, or function. Most artifacts range from roughly 5000 years to 500 years ago. This time range represents the majority of the artifacts in the RCALs collections. I chose to model artifacts from Shell Island so predominantly because I had access to them, they had provenience information, and many of them were unique in our collections. For example, a shell plummet was discovered at Shell Island. It is a rare find

and even rarer to find in inland Florida. It also has information that says where it came from on the Island. This combination of rarity and information made it an ideal model.

An example of digital technology being printed and used is a Shell Cup from Panther Tracks (8SE22), a pre-Columbian indigenous site in Seminole County, Florida. This impressive artifact is currently housed in the Rollins College Archaeology Lab. However, since it was found of state land, it must be returned to the Florida Bureau of Archaeological Research repository in Tallahassee. The shell cup is still partially encased in concreted shell; this makes it very heavy and very fragile. The shell cup is a great demonstration of how natural objects were turned into tools or ceremonial objects through human manipulation. However, it is difficult to pass this object around, and the full scope of the object is lost unless one is holding it. To solve this problem, a digital model was created and 3D printed. Now, the RCAL has an incredible digital model that

Figure 1: Original (left) and printed replica (right) of Shell Cup from Panther Tracks. (Photograph by Scott Cook.)

people can examine from all over the world, meaning when the cup is sent to Tallahassee, the RCAL will still have a copy of it. More impressively, we have an accurate replica of the artifact that is made from plastic. This print is light and very difficult to break. It is ideal for passing around between students. The intricate detail of the original is still captured, but the fragility and clunkiness are lost. There is a major discrepancy between the weights of the two objects, but the general idea of the artifact is still clear. I am hopeful that many more of the RCAL's more delicate

Museums and local historical organizations often have much more *stuff* than they have exhibition space. This disparity results in many collections and stories being left in the archives. Large museums can publish large online exhibits with photos and information, but smaller museums do not have the ability to do all of that. Digital models can help bridge this gap. As already noted, these models are very inexpensive and not very time consuming, so it is reasonable to assume that the important parts of a collection could be digitized and uploaded online with brief descriptions in relatively short time. (I assume roughly five hours per object.) This would make the museum's collections more accessible not only to the local population, but to a much broader online audience.

In the early 1990's, Rollins loaned multiple artifacts to the Orange County Regional History Center, Orlando's primary local history museum. Three of these artifacts have been on display almost continuously since; they include a rare whole pre-Columbian pot, a large and unique piece of fiber tempered incised pottery, and a piece of bone with a projectile point still embedded in it. These artifacts are special because they are rare and very fragile. Intact pots are almost never found in Florida, and it was very uncommon for weapons to be left in the bones of an animal. These are objects that cannot be seen in many places, so it was very important for the OCRHC to display them for the public to see and learn. Thousands of people have seen these artifacts on

display, but almost no Rollins students have. This is the downside of loaning out artifacts. However, over the summer of 2021, I had the opportunity to visit the museum and photograph these artifacts. I created full, 3D, digital models that can be accessed from anywhere. This makes the artifacts accessible to Rollins' students for the first time in decades. We are currently working to print accurate, to-scale replicas of the three aforementioned objects. Once we have these, we will be able to use them to teach future students about Shell Island with a more hands on approach. We are also working with the museum to give them 3D printed models of these artifacts. The intact pot is extremely fragile and cannot be moved frequently. A 3D replica would allow the museum to handle this artifact with less worry. It would also be very helpful and engaging to use at the many history camps the Museum offers. Tangible artifacts are always a hit with the younger audiences, college students included. The Museum is also working to embed these digital models into their website. It would elevate their digital catalog and make their website more engaging. It also allows them to link to the other artifacts from Shell Island that are in our collection in the Rollins College Archaeology Lab to allow for future investigation and education.

The RCAL is also working with the Seminole County Museum to digitize some artifacts from their collections. They have many pre-Columbian indigenous artifacts, seventeenth- and eighteenth-century military artifacts, and important historical and cultural Seminole County artifacts. The museum is very small and not very easy to access. By creating a digital collection of their artifacts, more people will be able to view and enjoy their collections.

Private collections are unique assemblages of artifacts that non-archaeologists have found, bought, and/or inherited. These collections can include any types of artifacts from anywhere or any time. However, many of the collectors do not like to publicize their collections for fear of legal ramifications or of archaeologists confiscating them. Archaeologists are also sometimes hesitant

to work with these collectors because they feel like private collecting is against the archaeological code of ethics. However, archaeologists and private collectors could both benefit from working together. The collectors could provide numerous artifacts and local knowledge, while the archaeologists could provide historical insight into the objects themselves. There is vast potential for the two teams to work together, but I will only be discussing one possible aspect of this partnership: digital replicas of private collections. Digital collections provide a compromise to satisfy both parties. Private collectors get to keep their collections and learn more about them. Archaeologists get to learn more about the collections and study the artifacts.

For example, I worked with Don Jacobs, a prominent local collector, on this project. He has a large collection of pre-Columbian artifacts that he found on his private property. Jacobs does not want to relinquish his collection, but he is curious about the history behind it. As archaeologists, we are deeply interested in this expansive and unique collection of pre-Columbian artifacts in a region that we frequently study. As a sort of compromise, I created 3D digital models of some of Jacobs' most impressive finds. This allows him to keep the real artifacts and allows archaeologists to study the finds. I photographed a stone celt, a bone pin, a clay plummet, and a bone pipe for Jacobs. These artifacts were chosen by a combination of Jacobs' and Dr. Gilmore's suggestions. They represent some of the most impressive and rare artifacts in our collection of digital models.

As noted, one of the biggest advantages of digital modeling in archaeology is the ability to place models online and make them available to researchers, students, and public stakeholders around the world. Sketchfab is the online website we use to host all of our digital models. Anyone can upload a model onto this site for free public viewing. Many of the models can also be downloaded. I upload all of the RCAL models to Sketchfab and allow free downloads. Sketchfab has a feature that allows people to charge for downloads of a model. Many people use this for

video game downloads. However, most cultural heritage accounts, including RCAL, allow unlimited free downloads.

Each model has a caption that explains what it is and any additional information that might be useful in understanding the artifact. For example, artifact type, date, found location, and current location. Many of these captions are written by myself and Dr. Gilmore.

Another great thing about Sketchfab is the ability to embed it into other sources and sites. For example, we are currently working on embedding a few of the more successful and impressive models into the Rollins Archaeology website. This would allow prospective students to see not only the cool digital work we are producing but also our impressive artifacts.

In addition to hosting models, Sketchfab also provides a few useful statistics related to the frequency and ways in which our models are being engaged by online visitors to the site. The Rollins Sketchfab page has been followed by many accounts including FPAN, the University of Florida's Ceramic Technology Lab, and Thomas Flynn (the Cultural Heritage Lead at Sketchfab). We currently have twenty followers. We are the sixth result if you search "college" on Sketchfab. This is really exciting for future students who may discover our page and become interested in archaeology at Rollins.

Sketchfab also has an engaging tradition of creating Weekly Top Ten collections of uploads from different categories. The Cultural Heritage Lead at Sketchfab, Thomas Flynn, puts together a weekly list of the Top 10 Cultural Heritage Artifacts. One of Rollins' Egyptian Scarabs made the list in Week 40 of 2021 (Flynn 2021). This was a huge acknowledgment from professionals in the field of digital heritage. Our model has over a hundred and sixty views and has been downloaded over fifteen times. It is the RCAL's most viewed and most downloaded model, with the St. Johns Pot in close second. Hopefully, more of our models will make this list in the future.

I have monitored the number of views, likes, and downloads of various models as well as new uploads every week. There is a clear connection between the number of views we receive and the number of likes. Our numbers have increased relatively consistently over the last few weeks. We just exceeded eleven hundred views and are almost to seventy-five likes.

Another thing that I have worked on this semester is training other Rollins students in photogrammetry techniques. This not only makes them aware of our models online, but it also gives them a chance to create their own models and learn a new skill set. The RCAL also benefits from this teaching practice because more models are made and uploaded to the RCAL's Sketchfab. This is also beneficial to the future of the Lab because it ensures that future students will be able to continue the practice of photogrammetry. I have created a step-by-step guide to creating digital models from the photography to the printing. The written and visual guides can be found in Appendix A.

I have also had the opportunity to work with the Orange County Regional History Center and the Florida Public Archaeology Network to teach local elementary and high school students about photogrammetry. I think this is really impactful because it is showing interested youth new avenues and opportunities in archaeology. Younger generations today are fluent in technology and pick up new software and methods very quickly. I believe photogrammetry should be one of those technologies.

