

Virtual Karam Collection: 3D Digital Imaging and 3D Printing for Public Outreach in Archaeology

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Archaeological museums are often perceived as repositories of relics, entrusted to preserve ancient material culture in perpetuity but at the same time committed to making it accessible. The fear of deterioration often denies access or imposes limits on the interactions between visitors and artefacts. This contribution will present the results of the Virtual Karam Collection, a digitization project of archaeological heritage consisting of a collection of artifacts that has limited access and is not properly shared and communicated with the public: The Farid Karam Lebanese Antiquities Collection of the University of South Florida's Libraries. 149 objects were 3D scanned and the digital models were shared with the public using an ad hoc web platform. It is clear that digital renderings cannot replace real objects; however, the digital surrogates and replicas make up for it by being available for experimentation and manipulation. In order to overcome the obvious limitations on tactile interaction with digital media, an alternative system was used, employing realistic 3D printed copies and having student stakeholders in the collection participate in creation of the replicas. The promising result of this project offers a new perspective on the practice of virtual mimesis of ancient artifacts as strategic educational tool both for people with visual impairments and cognitive disabilities, and for the general public which can learn more using the touch interaction.

Key words:

Digital Heritage, Accessibility, Touch Interaction, 3D Scanning, 3D Printing.

CHNT Reference:

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INTRODUCTION

The digital revolution in the sciences and humanities has encouraged the development of a wide range of new approaches to museum practice that are encompassed in the concepts of digital museology and digital heritage [Smith Bautista 2014; Hermon and Hazan 2013; MacDonald 2006]. This 'digital turn,' which has increased in intensity and scope throughout the past decade, has transformed museums—informing new approaches to public outreach, education, collections management, exhibit design, marketing, public relations, and leadership [Stobiecka 2019; Biehl and Harrison 2014; Srinivasan and Huang 2005; Baustista 2013]. These changes have also fueled a reassessment of the role of museums in the 21st century – in particular, raising the issue of how digital technologies enhance or undermine the museum standards and best practices set forth by national and international organizations [Mairesse and Desvallées 2009; Merritt 2008]. This concern is also prescient for digital heritage professionals who must navigate the confluence of material culture, preservation, and access in diverse contexts [Cameron and Kenderdine 2007].

There are still critical lacunae in the discussion of cultural heritage accessibility and the question of how the virtual museum can become a more inclusive and participatory institution. Learning from objects is a multisensory experience, and the use of haptic technologies, which recreate the sense of touch, are gaining traction in museology because they offer a new way of learning and teaching through objects [Chatterjee et al. 2008]. Haptic technologies limit direct human interaction with authentic objects, while still providing the engaging tactile experience of handling models. This not only aids in preservation, but also promotes the posterity of museum collections. It also

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demonstrates that haptic technologies can be mobilized as tool of cognitive accessibility for people with cognitive or physical impairments [Stanco et al. 2017]. While haptic technologies are still in development and expensive to integrate into museum settings, 3D printing in the past decade has exploded in its commercial availability and its potential for cultural heritage applications and can serve as a substitute for haptic technologies in today's cultural heritage sphere as they perform many of functions of haptic technologies mentioned above. Though 3D printing requires material inputs on top of the digital models, it is recognized as a useful tool in both archaeological research and outreach [Balletti et al. 2017; Dolfini and Collins 2018; Wilson et al. 2018]. Recent studies on engagement with 3D digital surrogates of museum objects have shown that both older and younger populations have emotional responses to 3D that are similar in type and strength as they do when engaging with physical objects in a museum [Alelis et al. 2015]. It is worthwhile, then, to explore if 3D prints of artefacts can also be experienced in meaningful way.

This short contribution details a project consisting of the scanning and dissemination of a collection of antiquities that has been largely inaccessible to the student body and the general public that it was donated to serve in a quasi-museum setting at the University of South Florida. Deploying well-established technologies, the “Institute for Digital Exploration” (IDEx) scanned and disseminated the collection online, with the ultimate goal of creating 3D printed and artistically rendered surrogates for the artefacts in the collection, in order to evaluate the effectiveness of using low-cost 3D printed digital rendering to engage stakeholders of the university collection. The contribution first provides a limited history and description of the collection itself, before discussing the methods used to scan the objects, process the data, and create the 3D printed artefact surrogates. The authors comment on the method that the data was curated throughout the project, then conclude with the results of the project thus far and outline future avenues of research for the project.

