5-2024

Ahead of the Digital Curve: Digitally Documenting and Interpreting the Historic Built Environment In Museums

Hannah St. Onge
hstonge@g.clemson.edu

AHEAD OF THE DIGITAL CURVE: DIGITALLY DOCUMENTING AND INTERPRETING THE HISTORIC BUILT ENVIRONMENT IN MUSEUMS

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
Historic Preservation

---

by
Hannah Paige St. Onge
May 2024

Accepted by:
Amalia Leifeste, Committee Chair
Amanda Brown
Patricia Lowe Smith
Michael Spencer

ABSTRACT

Digital documentation technology came into the mainstream of preservation in the late 20th and early 21st centuries. These technologies have also begun to make their way into museums, another piece of the preservation field. Literature detailing the use of digital documentation technology in museums focuses largely on isolated case studies, often from museums in Europe and Asia. The research on the topic currently lacks a broad understanding of the use of these technologies in museums across the United States.

This thesis utilizes a survey method to determine the scope of digital documentation technologies usage to create 3D digital architecture for the interpretation and stewardship of American historic structures operated as museums. Given a response rate of 24.21% and approximately one third of responses selecting "None of the above" when asked if they possessed a 3D digital product, the data suggests the use of digital documentation technologies is not widespread at this point in time. Survey data, however, reveals that the use of these technologies has been on the rise since 2016, with a significant increase in 2020. Respondents attribute the acceleration of the implementation of these tools to both the COVID-19 pandemic and the increased accessibility of the equipment needed to complete this work.

Survey data also revealed that the most common 3D digital architecture product possessed by respondents is 3D virtual tours (i.e. Matterport). Proprietary software, such as Matterport and Autodesk software (including Revit and 3ds Max) are more common in the creation of the 3D digital architecture products among the creators surveyed. 58.3%

of these creators hold a graduate degree as their terminal degree and 20.8% hold an undergraduate degree, and yet over three quarters of the creators learned the software used to produce the 3D digital architecture outside of an academic setting.

Using the survey methodology laid out in this thesis, the data presented can be utilized as a benchmark for later studies providing the field with a longitudinal understanding of how this technology usage changes over time.

DEDICATION

To my mom and dad, who let their little daughter use up all the scotch tape in the house to build little paper houses and other creations. Luckily, I've moved on to AutoCAD, SketchUp, 3DSMax… none of which require scotch tape.

ACKNOWLEDGMENTS

I must first thank the respondents who took the time to answer my survey. This thesis would not have been possible without your insight. Thank you for sharing your honest and thorough feedback.

A great deal of gratitude is also due to my committee. Thank you to my committee chair, Amalia Leifeste, for your guidance, motivation, and patience throughout this process. To my readers: Amanda Brown, thank you for your thoughtful feedback and for your encouragement. To Patricia Lowe Smith, thank you for all of your positivity and for being a part of this thesis from its earliest days when I was still workshopping ideas for a topic. To Michael Spencer, thank you for first introducing me to the world of 3D modeling and for sharing all of your knowledge.

I also need to thank Dr. Cristina Turdean, who fostered my passion for museum work and is one of the most encouraging and supportive advisors a student could ask for. To Chloe M., who listened to me talk about ideas until they coalesced into something that worked and spent many an hour at various coffee shops keeping me motivated and on track. To Alexis K., I am forever indebted to you for teaching me how a pivot table works; I dedicate my analysis to you. To Caroline B., thank you for sharing your Office expertise. To the campfire, thank you for the support, the laughter, and the venting. I couldn't have done it without you all.

Last but certainly not least, thank you to my parents, who have always been my biggest cheerleaders. I would not be where I am today without your steadfast love and support. To paraphrase the great Noah Kahan, thank you for letting me "go far."

TABLE OF CONTENTS

Page

Table of Contents (Continued) Page

LIST OF TABLES

Table Page

List of Tables (Continued)

Table Page

LIST OF FIGURES

Figure Page

List of Figures (Continued)

Figure Page

CHAPTER ONE

INTRODUCTION

In 1933, the Historic American Building Survey (HABS) was founded as the first federal preservation program in the United States. It was created via a private-public partnership with the National Park Service (NPS), Library of Congress (LoC), and the American Institute of Architects (AIA) as a response to the rapid loss of the country's architectural heritage taking place at the time. According to the NPS, HABS "…established methodologies that are now standard practice within the field such as the surveying and listing of historic sites and the creation of documentation for public benefit."[1] In 1969, the Historic American Engineering Record (HAER) was founded to accomplish similar goals, focusing on engineering and industrial heritage.[2] As early pioneers in the documentation of the built environment, HABS/HAER set the standards which preservation practitioners use to record architectural, engineering, and industrial heritage.