The goal of creating digital models of artifacts is to increase public engagement and accessibility to these collections. Artifacts all too often stay hidden and packed away in boxes meant to preserve them. However, the public loses valuable learning opportunities when artifacts are hidden away. Creating digital models helps to solve this issue. Artifacts can be preserved and

packed away, but they can also exist online where anyone and everyone can access them. Increased artifact visibility is very important especially with small college collections. These collections are very impressive but are not publicized nearly enough. Digital models that are free and available on the internet help to make these collections known. By using photogrammetry and Sketchfab, I was able to create digital models of artifacts that anyone can view and download online. To this day, over a thousand people have seen the artifacts that are uploaded to the RCAL's Sketchfab page. That number represents hundreds of people that would have never been able to make it to the RCAL in person to see these artifacts or never even known they existed. In my next chapter, I will discuss what important stakeholders think of digital models and how they believe they can be used to impact cultural heritage and engagement.

CHAPTER 4: STAKEHOLDER INTERVIEWS

INTRODUCTION

I hope I have made it clear that digital archaeology and digital artifact models can be used by people outside of the field of archaeology. I believe that they can be used to broaden education purposes and to engage the public. While I see endless possibilities for these technologies, I wanted to understand how professionals in fields related to cultural heritage and artifact collections felt about digital modeling. I spoke with museum professionals, archivists, archaeologists, and private collectors. I believe that these occupations cover some of the most immediate bases in the distribution of digital models. I interviewed Emma Dietrich (Public Archaeologist at the Florida Public Archaeology Network), Rachel Walton (Associate Professor, Digital Archivist & Records Manager at Rollins College), Gisela Carbonell (Curator at the Rollins Museum of Art at Rollins College), Whitney Broadaway (Collections Manager at the Orange County Regional History Center), Bennett Lloyd (Coordinator at the Museum of Seminole County History), and Don Jacobs (Private Collector).

I chose these stakeholders to gain an understanding of the unique needs and ideas of specific organizations, institutions, and communities in regard to digital technologies. Additionally, I have a pre-existing professional relationship with all of the people I interviewed and chose them because I know that they are interested in digital cultural heritage preservation. They also all have ties to Rollins which helps to promote the RCAL's collections outside of the Rollins community. These individuals represent a diverse group of organizations or institutions that are well connected in the community and can lead to future potential interviews and resources. Because this is a small sample size, I have analyzed the data as relevant to the individual organizations and this project. However, I believe that the perspectives of these individuals are representative of the views of individuals in similar institutions and communities.

Institutional Review Board Application and Approval

Before starting these interviews, I applied for and received IRB approval from the Rollins College Institutional Review Board. The recruitment letter can be read in full in Appendix B. I heard back positively from everyone I reached out to and set up interview times with them both in person and over WebEx. Before conducting the interviews, my interviewees signed consent forms that acknowledged they were aware of the risks to the survey. Additionally, the consent form included that anonymity could not be guaranteed due to the small sample size and the unique institutions. I also asked the interviewees if they were comfortably being recorded for the duration of the interview; all of them agreed. I recorded the interviews on my phone and will delete them upon completion of this project. The consent form can be seen in Appendix C.

My interview questions are listed above in the recruitment email. The goal of these questions was to discover how each institution could use digital models and 3D prints to their advantage to increase education and engagement. During the interviews, I tried to ask the questions in order because I feel that they follow a general path. However, some interviews jumped around while other interviewees answered multiple questions in one answer. The two consistencies were the first two questions. I always started with "What do you know about digital models?" and "Are you familiar with Sketchfab?" to ensure that everyone had the same general understanding of the process and basis of this project before answering the later, more specific questions.

Interviews

Archaeology

Professional Archaeologist: Emma Dietrich of the Florida Public Archaeology Network

One of my most important interviews was with Emma Dietrich. Emma taught me almost everything I know about digital modeling, so I knew my conversation with her would be

informative. She is a public archaeologist working for the Florida Public Archaeology Network (FPAN). In her position, she works primarily to make archaeology accessible and interesting to a general and wide public audience. She has taken on digital modeling as the next step in her journey to make Florida's artifacts more visible and educational. In her own words, her "experience with digital modeling comes from mostly what [one] would call macro scale digital modeling. And that is going to be the modeling of smaller artifacts, the handheld objects themselves… [Her] experience with modeling comes through the process of photogrammetry, and the small basic idea of what that is taking photos mathematically to create a 3D image using computer systems" (Dietrich 2022).

As she notes, Emma's experience, much like mine, is mostly in macro-scale digital modeling through photogrammetry. She focuses mainly on Florida artifacts from the Keys to the Panhandle and from Indigenous history to 1950's tourism objects. All of the models that Emma creates are uploaded to FPAN's Sketchfab site (which can be found here: https://sketchfab.com/fpan). She believes that Sketchfab is the best platform for these digital models to be hosted on right now. Due to the interactive nature of comments and likes, "it is almost like a social media platform for 3D modelers" (Dietrich 2022). There is also a great deal of involvement from the Cultural Heritage and History moderators on the site like Thomas Flynn. Thomas Flynn is the Cultural Heritage Lead at Sketchfab. He monitors and promotes model that fall under the umbrella of history or cultural heritage. One of the more important and impressive things that Flynn does is compile a weekly list of the top ten models in cultural heritage and history. I am not sure how he chooses these models, but when one is chosen, the interactions skyrocket. As already noted in Chapter 3, one of the RCAL's models (the Egyptian Scarab https://skfb.ly/o7JDM) made the list in 2021. Many of FPAN's models, mostly made by Emma,

make the list with regularity. Emma also discussed all the updated features that Sketchfab was releasing to customize the final view of your object. For example, the texture of the object can now be glossy or matte or rough. These are updates that have come about in just the last few months. We discussed other platforms to host models, but Sketchfab consistently seems to be the best. One of the other benefits of Sketchfab over other host sites is the ability to download files. FPAN and the RCAL alike make their models available for free public download. This feature allows the public to interact with and manipulate the models in ways that are useful to them. It also allows anyone with a 3D printer to print a replica of the artifact. Sketchfab also allows their models to be embedded into other sites and locations. This makes sharing models very easy across multiple websites or online platforms. "Online models and 3D prints are able to actually bring these artifacts out of curation to the public and also able to promote our partner organizations like the Seminole County Museum, the Sanford Museum, City of St. Augustine Archeology Program by hosting their digital platform, their 3D models, of some of their collections to promote visitation to see these original pieces" (Dietrich 2022).

One of the common threads in my interviews that Emma touched on was the accessibility of artifacts "beyond the glass. Although [one] might be engaging beyond the screen, [they're] able to manipulate an artifact in 360 degrees so [they're] no longer stuck with that 2D display" (Dietrich 2022). If these models are also 3D printed, then there is an added bonus of tactile learning opportunities, so a "person is able to engage in the way they want to in a safe manner versus being stuck and barricaded off" (Dietrich 2022). However, one thing that Emma and Don Jacobs agreed on was the importance and value of the original artifact. While it is hard to put into words, there is a certain magnetism that original artifacts have. Don Jacobs discusses it more below.

Photogrammetry can also be conducted as a sort of "catch and release archaeology" (Dietrich 2022). FPAN frequently surveys sites, but they do not collect many of the artifacts they may find. Photogrammetry can be used to record these artifacts as well as their provenience. In this way, "3D modeling [can] assist in the curation crisis where [archaeologists are] not able to have to collect everything" (Dietrich 2022). This is one clear way of addressing the curation crisis that is plaguing American and the field of archaeology. By digitizing records and artifacts in the field, less artifacts need to be brought back to curation facilities and thus stored in repositories. However, research can still be conducted with these digital models. "Researchers [can] promote their collections for people to do dissertation research, masters research. They're able to get more of their stuff out there" (Dietrich 2022). Digital models are no replacement for the original artifacts, but they do provide solutions to curation and research questions.

Emma ended our interview with where she thought the future of archaeology was going, "I think 3D modeling and documentation are where most institutions will be leaning" (Dietrich 2022). She went on to tell me that many archaeology positions nowadays expect photogrammetry to be a skill that applicants possess. In summation, Emma Dietrich firmly believes that digital artifact models have great potential for public education and archaeological research. There are still limitations of these digital models and 3D prints, but their conservation and preservation benefits outweigh the limitations.