THE FARID KARAM LEBANON ANTIQUITIES COLLECTION

The Farid Karam Lebanon Antiquities Collection was donated to the “University of South Florida” (USF) Libraries Special Collections in 1998 by Farid Karam with the stipulation that the artifacts would be exhibited to the student body. Consisting of 149 artifacts from Lebanon, the collection belongs to a wide chronological and cultural range from the Bronze Age to the 13th century CE (Figs. 1-2). These artifacts, according to the USF Libraries’ documentation, were wholly collected beginning in 1962 by Farid Karam in Lebanon prior to his immigration to the United States in the 1970s. Unfortunately, the collection lacks any other provenance information. According to internal documents of the USF library, the collection was purchased legally in Lebanon and imported legally into the USA. While publishing unprovenanced material can be problematic [Argyropoulos et al. 2011], research on the Karam collection does not increase the monetary value of the objects in any way, as they are in the trust of USF libraries in perpetuity. It was decided, therefore, that digitization of the objects for the university and global community would not be antithetical to current archaeological ethical standards. The collection consists of metal, stone, ceramic, and glass artifacts. The 48 metal artifacts are in part medical tools dating to the Hellenistic and Roman periods and in part Bronze Age toggle pins and other decorative objects. There are three alabaster artifacts, consisting of a large *alabastron* and two *unguentaria*—one of which is a double vial. Of the 20 ceramic artifacts there are eight lamps, dating from the Second to Thirteenth Centuries AD, and a series of unassociated undecorated ceramic bowls. There are 76 glass artifacts, largely comprised of glass *unguentaria* from the first four centuries of the first millennium, with a few glass vessels dating to the Hellenistic period.

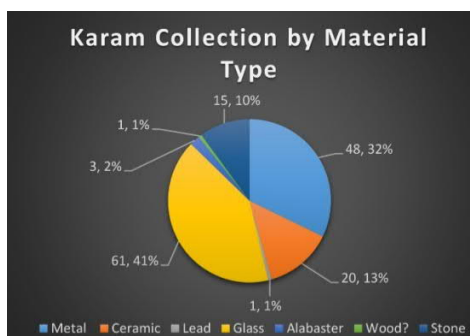


Fig. 1. Pie Chart indicating the different classes of materials in the Karam Collection

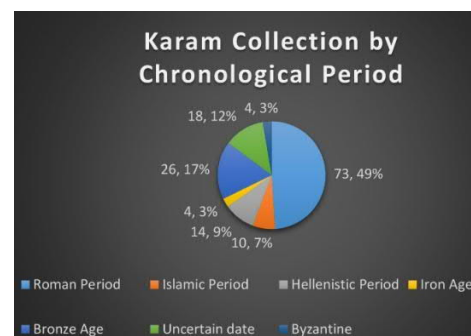


Fig. 2. Pie Chart indicating the chronological range of the Karam Collection

Though USF Libraries Special Collections has done everything it can to make the collection accessible, including hosting class visits and displaying photographs of particularly representative objects, the Karam Collection is unable to be fully exhibited due to lack of financial, material and human resources. In a letter from Farid Karam, he expressed interest in making the collection accessible online and creating a permanent digital exhibit in this way [Karam 2008] (Fig. 3). To respect Karam's wishes and make the collection accessible to the student body, a 3D scanning campaign was carried out by the Institute for Digital Exploration (IDEx) in the academic year of 2017-2018. The project was expanded to incorporate 3D printing of these artifacts to make them more accessible to students and those with disabilities, such as being blind or hard-of-sight, allowing them to engage with the collection tactilely. The first step of the project was that to update the obsolete graphic documentation (Fig. 4), producing new high-quality digital color pictures (Figs. 5-6) and to revise the historical and archaeological interpretation of the artifacts.