In the mid-1980s, HABS/HAER invested in computer-aided drafting (CAD) for the first time. At first, the programs were slow to adopt them, as they found that hand drafting still produced higher-quality results than CAD. Eventually, they adopted the use of AutoCAD, a proprietary CAD software.[3] By the publication of the December 2008

[1] Heritage Documentation Programs, "Historic American Buildings Survey," NPS.gov, National Park Service, September 20, 2023, https://www.nps.gov/subjects/heritagedocumentation/habs.htm.
[2] Heritage Documentation Programs, "Historic American Engineering Record," NPS.gov, National Park Service, September 20, 2023, https://www.nps.gov/subjects/heritagedocumentation/haer.htm.
[3] John A. Burns, "Chapter 1: Overview," in *Recording Historic Structures*, 2nd ed., ed. John A. Burns (Hoboken, NJ: John Wiley & Sons, Inc., 2004), 20.

edition of the HABS's Guidelines for Recording Historic Structures and Sites with HABS Measured Drawings, a section for "Computer-Aided Drafting (CAD) Drawings" had been worked into the document.[4] Also by that time, digital photography had become an "accepted standard" in documentation, as opposed to the film photography traditionally required by HABS.[5] HABS began use of another technology, photogrammetry, in the late 1980s.[6] By 2009, yet another technology, 3D laser scanning, was described as an "emerging photographic tool used to create accurate computer drawings of existing conditions."[7] In a field where film photography and hand-drawn hardline drawings had been the standard since the establishment of HABS in 1933, the late 20th and early 21st centuries have brought digital documentation technology into mainstream preservation.[8]

Documentation efforts are only one facet of historic preservation. Museums are another piece of the preservation puzzle, with some of the earliest large-scale, organized preservation efforts in the United States resulting in the founding of museums. The Mount Vernon Ladies' Association, for instance, opened Mount Vernon to the public in 1860.[9] The Colonial Williamsburg Foundation, responsible for the assemblage of historic

[4] United States Department of the Interior, "HABS Guidelines: Recording Historic Structures and Sites with HABS Measured Drawings," Heritage Documentation Programs, National Park Service, 2008, https://www.nps.gov/subjects/heritagedocumentation/upload/HABS-Guidelines-Measured-Drawings_508.pdf.
[5] Norman Tyler, Ted J. Ligibel, and Ilene R. Tyler, *Historic Preservation: An Introduction to Its History, Principles, and Practice*, 2nd ed. (New York: W. W. Norton & Company, 2009), 211-212; William L. Lebovich, "Chapter 3: Photography," in *Recording Historic Structures*, 2nd ed., ed. John A. Burns (Hoboken, NJ: John Wiley & Sons, Inc., 2004), 70.
[6] John A. Burns, "Chapter 1: Overview," 21.
[7] Norman Tyler, Ted J. Ligibel, and Ilene R. Tyler, *Historic Preservation: An Introduction to Its History, Principles, and Practice*, 211-212.
[8] John A. Burns, "Chapter 1: Overview," 2-3.
[9] Mount Vernon Ladies' Association, "About Mount Vernon," George Washington's Mount Vernon, 2024, https://www.mountvernon.org/about/.

buildings and reconstructions in Williamsburg, Virginia, was founded in 1926, and Mystic Seaport, an open-air history museum in Mystic, Connecticut, in 1929.[10] At museums such as these that interpret the built environment, the public has an opportunity to interact with the field of preservation, to see first-hand the work that preservationists do. Some museums, such as Colonial Williamsburg, Mount Vernon, and Drayton Hall, have dedicated preservation departments. At other museums, however, preservation work might be contracted out to an entity independent from the museum. Regardless of the model, preservation work is inherently entwined with museum work at historic houses and historic sites.

Does part of this relationship between museums and preservation involve the use of digital documentation technologies for preservation purposes? This connection is more difficult to define. Case studies provide examples of digital programs used for specific projects within museums. In "Virtual Museums: Dealing with Cultural Identity in the Digital Age," for instance, a team uses Unity3D, CryEngine, and Autodesk 3dsMax to build an immersive experience featuring virtual architectural reconstructions to evaluate e-learning (teaching which involves a digital component to help build new knowledge

[10] James M. Lindgren, "Chapter 4: 'A Spirit that Fires the Imagination' Historic Preservation and Cultural Regeneration in Virginia and New England, 1850-1950," in *Giving Preservation a History: Histories of Historic Preservation in the United States*, eds. Max Page and Randall Mason (New York: Routledge, 2004) 121-123.

and understanding) outcomes for a museum.[11] In another case study, a team in Italy creates virtual reconstructions to help visitors visualize missing elements from a statue and a building using open source software such as Agisoft Metashape.[12] While these case studies provide snapshots of digital program usage in museums and historic sites, they do not provide a more holistic, generalized view of the widespread use of such programs (or lack thereof).

In addition, these case studies lack detailed information on the educational background of the creators of the digital products. Some articles state the university the digital product-creating team is affiliated with, and one dissertation lists the degree the creator is pursuing, but the case studies do not delve deeply into the area(s) of study pursued by the creators of the digital products. Therefore, while the technologies used by the creators are a facet of preservation, it is difficult to determine from these readings if individuals with a preservation background are participating in such work in museums. This thesis seeks to provide quantitative and qualitative data to fill these gaps.