Cultural Heritage Museums

Museum Collections Manager: Whitney Broadaway of the Orange County Regional History Center

I interviewed Whitney Broadaway at the Orange County Regional History Center (OCRHC), and I do not think anyone was more excited about the prospects of digital modeling. I

had worked with Whitney during the Summer of 2021 when I digitized the artifacts that the OCRHC had from Shell Island. She was very passionate and interested in the photogrammetry process and results. Our interview reflected this enthusiasm for new technologies. Whitney brought up many ways in which the OCRHC could use these digital models and 3D prints for education and engagement. When displaying an artifact, the museum staff has "to try and choose what [the] main viewing angle is going to be. But there's going to be a part of [it] that's going to be hidden against whatever [it is] sitting on" (Broadaway 2022). By coupling display objects with small interactive screens that show the digital 3D model, museum attendees are able to manipulate and view the artifact from any angle. At the OCRHC, Whitney works frequently with young children in school groups and summer camps. She really emphasized how effective tactile learning was for these children, especially ones with visual impairments.

As an educational cultural heritage museum in Orlando, Florida, the Orange County Regional History Center receives many visitors of a young and curious age. These children flourish with interactive exhibits and are all very familiar and comfortable with technology. This intersection of education, technology, and interaction is an ideal place for digital models of artifacts. For example, a "3D jigsaw puzzle where kids can put [real artifacts] together" while the original artifact is also on display. Whitney hopes to be able to transfer this idea into the physical realm as well with 3D prints of artifact pieces. There would be the original artifact on display and then replicated pieces of it to construct back together. This ties together engagement and education.

As a museum curator, Whitney is also responsible for the preservation and protection of the OCRHC's collections. She mentioned that "any time [she] bring items, actual original artifacts out to be viewed by other researchers or, you know, school kids, [they] always run the risk of something's getting broken." By having digital models of these collections, researchers can

examine the digital copy instead of the original. There's the "advantage conservation-wise of being able to keep the originals safe in storage." Fragile objects are especially important to have digitized because they are often too delicate to display or pull out for research. Whitney confessed though that "there's just a certain power … handling the actual original artifact that will never be replaced by a reproduction." Whitney also remarked that it would be incredibly useful to link the Sketchfab models within the museum's catalog/database. This would allow people searching the catalog to view the artifacts with digital models all in one place.

One aspect of digital models and accessibility that the RCAL does not have to consider is funding. The RCAL is funded by Rollins College and will continue to be. The Orange County Regional History Center, however, needs to raise funds to cover the cost of operations from electricity and water to conservation and staff. By making their collections free to access online, they run the risk of losing paying visitors to the museum. Monetizing digital resources is something that cultural heritage intuitions are constantly struggling with. There is a fine line between accessibility and sustainable practices. Whitney and I discussed possible solutions for this issue, but we did not come to a conclusion that we felt was right. For example, some institutions charge a small amount to download their digital models (from Sketchfab). This ensures that viewing is not behind a paywall, but the institution is still sustaining itself.

Museum Coordinator: Bennett Lloyd of the Museum of Seminole County History

I also interviewed Bennett Lloyd at the Seminole County Museum. I chose to work with him because Dr. Gilmore had a working relationship with him, and Emma had previously modeled some of his artifacts. This gave me a strong foundation to start the interview process. Bennett was familiar with digital models and other digital technologies used in archaeology. He was also

familiar with and a huge fan of Sketchfab. He likes "the platform because [one] can send the link to anyone and anyone can see these objects and sort of like spin around and get a feel for their size, their condition" (Lloyd 2022). Sketchfab's easily understandable interface and website make it ideal for both beginners and experts to use. The Seminole County Museum is small, but it has a wide variety of collections. Digital modeling helps to highlight the major artifacts in each collection. It also allows the more delicate or fragile artifacts to be replicated and 3D printed. Carefully crafted 3D prints have been successful teaching tools for the Bennett in the past; he says that he has discovered "that by combining these sensory methods, it allows people to retain more information about what they're examining in a museum setting" (Llyod 2022). He does acknowledge though that printing these artifacts can be expensive. The cost of 3D printing artifacts is not something that I went into great depth with because I believe the main value of these models is the digital copy—the print is just a bonus. However, Bennett brought up a great point that these 3D prints may be very useful to small museums for tactile learning, but they can be hard to access and perfect.

As an alternative and possible future plan, Bennett would like to see many of these digital models put into Virtual Reality (VR) environments. These VR settings would be more than just analyzing the artifacts, they would be recreations of how the artifacts were used or created. This is very similar to González-Tennant's recreation work with the Rosewood Cemetery (González-Tennant 2018). Bennett believes that the Virtual Reality world is next for public engagement, outreach, and education. On the preservation side, Bennett does see some benefits to digital modeling. He described how "there can never be too much information" associated with an artifact. This information included provenience, provenance, owner, date, age, location, details, etc. Bennett thinks that these digital models can play into this information game in two ways. First,

they can help to display and store the information in a public facing venue. For example, Sketchfab allows uses to add annotations to their models. This feature allows scholars and creators to add more details and descriptions about their model and is especially helpful to individuals in the Cultural Heritage sphere. Second, the digital model can be stored with all of the digitized records of provenience, provenance, owner, date, age, location, details, etc. The digital file can act as another set of backup data to the original. It cannot replace the original, but if something were to happen to it or to the records, the digital model could help piece together the puzzle.

In regard to 3D prints of artifacts, I mentioned that Bennett was concerned about the price, but the timeline is also a concern. The Seminole County Museum is currently working with the local public library to print replicas for a Fort Mellon recreation. Bennett was frustrated with how long it was taking to get these models printed and returned to the museum. With advancements in technology, I hope that 3D printers will become economical enough for small museums to own one. This would allow them to print their own models on their own time. Bennett did have a few hesitations with these digital prints though. He says, “there's never a way that [one] can get the paint exactly right. The resolution is always going to be slightly off. And I mean, I look forward to the day when technology can prove me wrong on that. But I think that there's a long way coming. I think it provides a suitable substitute, a good facsimile” (Lloyd 2022).

In terms of the Seminole County Museum, and I believe many other similar small museums, one of their future goals is to make their collections more accessible to researchers. There are many privately donated collections that end up at the Seminole County Museum, many of which hold high research potential. Creating digital models of the artifacts not only gets them out to public but puts them out in a way that can be analyzed and studied from the beginning.

Art Museums

Art Curator: Dr. Gisela Carbonell of the Rollins Museum of Art

One of my more interesting interviews was with Dr. Gisela Carbonell at the Rollins Museum of Art. This was an interesting interview because Gisela's main focus is on art, not archaeology or history. Art does fall under the category of cultural heritage most of the time, but it is displayed and cared for in a way that is very different from artifacts. However, the Rollins Museum of Art does house many archaeological artifacts in its collections, most impressively The Banks Bequest. I began modeling the Banks artifacts in fall of 2022. It struck me as very odd that Gisela did not know that I had been modeling artifacts in her museum. She was very excited to hear about my work though. I began our interview by showing her the RCAL's Sketchfab site. Gisela was very impressed and expressed to me profusely about how it would be a fantastic opportunity to embed these models within the museum's website. I think that would be a fantastic idea; it is truly the definition of one department supporting another on campus. She also touched on how uploading models online, would make not only the RCAL's collections more accessible, but the Rollins Museum of Art's collections too. I was shocked when Gisela told me that the Museum only displays about "two percent of [their] collection at any given time" (Carbonell 2022). I think this is a great loss to our campus community—to have so many resources at our fingertips but kept locked away. This is where a digital catalog with models would be helpful and useful to students. The Rollins Museum of Art if first and foremost a teaching museum, so it would be very beneficial if students could learn from the entire collection. Gisela said that she thought a digital repository of artifacts would be "important in terms of accessibility, teaching, and education dissemination of the collection, both engaging our campus community or local communities, but also with visitors from elsewhere" (Carbonell 2022).

Since Gisela is primarily focused on art, she had many comments about the visual appearance of the models, or their 3D printed copies. She also discussed how photogrammetry software can be used to digitize the back or bottom of statues or sculptures. With this technology, 3D prints of various 3D art could be printed. This would allow the visually impaired to access an art museum. Gisela also made an interesting point about digitizing paintings to be able to see and feel the brushstrokes on the canvas. This would also be useful for very delicate pieces in the Rollins Museum of Art's collections. By having a 3D model of a unique object or piece of art, the art lives on.

In conclusion, Gisela wanted to promote the models of artifacts from the RMA, as all as work to create more. The goal of these models is to promote outreach and education through the museum to both a local and nonlocal audience. The Rollins Museum of Art is also working towards creating new resources for people with disabilities. For people with visual impairments, they would be able to interact with a 3D replica of an artifact or painting and understand some of the feel of the object without having to see it.