Fig. 3. Current setup of the Karam collection in the USF Library's Special Collection, stored in grey cardboard boxes



Fig. 4. Format of graphic documentation available at the USF Library's Special Collection for the artifacts of the Karam collection, color digital pictures



Fig. 5. New graphic documentation of the artefacts of the collection, produced at the beginning of the IDEx's virtualization project, selected glasses from IDEx website¹

¹ <http://history.usf.edu/idex/page13.html>

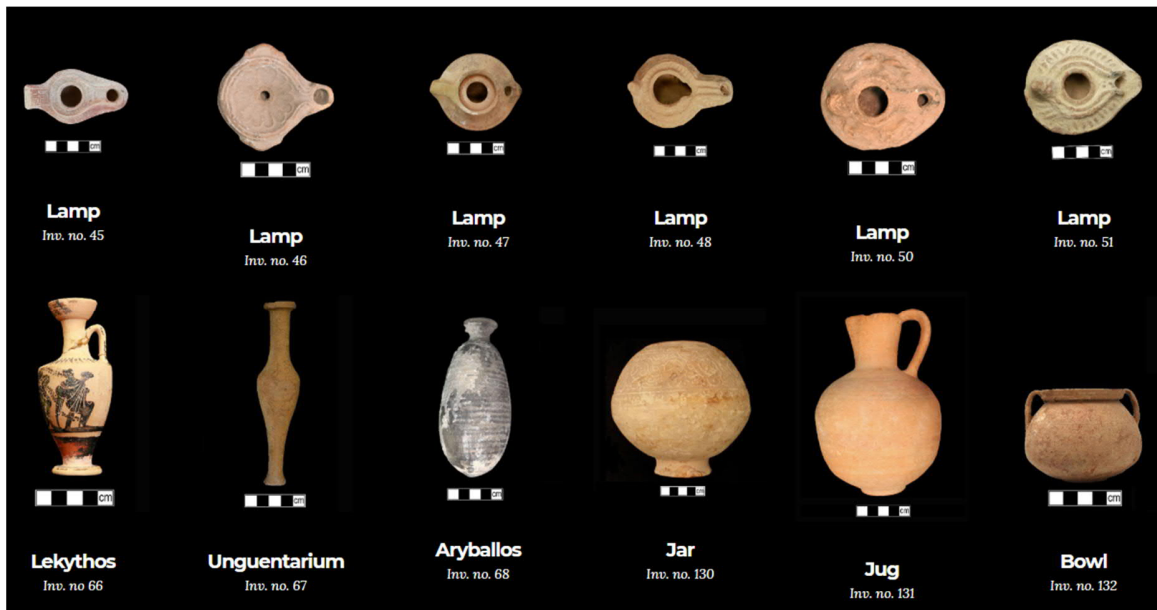


Fig. 6. New graphic documentation of the artefacts of the collection, produced at the beginning of the IDEX's virtualization project, selected ceramics from IDEX website

METHODS

The virtualization of the artifacts was carried out by employing a combination of two techniques: 3D scanning and digital photogrammetry which already largely proved their potential in the field of Heritage Studies [Lerma 2010; Chapman et al. 2013].

Laserscanning

A Faro Edge ScanArm laser scanner was used to digitize 44 of the 48 metal objects. Due to their small size and complex geometry, it was challenging to capture them with other techniques or devices. However, the fact that the scanner is not able to capture color represented a major limitation as those problematic objects should be experienced in full color to be appreciated by the public and to communicate relative data about their state of conservation. In other occasions, like with the Roman limestone bust of the bearded man (Inv. no. 63) such a scanner was employed to create a high-resolution 3D model to better study stylistic features not immediately visible via direct examination (Figs. 7-8). The ScanArm created geometrically accurate digital models with a margin of error of less than one millimeter. Multiple angles and positions of the same artifact were necessary in order to capture all sides of the artifacts. The artifact was scanned in one position and moved to another position. The arm scanner collected data directly in the Geomagic Wrap 2015 software. Upon completion of the data collection with the arm scanner, Geomagic Wrap 2015 served as the processing software as well (Fig. 9). This digital data was cleaned, the different positions were aligned and merged, and the final model was exported as an OBJ file for dissemination and analysis. The OBJs were then uploaded to the IDEX Sketchfab page to integrate them into the IDEX website² for dissemination and public engagement (Fig. 10).

² <http://history.usf.edu/idex/index.html>

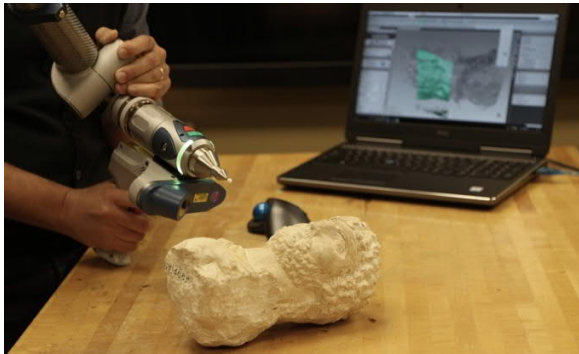


Fig. 7. 3D scanning of a Roman limestone bust from the Karam Collection (K63) with a Faro Edge ScanArm laserscanner