---

[11] Unity3D and CryEngine are both game engines, which allow creators to create interactive virtual experiences. Autodesk 3dsMax is a software where users can create photorealistic 3D models, renders, and animations, which can be imported into game engines. "Our Company: Who We Are," Unity.com, Unity, 2024, https://unity.com/our-company; "Features," Cryengine.com, CryEngine, 2024, https://www.cryengine.com/features; "Autodesk 3ds Max: Create Massive Worlds and High-Quality Designs," Autodesk.com, Autodesk, https://www.autodesk.com/products/3ds-max/overview?term=1-YEAR&tab=subscription; Dragoş Gheorghiu and Livia Ştefan, "Virtual Museums: Dealing with Cultural Identity in the Digital Age," in *The International Scientific Conference eLearning and Software for Education, Bucharest* (2018): 463-470, https://doi.org/10.12753/2066-026X-18-280.

[12] IBM defines open source software as software that is "developed and maintained via open collaboration, and made available, typically at no cost, for anyone to use, examine, alter and redistribute however they like." "What is Open Source Software?" IBM.com, IBM, accessed February 3, 2023, https://www.ibm.com/topics/open-source; R. Spallone, F. Lamberti, L. M. Olivieri, F. Ronco, and L. Castagna, "AR and VR for Enhancing Museum's Heritage Through 3D Reconstruction of Fragmented Statue and Architectural Context," *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLVI-2/W1 (2022): 473-480, https://doi.org/10.5194/isprs-archives-XLVI-2-W1-2022-473-2022.

This thesis examines the extent to which documentation technologies are being used to create digital products for the interpretation and stewardship of historic structures operated as museums and the extent to which people with a preservation degree are part of producing those digital products. To that end, this thesis asks the question; How widespread is the use of digital documentation technologies to create 3D digital architecture for the interpretation and stewardship of American historic structures operated as museums? For the purposes of this thesis, "3D" is used to refer to a digital product with three dimensions; either in the form of XYZ axes, or a two-dimensional representation that has a time sequence component as the third dimension, such as a video. "Digital products" and "products" are used to refer to digital architectural products, such as a 3D model, a 3D virtual tour, or a photogrammetric model. In the field of architecture, "digital architecture" has a slightly different meaning than that which this thesis uses. In "Re-Animating Greg Lynn's Embryological House: A Case Study in Digital Design Preservation," digital architecture is defined as "A[n architectural] work in which the computer was a fundamental part of the design process."[13] For the purposes of this thesis, "digital architecture" refers not to architecture that was designed with a computer, but instead refers to historic architecture that has been documented or reconstructed via digital means and is stored and accessed from a digital platform.

In addition to this overarching question, supplemental questions ask: When museums are using digital documentation technologies, what is the resulting product?

[13] Lawrence Bird and Guillaume LaBelle, "Re-Animating Greg Lynn's Embryological House: A Case Study in Digital Design Preservation," *Leonardo* 43, no. 3 (2010): 242-249, https://www.jstor.org/stable/26859538.

What was the intended use of the digital product? Are museums satisfied with that product? Are the products generated in house, out-of-house, or both? Who is involved in the creation of these products? Are people with preservation education involved in this work? Where are software skills learned for the creation of these products? What software programs are being utilized to generate digital products? How common are the digital products? Does staffing size, visitation, or budget have any correlation with the use of digital products? When were the digital products created?

To answer these questions, this thesis utilized a two-tiered survey. The primary focus of the first tier was collecting data about historic sites ("historic sites" will henceforth be used to refer to museums that interpret and/or steward a historic structure, including those that are no longer extant) that possess some sort of digital product, along with data pertaining to the product itself. To select the respondents for the first tier, this thesis consulted the directories of various museum organizations: the American Alliance of Museums, the Association of State and Local History, and the Southeastern Museums Conference. From these lists, the first tier of the survey asked basic questions to establish an institution's status as a museum, determine whether or not they have any digital products which capture an existing structure or recreated feature, and confirm whether or not their digital products were made in-house. This tier of the survey collected contact information for individuals who utilize digital documentation technologies to create digital products for museum use. This information was used to follow up with those individuals for the second tier of the survey.

The second tier of the survey followed up with the historic sites with staff generating their digital products in-house and with the individuals to whom historic sites have outsourced the creation of their digital products. The primary focus of this tier of the survey was examining the types of software being used in producing digital products for museums, as well as where the respondent learned the digital tools. As an extension, the survey examined the educational background of the creators of the product and when (if at all) during their schooling they learned such programs. This tiered approach allows this thesis to answer its questions regarding which programs are being used to create digital products for museums, who is involved in creating them, and what their educational background is.

This thesis is organized as follows: Chapter Two provides a review of literature pertaining to documentation software use in museums. It explores case studies that detail which digital programs have been used in specific projects, including how the tools were used to generate the product and why the tools were chosen for that specific case.

Chapter Three, "Methodology," details the creation of the two-tiered survey and selection of the respondents. It explores the sources used to generate a list of historic sites to distribute the first tier of the survey to, as well as those which informed the creation of survey questions for the second tier of the survey.

Chapters Four and Five examine the data collected at both levels of the survey. Chapter Four describes the findings of the first survey. It then presents the data captured in each question of the second-tier survey. Chapter Five includes an analysis of the data collected in the surveys, including an exploration of the extent of digital documentation

technology usage, the types of software used at historic sites, and the source of the respondent's knowledge of that software.