Archives

Associate Professor, Digital Archivist & Records Manager: Rachel Walton of the Rollins College Archives

Rachel Walton, Digital Archivist and Librarian at Rollins' Olin Library, was not originally on my list of interviewees, but I am so happy that I adder her. She provided incredible insight into the uses and applications of 3D models in archival and educational settings. Her knowledge of 3D models began with monuments and larger scale projects. She was the first person to bring this up to me. She was also aware that small objects, especially rare books, could be digitized in this way. My interview with Rachel Walton was unique because for the majority of the interview she asked

me questions about digital models. This was beneficial for me because it allowed me discuss ideas related to my research with someone new. She was very curious and interested that this technology was taking place on Rollins' campus and wanted the Archives to be involved. I am currently working on creating models of a selection 3D objects for the Rollins Archives that include rare examples of early writing and personal items that belonged to Mr. Fred Rogers.

Rachel was also very interested in the RCAL's Sketchfab page. She wanted to highlight it and share it with more of the Rollins community. I thought this was incredible. The Rollins Archive has a really strong social media presence and following. By sharing the RCAL's work, we are not only building Rollins community relationships, but we are sharing broader work between two audiences. I am sure that people who are passionate about the Archives' page would be interested in the RCAL's Sketchfab, and vice versa.

As someone who works with perishable materials, such as rare and vintage books, Rachel knows the importance of preservation and accessibility. Fragile documents are not able to be accessed as often. This issue can be solved by creating a digital scan of the text. However, what if the physical book itself is the remarkable and important part? A 3D model of the entire book would work the same way as a textual scan. The Library of Congress has done something similar with a Guttenberg Bible. They have the Bible open to a particular page, but next to it, they have a digital display of multiple pages and angles of the book. This keeps the Bible preserved and intact while allowing visitors and researchers to study the different aspects of it.

Private Collections

Private Collector: Don Jacobs of Central Florida

Probably the most unique interview that I conducted was with private collector Don Jacobs. Don is a Central Florida native and is very proud of his local heritage. He has lived in the same

area of Seminole County his entire life and has been collecting artifacts and fossils from local sites for decades. Working with private collectors is always tricky territory for archaeologists, but there is also so much to be learned. No one knows the local land and history quite like the local people. Jacobs is no exception, and he strongly believes in the power of local community.

Jacobs biggest complaint about archaeologists is that they excavate a site and then ship off their artifacts to some distant warehouse and leave it there. Because of this relocation process, many artifacts end up far from the local communities that may be interested in them. He wants these artifacts to be left in their local community. He understands that there might be some curation issues, but he is willing to address those issues as they arise. Jacobs is a firm advocate for artifacts staying local, so he was very on board with the idea of digital modeling. For the time being, he was pacified with the idea that the local community could keep the replica or the 3D print and access the digital copy, while the original artifact could go to a repository. However, Jacobs is hopeful that in the future, the original can stay with the local community and the state can get the digital model. I think either of these solutions is fair and decent. The curation crisis is real, and repositories are filling up. If local communities want to keep their artifacts and have a way to preserve them and make them digitally available, then I think that is a very sensible solution.

Another thing that Jacobs feels strongly about is that replicas are less meaningful and impressive than the original artifacts they represent. He argues that there is something special about holding a piece of pottery that was created by humans in the same area 4,000 years ago. I cannot argue with him on this matter because I do believe there is a unique human connection to the past that is inherently rooted in the tangible nature of archaeology. However, I believe that there is a lot of room for digital models and reproductions and prints to be used with children or in less controlled environments.

Analysis and Comparisons

While the individuals that I interviewed represent different institutions, there are some similarities in their responses. One of the main similarities was the emphasis that a 3-D replication was not the same as the original. I do not believe that anyone would believe a 3-D print is as good as the original; however, I thought it was interesting that everyone emphasized the fact that the replicas were in fact very different than the original. Many of the museum, archival, and curatorial professionals focused on the preservation benefits of these digital models. Museums' goals are to preserve artifacts and to display them. There is an interesting dichotomy here. Many artifacts would be better preserved in storage than they would on display. Museums are constantly finding new ways to ensure both preservation and education purposes are achieved. The museum and archival professionals all mentioned that an artifact could be modeled and then displayed digitally, or a replica could be displayed. The public archaeologist and private collector both focused on the public outreach and engagement that these artifacts and digital models can have. They saw the public-facing opportunities first and the preservation second. I thought this was very interesting. I see preservation and outreach as a compromise. Artifacts can be made accessible to everyone, while also being preserved for future generations. However, I do agree with the collectors and archaeologists in the sense that digital models can predominantly be used for public outreach. I think that preservation of artifacts is important, but a replica will never replace the original.

Another similarity in the interview responses I received was that digital models make collections more accessible. In one sense, they make collections more accessible to the general public, but in another, digital models allow researchers to locate artifacts they may need for research. Many museums like the Seminole Country Museum are too small to have large, publicly

accessible digital databases. However, they are able to host a Sketchfab page with their significant artifacts listed. Sketchfab results frequently populate near the top of a Google search for a particular artifact type. Emma mentioned that recently Sketchfab results were popping up before journal articles when she searched for artifact types (Dietrich 2022). For example, if I Google "St. Johns Incised," the fourth result is the RCAL's Sketchfab page. The fifth result is an article from JSTOR. If I wanted to find out more about St. Johns Incised pottery, I would be able to click on the Sketchfab link and see a 3D model of a real sherd. I would also be able to locate this sherd and inquire about it through Sketchfab's descriptions and comments. This not only makes artifacts accessible for professionals and researchers, but Sketchfab also makes these digital models easily searchable to the everyday person interested in archaeology. If smaller museums were able to upload more of their collections online, they would be searchable to a large audience. This would help both archaeological research as well as local interest.

One issue that came up in a few of the interviews was how to actually create the 3D models. I volunteered to create models for all of the institutions that I interviewed. Artifacts from different institutions can be found in labeled "Collections" on the RCAL's Sketchfab page (linked here: https://sketchfab.com/rollins_archaeology/collections). I know that through FPAN, Emma has also modeled artifacts for many of the non-Rollins institutions and organizations. However, without interested and dedicated volunteers, photogrammetry is difficult task to execute. As I have explained previously, it is very simple to learn, but this does not mean that there will always be people to do it. This is an issue for which I do not have a foolproof solution. Emma and I have both taught students and volunteers how to create these digital models with photogrammetry, but we cannot ensure that they will continue to create models for these institutions. No matter how

low cost or easy photogrammetry is, it is necessary to have an interested and willing individual to complete it.

My main takeaway from all of my interviews is that there are no downsides to having these digital models (excluding the modeling of sacred/sensitive objects or human remains). There are, on the contrary, many significant benefits to having these digitals models. From the perspective of museums and archives, artifacts can be preserved and stored safely, while digital or 3D printed models of the artifacts be displayed. For private collectors, 3D models can make their collections accessible to researchers while allowing them to stay in control and possession of their artifacts. For archaeologists, 3D digital models can be used to increase public outreach and education. For researchers, digital models can be searched for online and examined in my detail than a simple 2D photograph. For educational facilities, 3D models and prints can be used as tactile learning assistants in classroom and exhibit settings. There are endless possibilities for the benefits and uses of these digital models and their printed counterparts, while the disadvantages are hard to find.

CHAPTER 5: CONCLUSION AND LOOKING FORWARD

SUMMARY AND DISCUSSION

Photogrammetry and digital artifact models have already impacted the Rollins College Archaeology Lab (RCAL) in a dramatic way. For decades, the RCAL has operated largely in isolation, only rarely working with other repositories on campus, much less partnering with institutions in the local community or beyond. It did not have any substantial public facing or publicly available records or information, and its collections of artifacts were left to basically sit in a storage locker. Unfortunately, this situation is not an uncommon occurrence for archaeological collections, and it stems from what archaeologists today are calling the Curation Crisis. It is a crisis because thousands of archaeological collections are being forgotten about and not properly being taken care of after excavation and initial analysis. This is despite that fact that collections hold immense potential for new research and provide a more sustainable approach to archaeology.

As detailed in this thesis, one way we are combatting this curation crisis at Rollins College is digitizing our artifact collection. It is common for archaeological repositories to digitize their records and catalog, but the practice of digitizing the artifacts themselves is still relatively new. At the RCAL, we use photogrammetry to create a 3D digital reconstruction of the artifact. These models are uploaded online to a free website: Sketchfab. Online, these models can be viewed and manipulated by anyone with internet connection. The other benefit of these digital models is student involvement. Students participate in the photogrammetry process of creating the models as well as the educational benefits of having plastic replicas on hand in the lab. It has been demonstrated that students learn well though tactile experiences. Having accurate plastic 3D models of artifacts allows students to engage with them directly with no fear of damaging the original. It also allows students to interact with artifacts that are not physically housed at Rollins,

such as Shell Island artifacts that are currently on display at the Orange County Regional History Center.