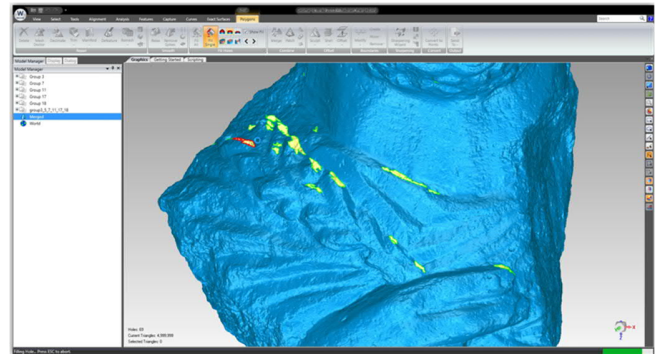


Fig. 8. Analysis of stylistic features of the bust examining the 3D model with Geomagic Wrap 2015

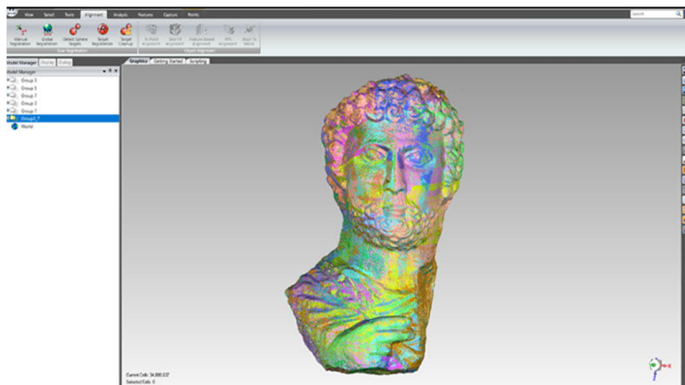


Fig. 9. Registration phase of the scans in Geomagic Wrap 2015



Fig. 10. 3D model of the Roman limestone bust of a bearded man (K63) from the Karam Collection

Digital photogrammetry

The digital photogrammetry survey was carried out on the majority of the artifacts using a Nikon D3400 at 6000 x 4000 px resolution for each image. This technique has already become the most popular among archaeologists and curators in museums for its low costs and high-quality results [Olson 2016]. Most objects were captured in two or three positions, with the camera taking photos from two or three angles for each object position, depending on the geometry of the object, from a 45-degree angle and a 90-degree angle at a horizontal from the object. Most artifacts were captured in an AmazonBasics lightbox with the automated turntable Orangemonkie Foldio 360 wireless turntable to ensure consistency and repeatability (Fig. 11). There were several artefacts with complex geometry or difficult to capture surface (e.g. many of the well-preserved translucent glass objects) that required several more positions or camera angles. Several artifacts, due to their size were captured free-hand by physically moving around a table upon which the artifact was placed. As with the arm laser scanner, the artifacts were captured in multiple artifact orientations in order to capture all sides and angles of the artifacts correctly. Photographs were taken with a scale and color checker. In general, the light conditions were favorable enough to keep the camera's settings on automatic, though certain objects required manually setting the aperture and shutter speed to better capture the data. Upon completion of the data capture, the images were brought into Agisoft Photoscan Professional 1.4.4 for the processing phase which consisted of the alignment of the pictures to the construction of the point cloud and the production of the mesh to the generation of the textured 3D model (Figs. 12-15). If there were any issues with the digital models that were untrue to the physical artifact, edits were done in Geomagic Wrap 2015 to ensure fidelity of

the digital versions. Upon completion of the textured mesh, the artifacts were exported as an OBJ with a 4k JPG texture file for dissemination and analysis. These OBJs and texture files were uploaded to the IDEX Sketchfab for integration into the IDEX website.