By performing this research, this thesis provides a clear, quantitative picture of the extent to which digital documentation technologies are being utilized by practitioners at historic sites. It fills a gap in the existing literature by undertaking a broad survey to collect data on this topic. It also provides a better understanding of who is participating in the creation of digital products for historic sites in the United States, and in doing so, it determines if individuals with preservation backgrounds are participating in that creation. The data collected and the analysis completed through this thesis can help serve as a benchmark for the field. By breaking down the demographics of museums who are using 3D digital products, museums can compare themselves to other institutions of similar size and resources to either begin implementing 3D digital products or compare their products to other museums. In addition, utilizing the case studies presented in the second tier survey data, various academic programs whose graduates tend to enter museum work may also consider adding documentation technologies and software into their curricula or elective offerings. Lastly, the findings of this thesis can serve as a benchmark against which future repetition of this survey work can be compared. This would help indicate how the field of interpretation and use of 3D digital products in museums is evolving.

CHAPTER TWO

LITERATURE REVIEW

To contextualize the research question, two main bodies of literature are explored. The first of those themes pertains to the use of digital documentation technologies to create 3D digital models in museums. Literature concerning this topic is first explored on the macro scale; general usage of this software and the products produced for museums using such software will be discussed. At this scale, much of the conversation about this topic is derived from journal articles, although organizations such as the American Alliance of Museums are also publishing on the topic. This examination leads from the macro level to the micro level with a discussion of case studies. These case studies explore instances where a digital product was created for individual museum projects and are largely found in journal articles and theses.

After establishing trends in the use of digital documentation technologies and the products generated with them for use in the museum setting, the discussion moves to the second overarching theme within the pertinent literature: digital documentation technology use in the preservation field. Like the literature concerning museums, this section is also organized into two subtopics: 3D digital model usage in preservation academia and 3D digital model usage by preservation practitioners. The section on usage in academia explores how the software used to create these models is being taught to students in preservation programs and related programs in the classroom, as well as how academics are publishing about the topic. This leads into a discussion of how preservation practitioners are utilizing digital documentation technology to complete

projects in professional settings. The similar nature of projects between the two camps contributes to the established relationship between preservation and museum work. However, the focused nature of the case studies that makes it difficult to gain a more holistic understanding of trends across the field. In addition, the literature lacks information regarding whether or not those creating these products in museums have a preservation background. For these reasons, the literature lacks a large-scale, clearly defined connection between preservation and museum work, which necessitates this research.

3D Digital Architecture Use in Museums

General Technology Usage & Trends

While not typically focused on the particular documentation tools and software used in museums, various publications have discussed the more general use of technology in museums. Early literature on this topic from the late 2000s and 2010s tends to discuss technology usage in a more theoretical sense, focused on the potential role it could have in the 21st century museum. In a 2007 thesis, Robert Charles Ackroyd explored the role that technology might have as museums change and evolve to meet the needs of 21st century visitors, with a specific focus on three different museums in Canada. While Ackroyd provides examples of the National Gallery and the Churchill Museum and Cabinet War Rooms (both in London, England) already using technology for interpretive purposes, his paper proposes potential technological approaches that his

three case study museums could take, rather than evaluating technology already in place.[14]

Ackroyd's two European examples align with an imbalance observed in the literature. 3D digital architectural products are more often discussed in European, Middle Eastern, and Asian museums. Literature on interpretive 3D digital models is not completely lacking in the United States, but publications detailing technology usage in museums here appeared less frequently than it does in European based literature. Of the five case studies considered within this literature review, one discussed a case in the United States, while the other four discussed cases in Europe.

In the early 2010s, it seemed that augmented reality (AR) was the next great technological advancement for museums. AR is a technology which allows the viewer to see virtual content layered over the real environment.[15] The 2011 Museum Edition of the New Media Consortium (NMC) Horizon Report predicted that this technology would become mainstream within two or three years, while others predicted a 'much longer timeframe for general adoption of AR.'[16] Indeed, a 2012 article in the American Alliance

[14] Robert Charles Ackroyd, "Smart Arts: Applying Digital Technology to Increase Engagement and Value in Museums and Historic Sites," Order No. MR33105, University of Alberta (Canada), 2007.
[15] Mandy Ding, "Augmented Reality in Museums," *Arts Management & Technology Laboratory* (Carnegie Mellon University, May 2017), https://static1.squarespace.com/static/51d98be2e4b05a25fc200cbc/t/5908d019f5e2314ab790c269/1493749785593/Augmented+Reality+in+Museums.pdf.
[16] "More Than Real," from "Trendswatch 2012: Museums and the Pulse of the Future," Center for the Future of Museums, American Alliance of Museums, 2012, https://www.aam-us.org/wp-content/uploads/2017/12/2012_TrendsWatch.pdf.

of Museums' 2012 TrendsWatch report did cite examples of museums in both the United States and Europe who had begun experimenting with AR.[17]