The collaborative potential of digital artifact models does not end there though. Photogrammetry allows the RCAL to expand its reach and accessibility. As a result of this project, other repositories on campus are also more aware of what the RCAL has to offer, both physically and technologically. In turn, the RCAL is more aware of the other resources on campus and how they can contribute to the increasing engagement and accessibility of the RCAL's collections. For example, the Rollins Museum of Art (RMA) has more non-student visitors than the Archives or the Archaeology Lab. It is an educational museum that is predominantly public facing. When the RMA includes links to the RCAL Sketchfab page on their website, they are boosting our views and engagement. It is also likely that people will click from there to view to the rest of our digital collection.

An important aspect of the collaboration process was interviews with relevant professionals. I interviewed Emma Dietrich (Public Archaeologist at the Florida Public Archaeology Network), Rachel Walton (Associate Professor, Digital Archivist & Records Manager at Rollins College), Gisela Carbonell (Curator at the Rollins Museum of Art at Rollins College), Whitney Broadaway (Collections Manager at the Orange County Regional History Center), Bennett Lloyd (Coordinator at the Museum of Seminole County History), and Don Jacobs (Private Collector). I chose these individuals because they represent an important community in Central Florida's cultural heritage preservation and education. Through my interviews, it was clear that these digital models are going to be an important next step in the field of archaeology. While there were limitations to what models could do, there were no glaring issues that indicate creating and having these models is a bad idea. The weight and texture of a 3D print might not be right, but

it still allows children to play with it to gain an understanding of the shape and size of the artifact. The digital file will never replace the original artifact, but in the event of loss or disaster, a digital copy can be useful in reconstructing the past.

So why does this research matter? The short answer is that this research matters because the accessibility and engagement of the Rollins College Archaeology Lab needs to be increased. The RCAL has too many archaeologically significant artifacts and collections (e.g., our shell tools and extensive pottery collection) to remain unstudied and unutilized. In many cases, archaeological sites were damaged or destroyed in the recovery of these collections. It is therefore ethically imperative that we work to make the RCAL's contents more active and publicly visible. By doing so, general knowledge about Rollins' and Florida's history is made more accessible to the local community members and beyond.

Figure 2: Full photogrammetry set up. (Photograph by Scott Cook.)

There are multiple additional benefits of this project as well. First, students learn a valuable skill that they can put on their resumes. Photogrammetry is gaining popularity and prevalence in the field of archaeology, especially in higher education, and is a highly marketable skill for students to have. Second, in learning photogrammetry, each student will create their own 3D models of unique artifacts from RCAL's collections, ensuring that artifacts curated at Rollins will continue being digitized and made publicly accessible. While the quality of the resulting models may be variable, their creation will help ensure that Rollins' archaeological collections remain an active resource in the future. Third, each students gains a deeper understanding of the artifact they chose to model. This hands-on connection to the class and to history is very engaging in and of itself. As Nancarrow (2016) states, students learn more from engaging with these artifacts and creating models of them than they do simply looking at them.

RECOMMENDATIONS FOR THE FUTURE

Through this research, I have compiled a series of recommendations to continue making the RCAL's collections a tool for student and public engagement. I hope that this plan can also be used by other schools and institutions to increase their collections' accessibility. The first step in this process was making the Rollins College Archaeology Lab's collection accessible through digital 3D models of artifacts. I created over forty-five models myself and uploaded them to the RCAL's Sketchfab page. Perhaps more significantly, however, I helped lay the groundwork for teaching future Rollins students how to conduct photogrammetry in various archaeology classes. Once I had a thorough understanding of the photogrammetry process, I wrote a detailed workflow for other students to use (Appendix A). This workflow includes all of the basic information as well as detailed images and troubleshooting solutions. My knowledge and this workflow were put to the test this semester in ANT395: Curating Archaeological Collections. As part of the final project, every student was tasked with creating their own digital model of an artifact from an assigned

collection. Every student was given the workflow, and most were able to complete the process with very few issues. Through this process, I was also able to find the places that my workflow was unclear or incomplete, and I have made revisions based on the information gathered. I also added a visual component to the guide to further assist inexperienced modelers who are unfamiliar with the software. This completed and revised workflow is available in the RCAL and through Dr. Gilmore for future students to use.

From my time conducting photogrammetry, I have learned numerous tricks strategies that help produce the best models that I have since passed on to other students. First, choose an artifact that has a clear interior and exterior. Objects with surfaces that are difficult to distinguish will be harder to compute later. Second, take more photos than necessary. Sometimes it is impossible to rephotograph an artifact, so it is always better to have too much data than not enough. Third, be patient. The "clean-up" stage of the modelling process when using Agisoft/Metashape can be very tedious but yields impressive results.

I strongly recommend incorporating digital modeling and photogrammetry into more classes at Rollins, especially those focused on archaeology or materiality. As I have stated above, there are many benefits to teaching students photogrammetry. Based on my experience in several Archaeology and Art History classes, this technology would be an incredibly worthwhile addition. For example, I recently created multiple models of the Banks Bequest for use in future iterations of ARH213: Archaeology of Egypt and the Near East. In this class, every student is required to choose an artifact from the Banks collection, researched its context, and write a description of the artifact for future reference. Most of the artifacts currently have only a single photo record. It would be helpful to future students for these artifacts to be available for 3D digital inspection. It

is my suggestion that any class in the future that centers around a physical collection housed at Rollins include a photogrammetry assignment.

Having the proper equipment is important for creating photogrammetric models and teaching the technique to students. The RCAL invested in the high-quality photogrammetry equipment that I have previously discussed, including an automated turn table, light box, and high-quality camera. The only suggestion I would make would be to invest in another set of equipment so more than one person could photograph at a time. The Agisoft/Metashape software is another important investment in the photogrammetry process, one that makes photogrammetry learnable for students with little or no previous experience. I am very familiar with Agisoft/Metashape, and I think that it works very well. However, there are always new technologies emerging. Reality Capture is a software owned by Epic Games that is specifically designed to model objects. Agisoft/Metashape can create both landscapes and objects, but Reality Capture is programmed to look for and create individual objects. Because of this, there is less editing and cleaning up in the creation process. I have just begun to experiment with Reality Capture, so I cannot say if it is better than Agisoft/Metashape yet. However, I recommend that the RCAL continue experimenting with new modeling softwares and technologies as they are released.

My next recommendation is to use 3D modelling as a tool for increasing collaboration with stakeholders both around and beyond Rollins' campus. While the RCAL has an abundance of artifacts to model, one way to increase engagement and visibility is to work more frequently with other on-campus repositories, such as the Olin Library Archives and the Rollins Museum of Art. The Rollins Museum of Art has many collections that are predominantly artifacts. By collaborating with the RMA, the RCAL was able to help document and preserve artifacts with great archaeological significance. For example, many of the Egyptian artifacts from the Banks Bequest

are among the most viewed and liked objects on our Sketchfab page. I strongly recommend that the entire Banks Bequest be digitized. It is an important collection of Egyptian and Near Eastern artifacts with an equally interesting provenance. In addition to the Banks Bequest, I am currently in the process of working with the Rollins Archives to model some examples of Egyptian artifacts and various Mr. Rogers memorabilia. I suggest continuing to work with the Archives to digitize their collections, which include everything from ephemera related to Rollins' early history.to. Cuneiform tablets from ancient Mesopotamia. The Archives also has many resources for publicizing artifact models and maximizing their public engagement impact, including various social media accounts and a blog.

Collaboration through 3D modelling benefits everyone involved. Not only does the RCAL gain exposure to the other collections housed on campus, but the Archives and the Rollins Museum of Art are able to learn more about their collections and what the RCAL has to offer. The RMA and the Library Archives can increase public engagement by offering another outlet for the models to be displayed, while the RCAL can provide the actual technology to create the models. The RCAL can also create 3D printed replicas of artifacts held in either the RMA or the Archives to have available in the Lab at all times. In summation, I recommend that RCAL students continue to work with other repositories on campus to digitize their collections and continue increasing public awareness.