Fig. 11. Acquisition of the Karam Collection artifacts with a Nikon D3400 and the setup with the AmazonBasics lightbox and Orangemonkie Foldio 360 wireless turn table

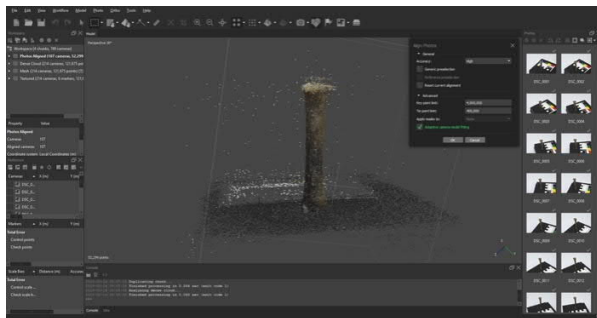


Fig. 12. Processing phase with Agisoft Photoscan, sparse cloud built on aligned photos

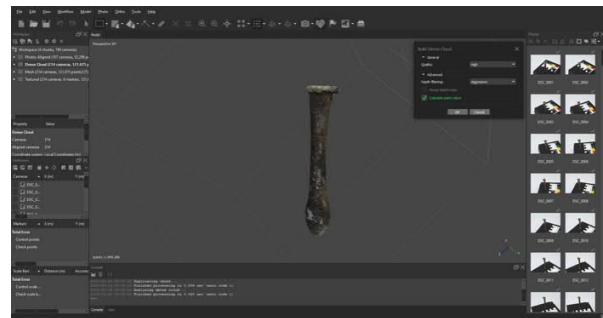


Fig. 13. Processing phase with Agisoft Photoscan, clean dense cloud

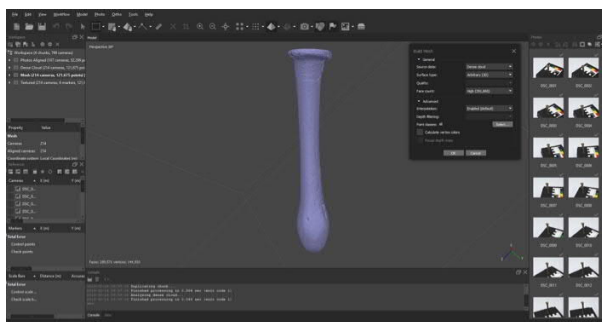


Fig. 14. Processing phase with Agisoft Photoscan, clean merged mesh

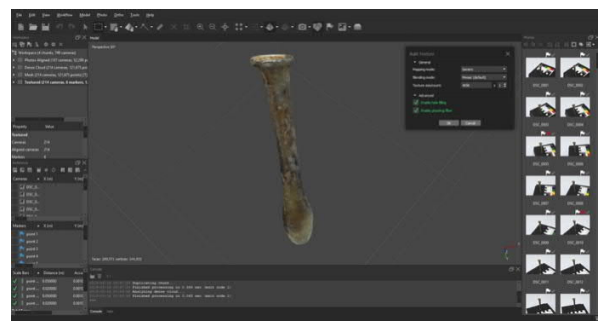


Fig. 15. Processing phase with Agisoft Photoscan, final texture

3D Printing and artistic rendering

The 3D prints were made using the Creality 3D printer CR-10 S5 with the Ultimaker Cura 3.4 and 3.5 software (Fig. 16). Objects were printed with white eSun PLA Pro. OBJs of each object were imported into the Cura program and situated in such a way that would use the least amount of support material, thus leaving fewer artifacts from the printing process. The printed objects were then cleaned and marked with their catalogue number using tape. All 149 3D models of the artifacts were 3D printed in scale 1:1. Subsequently, IDEx student interns started to paint them using acrylic colored paints in order to render artistically the original appearance using the 3D model as reference (Fig. 17), a practice which proved to be very effective both for students, who are learning about those ancient artifacts and deepened their knowledge through the direct tactile interaction with them, and to the public thanks to engaging power of the touch interaction [Means 2014; 2015; 2017]. In some cases, results of this artistic process were outstanding, with 3D prints effectively resembling the originals (Fig. 18).