On the other hand, sources from around this time period seem to suggest that the technology was less widespread and not catching on as predicted. Another 2012 study on mobile device (including museum-provided devices and smartphones) usage in museums noted that only 1% of museums in the United States had begun embarking on AR.[18] While many factors can influence this low number, an article entitled "Disconnecting to Reconnect," published in 2013, may help explain one of the factors relating to the infrequency of publications regarding widespread technology use in museums. The article recognized that Americans were spending more time than ever on electronic screens, but that this 'hyperconnectivity' came with pushback as people worried about the effects of such extensive screen time. The work suggested that:

> Museums should still pay attention to all the projections about mobile devices, embedded devices, augmented reality, social media, etc. as highly likely features. But they should also pay attention to the educators, critics, philosophers, museum-goers and others who lament the loss of quiet, contemplative, unconnected spaces in society such as those that museums have traditionally provided.[19]

This quote illustrates the state of flux that museums found themselves in at this point. Literature from around 2012 advocates for museums to use technology as a way to fit

[17] "More Than Real," from "Trendswatch 2012: Museums and the Pulse of the Future." Of note, the case studies in this article seem fairly evenly split between U.S. and European examples. This is different from the trend seen in stand-alone case studies published in journals, which will be discussed in depth under the 'Case Studies' subheading.
[18] Fusion Research + Analytics, *Mobile Survey* (Museums Association, 2012), https://archive-media.museumsassociation.org/15052012-ma-mobile-survey.pdf; Mandy Ding, "Augmented Reality in Museums."
[19] "Disconnecting to Reconnect," from "Trendswatch 2013: Back to the Future," Center for the Future of Museums, American Alliance of Museums, January/February 2013, https://www.aam-us.org/wp-content/uploads/2017/12/2013_TrendsWatch.pdf, 33.

into the modern world. A quote from a small museum in "Disconnecting to Reconnect" voices the concern about appearing dated to younger visitors who "'…don't necessarily know how to relate to some of the older presentations'" because younger people are used to seeing more technology.[20]

Yet simultaneously, there was an undercurrent within the modern world to shift away from the constant use of technology. "Disconnecting to Reconnect" went so far as to encourage museums to set aside certain times or spaces to be 'unplugged,' or even to become 'unapologetically disconnected' in order to become a destination for those looking to escape screens for a time.[21] These suggestions are especially intriguing as this article was published in the American Alliance of Museum (AAM)'s 2013 TrendsWatch report. The TrendsWatch reports are published by AAM's Center for the Future of Museums as forecasting reports for the field. It is of note that only a decade ago, this suggestion for museums to be spaces to unplug was making its way into a national report on technology usage in museums.

Despite this suggestion, the 2013 TrendsWatch report does not stop AAM from mentioning digital products in their publications moving forward. Technology usage appears in the TrendsWatch report twice more, once in 2014 and once in 2016. In a 2014 article from the report, the author focused on the creation of sensory experiences which incorporated scents and sounds into museum exhibits rather than on the use of technology

[20] "Disconnecting to Reconnect," from "Trendswatch 2013: Back to the Future," 33.
[21] "Disconnecting to Reconnect" from "Trendswatch 2013: Back to the Future," 33.

to interpret the built environment.[22] However, some of the projects done to create a multisensory experience are tangentially related to the types of projects done with 3D digital architecture software, as they are designed to create an immersive experience for the visitor.

Perhaps reflecting, in part, the desire to unplug expressed in the 2013 TrendsWatch report, only one additional discussion relating to 3D digital architecture software occurred in the TrendsWatch reports during the second half of the 2010s. An article in the 2016 report discussed the usage of AR and virtual reality (VR) in museums, suggesting that they can be used to support both formal and informal learning.[23] This infrequency of mentions in AAM publications suggests that 3D digital architectural work was not happening frequently enough to be picked up by AAM, and/or was not part of the organization's vision for the future of the museum experience.

Less than a decade later, 2020 shows the literature moving away from museums trying to find ways to participate in a more technologically-inclined world, and rather began to focus on how technology could be used to solve problems within the museum first created by the COVID-19 pandemic. The pandemic forced museums to pivot from their standard operating procedure as buildings were forced to close to the public. An article appeared in the 2021 issue of TrendsWatch which examined and proposed the use of digital tools to help museums survive the pandemic. The article was entitled, "Digital

[22] "Synthesia: Multisensory Experiences for a Multisensory World," from "Trendswatch 2014," Center for the Future of Museums, American Alliance of Museums, 2014, https://www.aam-us.org/wp-content/uploads/2017/12/2014_TrendsWatch.pdf.
[23] "Me/We/Here/There: Museums and the Matrix of Place-Based Augmented Devices," from "Trendswatch 2016," Center for the Future of Museums, American Alliance of Museums, 2016, https://www.aam-us.org/2016/05/01/meweherethere-museums-and-the-matrix-of-place-based-augmented-devices/.

Awakening: Essential Technologies for Pandemic Survival and Future Success," which in itself is telling of trends in technology usage in museums. 'Awakening' is defined as "a rousing from inactivity or indifference" or "a revival of interest in something."[24] The use of 'awakening' in the title implies that in the period predating the article's writing, such technologies were not of high interest nor frequent use within the field. There had obviously been some digital activity in the decade preceding the publication of the article as earlier pieces of literature indicate, but the theoretical nature of the works (making suggestions and citing occasional case studies rather than reporting on large scale usage) makes it difficult to determine just how widespread technology usage actually was within the museum field in the years prior.