Another important part of making the Rollins College Archaeology Lab's collections more engaging is working with local museums and cultural heritage institutions. Through my work with the Orange County Regional History Center and the Seminole County Museum, many artifacts were digitized that would otherwise have remained unnoticed on the shelves of local museums. By collaborating with the RCAL, these museums obtained digital models of their artifacts, and, in

return, the RCAL hosts these artifacts on their Sketchfab page. This is likely to increase visibility and interaction with other RCAL artifacts as interested website visitors view the museums' artifacts. To further increase engagement and visibility, I recommend that these models be linked though the museums' websites and digital catalogs. While the models on Sketchfab have the institution's name attached, it would be more helpful if the institution itself promoted these models. My other recommendation is to continue working with the OCRHC and the Seminole County Museum, but to also reach out to other museums in the Central Florida area. The Sanford Museum has a relationship with FPAN, and I have worked with them to teach high school students about photogrammetry. This museum would be a great addition to RCAL's outreach. Additionally, I suggest reaching out to the Museum of Geneva History in Geneva, Florida and the Morse Museum in Winter Park, Florida. Both of these museums have collections with untapped potential.

Avocational archaeologists and private artifact collectors are also an important stakeholder in this discussion. Many collectors have access to a vast array of artifacts that researchers and the general public alike would benefit from seeing. Some archaeologists object to working with any collectors on ethical grounds; however, the RCAL has set a standard of working the collectors who operate within the boundaries of historic preservation laws and whose motivations are primarily educational. I hope that by continuing to work with Don Jacobs, that the RCAL can reach out and collaborate with other private collectors in the Central Florida area. This partnership can continue to make private collections visible to the public and researchers.

In conclusion, digital modeling and photogrammetry have been my passion and fascination for over a year. I strongly believe that there are countless opportunities for good that these models can facilitate. They make archaeology accessible to anyone with internet. These digital models can be access from anywhere by anyone—teachers, students, professionals, hobbyists, curious

individuals. Digital models take archaeology out of the field and the lab and put it in the public eye. 3D prints can be used to increase engagement even more through tactile experiences and hands on learning. I will continue to work with this research to promote accessibility and public engagement of archaeological collections.

APPENDIX

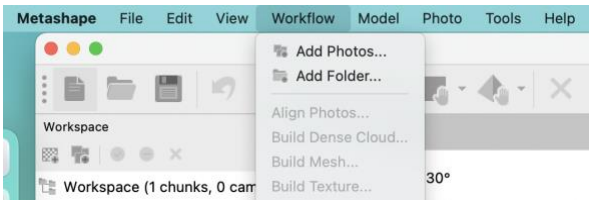
Appendix A: Photogrammetry Instructions

RCAL: Photogrammetry Workflow

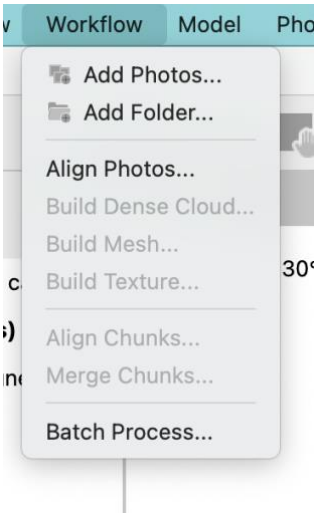
1. Setting Up
    a. Make sure the lightbox is set up and the turntable and lights are plugged in.
    b. Download the Foldio360 App by ORANGEMONKIE / 360° Product Photography
        i. The app is free and will ask you to create an account. They will not send you emails or contact you, so sign up with your Rollins email.
    c. In the app, chose *Turntable Control.*
    d. Then click *Select Device* and chose *Foldio360*.
        i. The turntable should have a blinking blue light to let you know it's on.
    e. You want roughly 24 images per cycle, so set your turn to 15 degrees.
        i. This will ensure that each photo overlaps and connects once uploaded.
    f. Turn on the lights.
    g. Place the artifact in the center of the turntable.
        i. Make sure the artifact is stable.
        ii. You can use white mounting putty to secure an artifact or to get a better angle of it.
    h. Turn on the camera and make sure the flash is off. The micro lens is best for photogrammetry.
        i. If your photos are coming out dark, use the P setting instead of Auto.
    i. Focus the camera on the area of the artifact you want to capture in the most detail.
    j. You can also automate this process by turning on the Remote Control Access in the camera's menu and selecting Quick Time Response. Then, in the Foldio360 app (after you've already selected and tested Turntable Control), you can select the DSLR option. Then click the drop-down menu and select Nikon 1. At the bottom, select 36 or 48 pictures, this ensures that you will get enough photos. Click Connection Test to make sure that the app, turntable, and camera are all connected. If this works, then click the large orange button and let it take your round of photos. If the Connection Test does not work, you can try turning the camera on and off again, or just take the pictures manually.
2. Taking Photos
    a. Begin alternating taking a photo and rotating the turntable 15 degrees.
        i. There is a piece of putty on the turntable that should begin above the blue light. When it reaches the blue light again, you know you have done a full cycle.
        ii. Do not move the artifact during a cycle. You can slightly move the camera, if necessary, but try to avoid it.

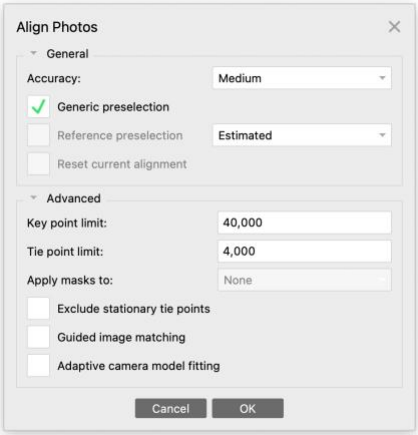
b. Once you have finished your first cycle, you will repeat the process until you have fully captured the artifact. The image to the right is the general idea of the different angles of the artifact you want to capture. Each photo should overlap with ⅔ of the next photo (that includes left and right, but also up and down). If you have a small object, you can usually get away with three rounds of the object on one side, then flip it and do another three rounds (from below, level, and from above). If your object has an interior (like a pot), you will have to take additional images and rounds of the inside to capture the details and texture.
c. In the end, you should have over 150 photos of the artifact on the artifact.

3. Uploading Photos
    a. Upload the photos from the SD card onto the computer. Put them into a file and label it with the name of the artifact.
        i. **It is essential that once you upload the photos to Metashape, you do not move them or rename the file, so pick a good name and stick with it.**
4. Metashape / Agisoft
    a. Open Metashape and start a new project.
        i. Sidenote: If you're not sure, just try something! You can always start the process over again if something goes wrong. The best way to learn is through trial and error.
    b. Go to Metashape Preferences and select GPU along the top. Make sure that the correct GPU on your computer is selected.
    c. Click **Workflow** and *Add Folder*. Select the folder you just created and uploaded the photos into.
        i. You can also select *Add Photos* and select just the photos you want to upload.
        ii. Select *Single Camera* if prompted.



    d. Once your photos are in Metashape, click **Workflow** and then *Align Photos*.
        i. This will give you options. You want to align your photos on Medium or high for best results.
        ii. If you are using a high-powered computer, you should align the photos on High.
        iii. The rest of the settings remain the same (Estimated, 40,000, and 4,000).

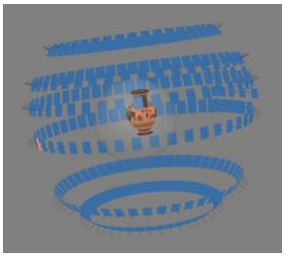




    e. When your photos have finished aligning, you should have a Point Cloud. This needs to be cleaned up before the Dense Cloud can be made.

i. It is okay if 3-5 of your cameras do not align. However, if more than 10 are not aligned, you will need to take more photos.

f. You can rotate your point cloud by selecting the arrow symbol at the top under **Workflow** (it is most likely already selected). You can also right-click on the model to move it around. You can continue to use these methods to move and manipulate your model throughout the editing process.

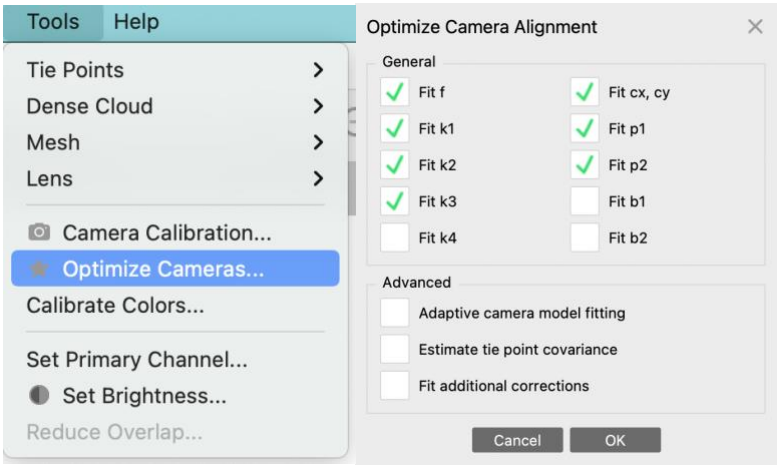


g. You may see the icons of photos around your model. To make this go away, select the camera icon at the top right of the screen and unselect *Show Thumbnails*.