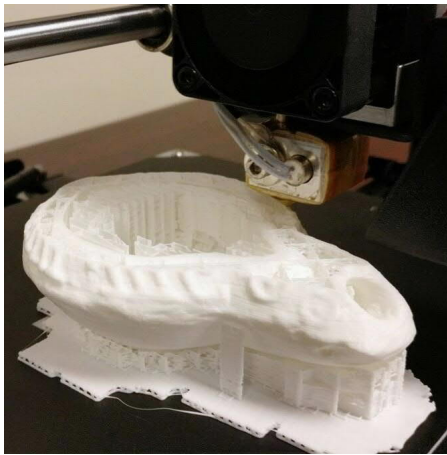


Fig. 16. 3D printing of the 3D model of a Roman lamp with a Creality CR-10 S5

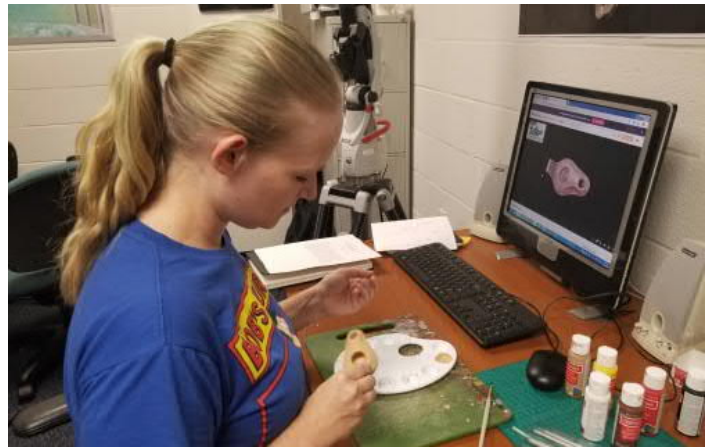


Fig. 17. An IDEx student intern painting the 3D print to render artistically the original appearance using the digital model as reference



Fig. 18. A comparison between the 3D models of three Roman lamps (left), photographs of the original lamps from the Karam Collection (center) and 3D printed and painted replicas (right)

DATA CURATION

The digitization of the artifacts and the processing of the 3D models went hand in hand with an in-depth archaeological and historical research to revise the first and very preliminary classification of the objects, to interpret their function, to define their typology and chronology. The amount of metadata generated by this exercise was systematized through a custom-built database where information was organized following the USF Libraries' metadata schema [Mi and Pollock 2018] (Fig. 19). In order to abide by the 7th Seville Principle (Scientific Transparency) of the International Guidelines for Virtual Archaeology (2013) [Lopez-Menchero Bendicho 2013] paradata were meticulously gathered during the capturing and processing phases and organized in order to be shared in accordance with the definition of paradata presented in the glossary of the London Charter: "information about human processes of understanding and interpretation of data objects. Examples of paradata include descriptions stored within a structured dataset of how evidence was used to interpret an artefact, or a comment on methodological premises within a research publication. It is closely related, but somewhat different in emphasis, to 'contextual metadata,' which tend to communicate interpretations of an artefact or collection, rather than the process through which one or more artefacts were processed or interpreted" [Denard 2013]. However, although the theme of heritage paradata has involved several authors [Apollonio and Giovanni 2015; Bentkowska-Kafel et al. 2012], who in the last decade have proposed various application of the London Charter directions to create paradata schemas, there is still no models to which the consensus of scholars have agreed upon. Therefore, the authors have decided to structure paradata in form of concise lab notes that detail the method in which the data was collected, with particular attention paid to the data capture of particularly complex artefacts in order to provide the essential information for transparently communicating the methods used and allowing individual users and researchers to reproduce or improve upon these methods

DISSEMINATION

While the USF Libraries' specialists have decided to disseminate the collection through their own online platform, Digital Collections³, using the un-textured models, a minimal version of the metadata and no paradata – due to technical constraints imposed by the design of the platform itself – the authors have decided to embrace a different model. Without entering into the debate of the best 3D Web Viewer/Platform [Scopigno et al 2017], a compromise was disseminating the collection through a combination between the popular online repository Sketchfab and a website designed ad hoc. All the 3D models were first slightly decimated uploaded on one of IDEX's collection on Sketchfab⁴ to allow the public better access to these models, regardless of the device on which they attempt to view the models and to provide the textured models to meet public expectations regarding virtualization of the Karam Collection. Subsequently, a website dedicated to the Virtual Karam Collection virtualization project, has been designed on purpose⁵ (Fig. 20). The website consists of a landing page that introduces the history of the collection, the artifacts, and the digitization project, with pictures and videos highlighting the main stages of the production process. From the landing page, visitors can access another page through which they can browse the collection. Clicking any of the artifact images brings the visitor to a page detailing that artifact. A separate webpage was created for each artifact to present the technical and historical metadata and paradata alongside the 3D model hosted by Sketchfab and embedded into the webpage (Fig. 21). An agreement between IDEX and USF IT Research Computing will guarantee long term maintenance and longevity to the data beyond the experience of IDEX itself.