"Digital Awakening: Essential Technologies for Pandemic Survival and Future Success" follows much of the same pattern as earlier pieces of general usage literature, suggesting scenarios in which these technologies can be used with a handful of case studies. Unlike this thesis, the article largely focuses on the use of technology at every level of the museum rather than in interpretation and management of the physical fabric of historic structures. It touches briefly on the use of online exhibitions and educational programming, but also focuses in large part on using technology to market the museum, generate revenue, and offer membership benefits.[25] This more holistic focus is not a slight on the generation of projects that are the concern of this thesis; rather, it is

[24] *Merriam-Webster.com Dictionary,* s.v. "Awakening," accessed October 31, 2023, https://www.merriam-webster.com/dictionary/awakening.
[25] "Digital Awakening: Essential Technologies for Pandemic Survival and Future Success," from "TrendsWatch: Navigating a Disrupted Future," Center for the Future of Museums, American Alliance of Museums, 2021, https://www.aam-us.org/wp-content/uploads/2021/02/2021_TrendsWatch_V1_full_draft_Hyperlinked_v3.pdf.

reflective of a field struggling to stay afloat faced with factors that change the very core of its work.

In an article entitled "Virtual Museums as an Extended Museum Experience: Challenges and Impacts for Museology, Digital Humanities, Museums and Visitors - In Times of (Coronavirus) Crisis," author Bernadette Biedermann more clearly bridges the gap between the above topic and this thesis. Bidermann focuses on the use of technology to address COVID-era problems, similar to the 2021 TrendsWatch report which addresses these issues. The primary purpose of "Virtual Museums" is advocating for the use of digital museums to augment the visitor experience. Bidermann discusses virtual museums primarily as a space for the digitization and contextualization of artifacts, but also cites the use of AR to create a more interactive experience. She importantly notes that digitization does not "replace real experiences or physical encounters."[26] This could be another factor relating to the hesitancy of museums to adopt digital products relating to the trends noted in the 2013 TrendsWatch report. Despite this, Bidermann argues that technology can be used to make objects or spaces accessible virtually when the physical museum space or collection cannot be open to the public.[27] This results in the creation of digital products such as photogrammetric scans and virtual tours, products that were encountered in the survey results for this thesis.

[26] Bernadette Biedermann, "Virtual Museums As an Extended Museum Experience: Challenges and Impacts for Museology, Digital Humanities, Museums and Visitors - In Times of (Coronavirus) Crisis," *Digital Humanities Quarterly* 15, no. 3 (2021). http://libproxy.clemson.edu/login?url=https://www.proquest.com/scholarly-journals/virtual-museums-as-extended-museum-experience/docview/2603407527/se-2?accountid=6167.
[27] Bernadette Biedermann, "Virtual Museums As an Extended Museum Experience."

Case Studies

It is also of note that "Virtual Museums" was published by a German author. This leads into a trend seen across many of the stand-alone case studies published in academic journals, which include numerous examples of European, Middle Eastern, and Asian cases with less frequent examples from the United States. Of the five articles reviewed in this section, one discussed a case study in the United States, while the other four discussed cases in Europe.

In addition to providing this geographic understanding, the case studies also reveal the types of goals that museums desire from products generated from digital documentation technologies. In one instance, a student created 3D models of archaeological and ethnographic artifacts for use in the Cravens Virtual Museum with the goal of increasing accessibility of the objects and creating education and outreach opportunities.[28]

Other case studies have similar educational goals with additional focus on generating effective engagement. A team from Romania discussed their virtual museum project, "Time Maps," which combined digital reconstruction of the built environment with aspects of intangible heritage, presented both in the digital sphere, as well as in videos of re-enactments, in order to create an immersive experience where visitors can learn about the lives of people in a historic town. Their goal was to help users better

[28] Conner Awayda, "Cravens Virtual Museum Project: A Case Study of Digital Heritage and Museum Education," Order No. 10822826, State University of New York at Buffalo, 2018.

understand and connect with intangible aspects of life in the past.[29] Another group explored the use of digital reconstruction and VR to improve informal learning in the museum setting, going a step further by including a gamified component in their digital reconstruction of the neolithic La Draga settlement in Catalonia to increase user engagement with the reconstruction.[30]

Other case studies focus less on engaging with a landscape or environment, and instead aim to reconstruct an existing component of extant objects that are missing certain aspects or inform restoration efforts. One team from Italy used photogrammetry to document an existing Buddha statue housed in the Museum of Oriental Art (MOA) in Turin, and then digitally reconstructed missing parts of the statue. They then used AR and VR experiences to place the statue into its architectural context: a digitally-reconstructed shrine in Balo-Kale, Pakistan, where the statue is originally from, which is a partially-extant building that was excavated in the 2010s.[31] Another group, again working in Italy, used photogrammetry like the team from MOA, and worked along with the Istituto Superiore per la Conservazione e il Restauro to document a statue. Computer-aided drafting (CAD) and computer-aided engineering (CAE) were then used to model a support frame for the statue, which helped the team learn about how the statue might be assembled. With this knowledge, they could better understand how the statue was