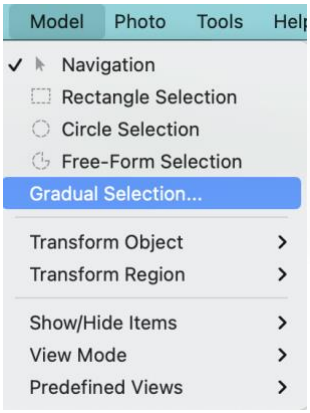
h. There are five steps to clean up a Point Cloud.

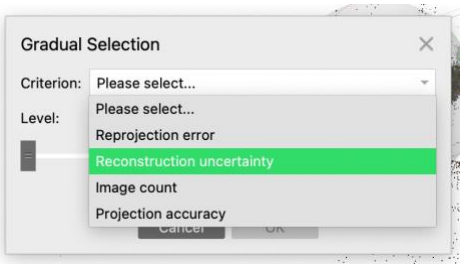
i. First, go to **Tools** and select *Optimize Cameras*.

1. You might also find that some of your cameras fall out of alignment during these steps. That is okay as long as there are not over 10 cameras unaligned.

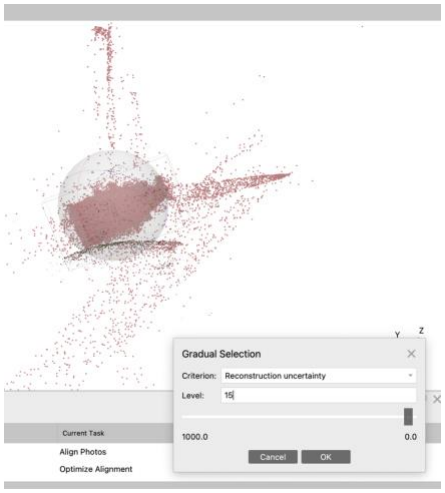


ii. Second, go to **Model** and click *Gradual Selection* then select *Reconstruction Uncertainty*. Type in 15 in the number box. Hit enter and you should see lots of red points. Click delete (Delete key on PCs and Fn+Delete on Macs) and your point should look much clearer. Go to *Tools* and select *Optimize Cameras* again.





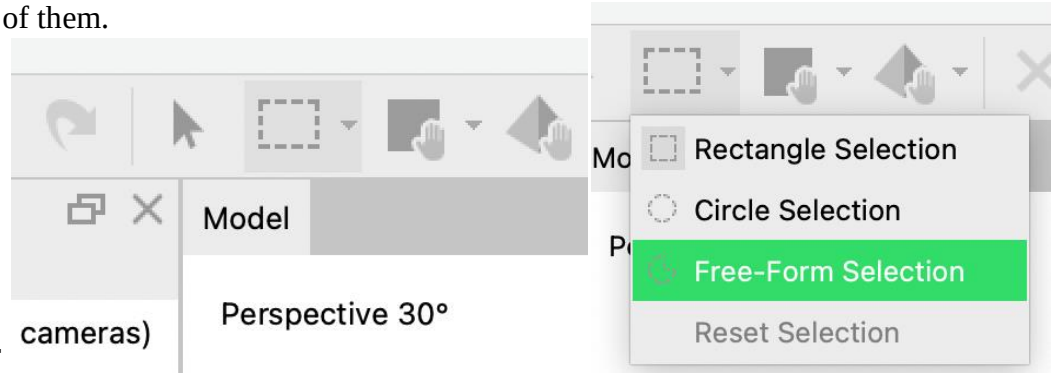
iii. Third, go back to *Gradual Selection* and select *Projection Accuracy*. This number is a little tricky. When you type in a number, the number of points that are selected should appear in the bottom left corner. You want this number to be a little less than half of the total points. The first number you should try is 4, if that is too high, try 5, then 5.5, then 6. (It

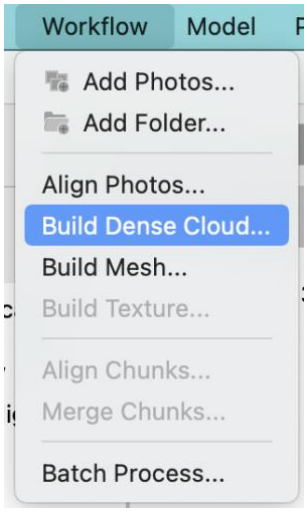


is alright to use up to 11, but try not to). Most of the time somewhere between 5 and 5.5 works the best. Use your judgment and hit enter. Then delete. Then go to *Tools* and select *Optimize Cameras* again.

iv. Fourth, go back to *Gradual Selection* and select *Reprojection Error*. The number of selected points should be about 10% of the total number of points. Drag the slider so that the number in the bottom left corner shows that roughly 10% of points are selected. Hit enter, then delete. Finally, go to *Tools* and select *Optimize Cameras* one last time.

v. Lastly, there will probably still be some outlier points. You will have to manually clean these up. Select the Dotted Box under where it says **Photo** at the top. Click the drop-down arrow and select the *Freeform Selection* tool. You can use this to select any area of the model and delete it. To clean up the outliers, simply draw a shape around them. When they're selected, they will turn red like the selected dots in steps 1-4. Hit delete, and you're set. Try to clean up as many points that do not fit into the final desired model as possible. You will have to rotate the point cloud to see all of them.





i. Once your Point Cloud is clean, you are ready to make the Dense Cloud. Go to **Workflow** and select *Build Dense Cloud*.

i. Depending on the quality of the model required, you will select Low, Medium, or High. The rest of the settings will stay the same.

ii. Letting the Dense Cloud run can take up to 3 days depending on what level you run it at.

j. When your dense cloud finishes, double-click *Chunk 1* on the side of your screen and then select *Dense Cloud*. You will see that there is once again a lot to clean up. Select the *Freeform Selection* tool and start deleting points that do not make up your model.

i. Be careful when editing to not take out a chunk of your model in the process. There is an undo button in the top left corner should you need it.

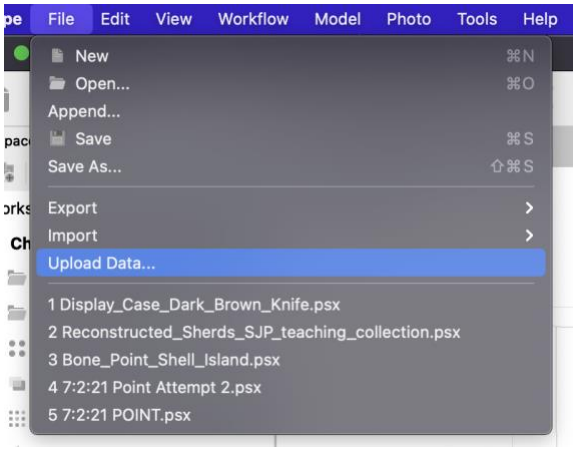
k. Once you have cleaned your model from all sides, go to **Workflow** and select *Build Mesh*.

i. The settings for the mesh should be Dense Cloud, Arbitrary, Medium, Enabled, and check Calculate Vertex Points.

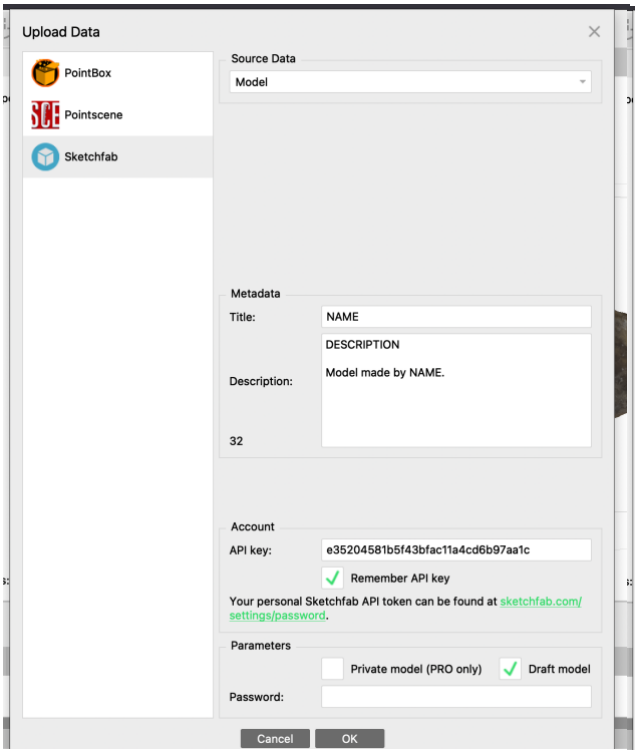
l. Next, go to **Workflow** and click *Build Texture*.
   i. The settings should be diffuse map, images, generic, average, 4096x1, and check enable hole filling.