³ <http://digital.lib.usf.edu/karam>

⁴ <https://sketchfab.com/cvast/collections/the-farid-karam-antiquities-collection-at-usf>

⁵ <http://virtualkaram.com>

IDEX Code	1
Title	Toggle Pin
Alternative title	R30-00001
Creator	Stephan Hassam
Contributor	NA
Acquisition date	11/15/2018
Record creation date	11/21/2018
Language	English
Country	Lebanon
Location	Tampa, FL
Cultural heritage type	Syrian Middle Bronze Age
Time period	1500-1200 B.C.
Dimensions	12.2x0.2-0.7
Materials	Copper Alloy
Description	The head of the pin has a rectangular cross section, which it maintains past the bulge around the eyelet, before tapering into a rounded section about two thirds down the shaft. The eyelet is 3 cm below the head.
Digital format	OBJ
Imaging technique	Laser Scanning, Geomagic Wrap 2015
Equipment	Romer AbsoluteArm
Paradata	Scans were captured in two positions with a stabilizing clamp to hold the artifact off the table. The first position was captured and then the artifact was rotated 180 degrees and the clap was moved. Upon scanning, the two positions were registered, cleaned, and merged in Geomagic Wrap 2015.
Subject	Copper Toggle Pin
Keywords	Karam Collection, Copper
Hashtags	#Karam
Affiliations	Department of History
Institution	University of South Florida
Holding location	USF-Tampa Library Special Collections
CHO Identifier	Farid Karam Lebanon Collections of Antiquities
Institution identifier	http://history.usf.edu/idx
Resource identifier	https://sketchfab.com/models/6fd6b89b699749b3b1e6b9996144b27c
Resource link	http://history.usf.edu/idx/page13.html

Fig. 19. Metadata schema used to curate historical and technical data for the artifacts of the Karam Collection

University of South Florida Libraries' Farid Karam M.D. Lebanon Antiquities Collection Virtualization Project: Virtual Karam Collection

In 1998, a collection of 149 archaeological artefacts from Lebanon, ranging from Middle Bronze Age to Early Medieval period, was donated to University of South Florida (USF) Libraries' Special Collections by

Dr Farid Karam with the agreement that it would be musealized and shared with the public. Since then, due to lack of funds and appropriate space, the unpublished collection was never exhibited and shared with the global public.

Between 2017 and 2018, Dr Davide Tanasi and his team of graduate students of the USF History Department undertook a virtualization and digital dissemination project of the entire Karam collection.



[Browse the collection](#)

Fig. 20. Virtual Karam Collection website (<http://virtualkaram.com>)

Lekythos - Inv. no. 66

IDEX Code: 66
Title: Lekythos
Alternative title: R30-00066
Creator: Kathryn Kingland
Contributor: Stephan Hassam, Frank Amico
Acquisition date: 4/2/2018
Record creation date: 3/29/2018
Language: English
Country: Lebanon
Location: Tampa, FL
Cultural heritage type: Greek
Time period: 5th-4th centuries B.C.
Dimensions: 9.9x4.7x3.1
Materials: Ceramic
Description: Small pouring vessel has a single handle which attaches at the neck and at the shoulder. The base is a flat disk. Black figures of Trojans fighting the Trojans decorate the red surface. The object has been repaired at the base with pink clay. It has also been broken and repaired with glaze at the neck and the handle.

Digital format: OBJ
Imaging technique: Digital Photogrammetry, Bentley ContextCapture 4.4.9
Equipment: Nikon D3400, AF-P Nikkor 18-55 mm 1:3.5-5.6
Paradata: The artifact was captured in two artifact orientations with three camera positions for the first artifact orientation and two camera positions for the second artifact orientation. The camera positions were from a high, lower, and straight on angle for the first artifact orientation and from a straight on and high angle for the second artifact orientation. Each camera position captured 24 images during a full rotation of the turntable. The artifact was sitting upright in the first orientation, stabilized with a foam base, and upside down in the second orientation, stabilized with a foam base. The 3D model was created using 120 images in Bentley ContextCapture.