[29] Dragoş Gheorghiu and Livia Ştefan, "Virtual Museums: Dealing with Cultural Identity in the Digital Age."
[30] Anna Puig, Inmaculada Rodríguez, Josep Ll. Arcos, Juan A. Rodríguez-Aguilar, Sergi Cebrià n, Anton Bogdanovych, Núria Morera, Antoni Palomo, and Raquel Piqué, "Lessons Learned from Supplementing Archaeological Museum Exhibitions with Virtual Reality," *Virtual Reality* 24, no. 2 (06, 2020): 343-358, https://doi.org/10.1007/s10055-019-00391-z.
[31] R. Spallone, F. Lamberti, L. M. Olivieri, F. Ronco, and L. Castagna, "AR and VR for Enhancing Museum's Heritage Through 3D Reconstruction of Fragmented Statue and Architectural Context."

currently supported, how it might react to certain environmental conditions such as seismic activity, and plan for future preservation interventions.[32]

These case studies provide examples of both public facing and internal facing applications of 3D digital architecture documentation technologies and the products produced with them. It should be noted that in these case studies, longer term updates are rare. The goals of the products are discussed, but whether or not the product hits those benchmarks is often not discussed. The survey work with this thesis briefly asked respondents to rate their satisfactions with the digital products used at their museums in order to address this gap in the literature.

3D Digital Architecture Use in the Preservation Field

Use in Preservation Academia

The practices and digital products seen in case studies from museums are similar to those being produced in the preservation field. This correlation can be seen by examining what academics are publishing about the software used in digital documentation, how it is taught to students in the classroom, and how it appears in their theses. Publications from academics in the past decade have focused on a variety of principles regarding the merging of technology with documentation work. In an article written in 2013, author Serra Akboy-İlk discusses the integration of technology into documentation work. She highlights the ways in which technology not only contributes to

[32] M. Bici, F. Campana, O. Colacicchi, and G. D'Ercoli, "CAD-CAE Methods to Support Restoration and Museum Exhibition of Bronze Statues: The 'Principe Ellenistico'," *IOP Conference Series: Materials Science and Engineering* 364, no. 1 (06, 2018), doi:10.1088/1757-899X/364/1/012014.

but enhances documentation work. In the two decades prior to this article's publication, technology in the field saw increasing popularity due to its ability to quickly capture highly accurate data in the field, allow for formerly inaccessible surfaces to be documented, and due to its 'nonintrusive character.'[33]

Despite these benefits, Akboy-İlk points out that reliance on this technology can change the way the documenter interacts with the historic built environment, at times in a negative manner. Using technology such as laser scanning to document buildings without also getting up close and interacting with the building can result in a disconnect between the documenter and the resource, causing the person to miss out on a deeper understanding of the way the building was constructed and the more abstract thinking skills that come with that knowledge. Keeping both these benefits and pitfalls in mind, Akboy-İlk comes to the conclusion that there is a place for both traditional hand-drawing, which can help people better understand details and construction of a building, and technology-aided documentation, which can help record the larger context of the building and still requires its own set of skills. In short, technology can fill gaps with structures that cannot be documented easily or at all with hand measuring. This conclusion is also summarized by a quote from Dana Lockett of the Historic American Buildings Survey (HABS), quoted by Akboy-İlk in this work: "Digital tools have a home in historic preservation."[34]

---

[33] Serra Akboy-İlk, "The Mediated Environment of Heritage Recording and Documentation," *Preservation Education and Research,* Vol. 6, 2013, https://www.ncpe.us/wp-content/uploads/2014/11/PER2013-offprint-AKBOY-ILK.pdf.
[34] Serra Akboy-İlk, "The Mediated Environment of Heritage Recording and Documentation," 19.

These themes continue throughout other pieces of literature published by academics in the years that follow. In a 2019 article, Dr. Brent R. Fortenberry discusses how the ways a documenter examines and records a building impacts how they construct meanings regarding the building on both a micro (dating the building, identifying later interventions) and a macro (connecting the building to the larger building culture) scale. Like Akboy-İlk, Fortenberry also notes similar positive qualities of digital documentation, such as the ability to collect data more quickly and with greater accuracy. He notes further limitations such as the need for an unobstructed line of sight for data collection and restrictions imposed by weather, battery life, or material composition and lighting issues.

Fortenberry points out a few additional negative themes which recur in other literature; the high cost of such projects (although it had begun to decrease), problems with file storage, and eventual obsolescence of the technology. Similar to Akboy-İlk, Fortenberry comes to the conclusion that digital documentation should not replace traditional analog documentation, but rather, "it is a means to push forward and expand, not replace, our methodological toolkit."[35] Fortenberry also notes that in 2019, historic preservation programs were quickly adding digital documentation training to their courses, with the prediction that digital documentation would become commonplace in the near future. This serves as an apt transition to exploring how such themes have been addressed in classroom settings.

[35] Brent R.Fortenberry, "Research Notes: Digital Documentation in Vernacular Architecture Studies," *Buildings & Landscapes: Journal of the Vernacular Architecture Forum* 26, no. 2 (2019): 98–114, https://doi.org/10.5749/buildland.26.2.0098.