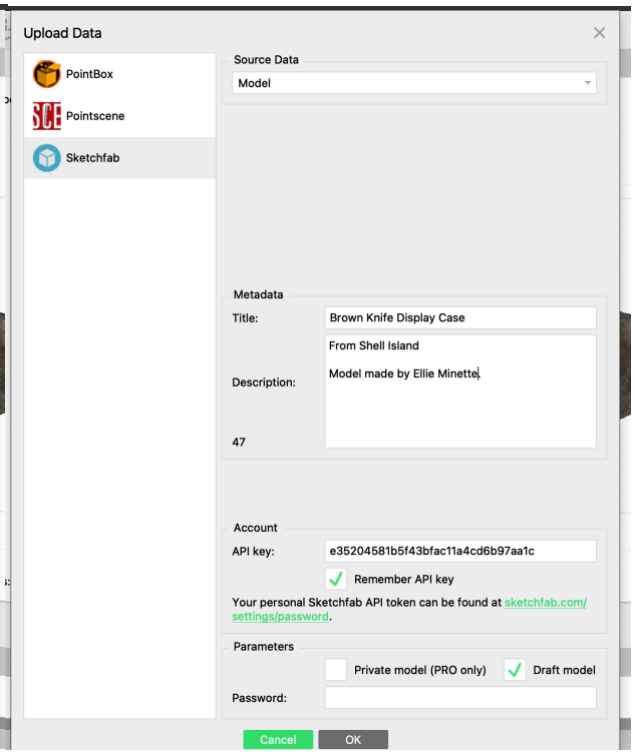
m. Once the texture finishes, you are done with your model!
   i. Make sure you save it and name it something you will remember.

5. Exporting your model to Sketchfab
   a. To upload your model to Sketchfab, go to **File** and select *Upload Data*. A popup window will open and allow you to upload your model directly to Sketchfab. Make sure you're uploading Model where it says Source Data.



   b. The other fields should be:
      i. Title: What is the artifact
      ii. Description: More information on the artifact and "Model made by [your name]"
      iii. The API key is: e35204581b5f43bfac11a4cd6b97aa1c
      iv. Make sure you check *Draft Model* when you're uploading. This will allow you to go into Sketchfab and edit the caption and 3D settings before you publish it.





Appendix B: Interview Recruitment Email

Hello there!

I am Ellie Minette, a senior at Rollins College. I am currently working on my Honors Thesis. I am researching the uses and applications of 3D digital models of artifacts to make the Rollins College Archaeology Lab more accessible and engaging.

I would like to interview you as part of this research. I feel that you are qualified to answer these questions and provide a unique perspective with your answers. Below you will find the list of questions.

I want to make it clear that your involvement in this interview is entirely optional, and you may withdraw your involvement at any time before, during, or after the interview, up until April 1st, 2022. To withdraw, email me (eminette@rollins.edu) that you would like to withdraw and I will delete your information and responses from my phone and thesis. You are welcome to skip or not answer any questions you would not like to answer. Due to a small sample size, I cannot ensure confidentiality or anonymity in this study. When we conduct this interview, I will have a consent form for you to sign that confirms your consent to participate and your consent to be audio-recorded. You may choose to opt out of the latter option. If you would not like to participate, please let me know. I am more than happy to answer any additional questions you may have regarding this project and process.

Would you prefer to conduct this interview in person or via Zoom/WebEx? Additionally, what days and times are convenient for you? I expect this interview to take about 30 minutes.

Interview Questions:

1. Are you familiar with digital modeling of artifacts? If so, what is your experience with it? How were you exposed to it?
2. Sketchfab is an online platform that hosts thousands of digital models of all kinds. We upload all of our 3D models to Sketchfab so anyone with internet can see them and interact with them. Here is a link to the Rollins College Archaeology Sketchfab account [https://sketchfab.com/rollins_archaeology]. I encourage you to check out our models as well as other ones listed on the site. Was this your first time on Sketchfab?
    a. If so, what were your first impressions?
    b. If not, why had you been on it before?
3. How can digital models be used for public outreach and engagement?
4. How can digital models be used for preservation?
5. How can 3D printed models be used for public outreach and engagement?
6. How can 3D printed models be used for preservation?
7. How can your institution would benefit from using digital models online? Do you think they would benefit more from posting them on social media, Sketchfab, or the institution's website? Why?

8. How do you think that your institution would benefit from using 3D printed models in person, either on display or for tactile learning opportunities?

Looking forward to hearing back from you!

Best,
Ellie Minette
Anthropology | Archaeology
Rollins College ’22”

Appendix C: Interview Consent Form

CONSENT FORM

STAKEHOLDER INTERVIEWS ON THE APPLICATIONS AND USES OF DIGITAL MODELS OF ARTIFACTS

Principal Investigator: **Elizabeth Minette, Student, Rollins College**
Faculty Advisor: **Dr. Zackary Gilmore, Professor, Rollins College**

You are invited to participate in a research study about **the applications and uses of digital models of artifacts in promoting accessibility and public engagement for schools and cultural heritage institutions, especially the Rollins College Archaeology Lab.**

If you agree to be part of the research study, you will be asked to participate in a 30-minute audio recorded interview, either virtually or in person, where we will discuss the applications and uses of digital models of artifacts in promoting accessibility and public engagement.

Benefits of the Research: A more complete idea of how digital artifact models can be used for education and preservation by schools and other cultural heritage institutions.

Risks and Discomforts: There are no risks or discomforts in this study.

Compensation: There will be no compensation for your participation in this interview.

Participating in this study is completely voluntary. You may withdraw your involvement at any time before, during, or after the interview, up until April 1st, 2022. To withdraw, email me (eminette@rollins.edu) that you would like to withdraw, and I will delete your information and responses from my phone and thesis. You are welcome to skip or not answer any questions you would not like to answer. Due to a small sample size, I cannot ensure confidentiality or anonymity in this study. When we conduct this interview, I will be audio recording our interview for the purpose of quoting you. The recordings will be stored on my cellphone and will be deleted May 1, 2022 when this project has come to an end. You can opt out of audio recording

below. You can still participate in this interview if you refuse to be audio recorded. Please check the box below that corresponds with how you would like to proceed.

[] I consent to being audio recorded **[] I do not consent to being audio recorded**

Information collected in this project may be shared with other researchers, but we will not share any information that could identify you without your express permission.

If you have questions about this research study, please contact Elizabeth (Ellie) Minette at *eminette@rollins.edu* or Dr. Zackary Gilmore at *zgilmore@rollins.edu*

If you have questions or concerns about the study, please contact:

Rollins College Institutional Review Board
Dr. John Houston, IRB Chair, Rollins College,
1000 Holt Avenue, Winter Park, FL 32789-4499
Telephone: 407-646-2099 E-Mail: jhouston@rollins.edu

If you consent to participating in this research, please sign here:

_____ _____
Signature Date

Appendix B: Interview Recruitment Email

Hello there!

I am Ellie Minette, a senior at Rollins College. I am currently working on my Honors Thesis. I am researching the uses and applications of 3D digital models of artifacts to make the Rollins College Archaeology Lab more accessible and engaging.

I would like to interview you as part of this research. I feel that you are qualified to answer these questions and provide a unique perspective with your answers. Below you will find the list of questions.

I want to make it clear that your involvement in this interview is entirely optional, and you may withdraw your involvement at any time before, during, or after the interview, up until April 1st, 2022. To withdraw, email me (eminette@rollins.edu) that you would like to withdraw and I will delete your information and responses from my phone and thesis. You are welcome to skip or not answer any questions you would not like to answer. Due to a small sample size, I cannot ensure confidentiality or anonymity in this study. When we conduct this interview, I will have a consent form for you to sign that confirms your consent to participate and your consent to be audio-recorded. You may choose to opt out of the latter option. If you would not like to participate, please

let me know. I am more than happy to answer any additional questions you may have regarding this project and process.

Would you prefer to conduct this interview in person or via Zoom/WebEx? Additionally, what days and times are convenient for you? I expect this interview to take about 30 minutes.

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Looking forward to hearing back from you!

Best,
Ellie Minette
Anthropology | Archaeology
Rollins College '22"

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