Subject: Ceramic, Lekythos
Keywords: Karam Collection, Lekythos, Ceramic
Hashtags: #Karam
Affiliations: Department of History
Institution: University of South Florida
Holding location: USF-Tampa Libraries Special Collections
CI-0 Identifier: Farid Karam Lebanon Collections of Antiquities
Institution identifier: <http://history.usf.edu/index>
Resource identifier: <https://sketchfab.com/models/75a0192809246f93ab6b3218797038>
Resource link: <http://history.usf.edu/index?page=13.html>

66, Lekythos by Institute for Digital Exploration (USF IDEX) | Sketchfab

Fig. 21. An example of an object in the Virtual Karam Collection website with its metadata and paradata displayed next to the embedded Sketchfab model

DISCUSSION

After more than twenty years since the donation, the Virtual Karam Collection's online publication fulfills the wishes of Dr. Karam by providing a digital exhibit of his artifacts to the USF student body as well as the global community. The digital models, along with the accompanying metadata and paradata, allow researchers and the public to view the digital artifacts more holistically. The website page also sorts the artifacts by materials, allowing individuals to find artifacts of similar material to their artifact. The Virtual Karam Collection essentially serves as a virtual comparative collection for researchers, something which is usually done with images and drawings. With 3D digital artifacts, individuals can manipulate virtually the artifacts in a way in which methods such as photography and written description cannot. The collection will also remain preserved as it existed in 2017 and 2018, allowing conservators to understand how the artifacts are faring in the future. If desired, the process could be repeated in order to continually preserve track the artifacts' change over time.

The accessibility to the Karam Collection has been finally greatly improved. The collection could only be seen by scheduling an appointment with Special Collections and then, researchers, would be able to view the artifacts for only a limited amount of time. Now, individuals can remotely view and research these artifacts while providing an educational tool the community. Researchers can spend as much time as they like with the artifacts without risk to the artifacts themselves. Accessibility is greatly improved via the 3D printing as well, as those with visual impairments or cognitive disabilities are able to physically touch the printed objects. Without a 3D printed version which can easily be replaced if broke or lost, these individuals would not be able to engage with the artefacts through touch. Dolfini and Collins recently published on the utility of object replication in research on archaeological materials [2018]. While their criteria and goals were different, they noted the ability of object replication to inform and deepen research objectives, as well as its use in teaching and public engagement, which is the focus of this contribution. Experimentation involved in the replication of the 3D objects is an exercise in object research in and of itself. Students become acquainted with the variations in the color of the fabric of ceramic objects, while engaging with color differentiations in the ceramic fabric. When it comes to the metals, variations in color of the oxidized metal raises questions of preservation and chemistry that cause different color variations within the metal artefacts. Coupling the monochromatic 3D print with the textured 3D models online, students' ability to interact with the object was enhanced as they could physically touch the object, rotate it, and understand the various aspects of the artifact's 3D printed surrogate while engaging with the texture of the 3D models, which they could rotate as well. In the process of painting the objects, the students had to engage with the objects in a critical way in order to accurately reproduce the colors and shading, questioning material colors, inclusions, and methods of production which are key questions in any archaeological analysis of an assemblage or museum collection. Anecdotally, the interns, who had little to no archaeological or art historical training, began asking questions about objects through the process of handling them and artistically trying to recreate them through painting, demonstrating the great potential for the project in increasing learning outcomes and engagement with a non-expert public.

CONCLUSION

The scanning campaign consisted of a heuristic exercise in developing a workflow and methodology for capturing, processing, and disseminating 3D digital data of the complex collection. With the developed workflows, the Karam Collection was ultimately digitized using two different methods, dependent upon the differing materials, shapes, and sizes of the artifacts themselves. The collection was disseminated online via the IDEX website with the 3D models hosted on Sketchfab. In terms of the Virtual Karam Collection, exciting new outreach and research is possible upon completion of the digitization campaign. Though there is a small body of literature dedicated to the tactile interaction with objects and artifacts, further research to develop and better understand the effectiveness of 3D printed and painted artifacts in education is necessary. The Virtual Karam Collection project shows promise in generating data on museum replica usage and audience engagement with "inauthentic" objects.

With the entire collection now online as IDEX's Virtual Karam Collection, the next step is to request DOIs for each 3D model through the USF Libraries in order to structure each webpage with the 3D model, the metadata, and the paradata as a catalogue entry in a born digital catalog of an exhibition. A physical exhibition using both the 3D printed and painted object surrogates is planned for the future. These will be accompanied by access to the 3D digital surrogates on the website, provided by fixed interactive screens, so that visitors can both touch the physical object and see the digital scans. Data will then be collected on emotional and intellectual engagement with the objects in both digital and physical form both quantitatively and qualitatively through surveys and visitor observation.

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