Examining earlier integration of digital documentation software to preservation and adjacent field classrooms, a 2009 article in the *Preservation Education and Research* journal titled, "'So, Can You Revit?' Historic Preservation Design Education and Digital Media" is notable. Given the context that the classroom discussed in the article happens to be a historic preservation studio within a graduate school of architecture rather than a dedicated preservation program, author Paul Hardin Kapp referred to AutoCAD as antiquated. He states that rather, construction and engineering students should be learning integrated design and Building Information Modeling (BIM).[36]

Kapp argues that in order for architects to adaptively reuse, rehabilitate, or restore a historic building, they must understand the way the building was constructed, which they can gain from BIM. He does make the distinction that students cannot use the program in the same way that they do for new construction; he notes that it is important not to get lost in making 'impressive graphics' rather than building an understanding of how a historic building was constructed and how it ages. Kapp suggests that BIM could be a helpful part of preservation in the future, but he notes its limitations and the fact that he is mostly focused on design (which is logical for a studio of architecture students).[37]

[36] Paul Hardin Kapp, "'So, Can You Revit?' Historic Preservation Design Education and Digital Media," *Preservation Education and Research* 2, (2009): 15-26, https://www.ncpe.us/wp-content/uploads/2012/06/KAPP.pdf.; Building Information Modeling (BIM) is defined by Autodesk, the creator of Revit (a popular BIM software), as "… the holistic process of creating and managing information for a built asset. Based on an intelligent model and enabled by a cloud platform, BIM integrates structured, multi-disciplinary data to produce a digital representation of an asset across its lifecycle, from planning and design to construction and operations. "Building Information Modeling," Autodesk.com, Autodesk, 2024, https://www.autodesk.com/solutions/aec/bim.

[37] Kapp, "'So, Can You Revit?'."

Three years later, in 2012; however, a symposium held at the University of Mary Washington to examine differences and similarities between undergraduate historic preservation programs in the United States did not appear to include discussion on this aspect of preservation's future. The event was primarily concerned with the strengths and weaknesses of the different programs, especially relating to pedagogy, curriculum, and placement. It appears that no formal discussion of integration of design and documentation technology into preservation curricula occurred at this event, although it should be noted that this does not mean there was no discussion on the topic whatsoever. It is possible that technology integration just was not the priority at this time, and so it was not included in the discussions reported on in the journal article.[38]

Two years later, in 2014, discussion looped back to the integration of BIM in preservation education happening in architectural design studios. In this chapter of *Preservation Education: Sharing Best Practices and Finding Common Ground,* co-authors Paul Hardin Kapp, Lauren Weiss Bricker, and Luis Hoyos take a different tone towards BIM than Kapp's earlier article. Recognizing the shortcomings of BIM noted at the earlier date, the authors discuss the incorporation of HABS standards into the architectural studio along with the use of non-parametric based programs such as

[38] Andréa Livi Smith, "The Young Preservationist: Findings from the First Undergraduate Historic Preservation Education Symposium," *Preservation Education and Research* 5 (2012): 87-96, https://www.ncpe.us/wp-content/uploads/2014/03/PER2012-offprint-SMITH.pdf.

AutoCAD.[39] By teaching HABS standards rather than BIM, the authors found that students better understood the details that make historic buildings unique, how to represent that uniqueness, and how the structures were constructed.[40] This pivot from the earlier article aligns with a pattern of debate seen throughout many articles, where certain aspects of technology are pushed back against as academics struggle with whether or not to accept technology into their programs.

Other literature postdating the 2014 book on preservation education suggests that CAD software is more common than BIM or parametric-based software such as Autodesk Revit for preservation uses. A 2017 article, in which Dr. Carter L. Hudgins and Amalia Leifeste discuss the evolution of the Investigation, Documentation, and Conservation (IDC) course at Clemson University, discusses the use of AutoCAD at the start of the course to help students understand the basics of turning field notes into measured drawings drafted on the computer. A student within the course found this tool helpful enough to advocate for more time spent on AutoCAD over the course of the class. From these observations, Hudgins and Leifeste noted that CAD and digital measurement techniques became an 'increasingly large' portion of the drawing sections within studio

[39] Adobe defines 3D parametric modeling as "…a computer-aided design (CAD) technique that involves creating 3D models using parameters, relationships, and constraints. It allows designers and engineers to build and manipulate 3D objects while maintaining control over various design parameters." Non-parametric based programs (like AutoCAD), allow the creator less automated control over the 3D object. Instead, the creator builds the model by "…directly manipulating vertices, edges, and faces without relying on explicit parameters." "What is Parametric Modeling & How Does it Work?" Adobe.com, Adobe, 2024, https://www.adobe.com/products/substance3d/discover/parametric-modeling.html.

[40] Paul Hardin Kapp, Lauren Weiss Bricker, and Luis Hoyos, "Documentation and Design in Association: Historic Preservation Design Using Social History, Advocacy, and Drawing in the Architecture Design Studio," in *Preservation Education: Sharing Best Practices and Finding Common Ground*, ed. Barry L. Stiefel and Jeremy C. Wells, 175-191 (University Press of New England, 2014).

courses including IDC. They predicted that the trend would increase as students came to the program with computer skills and the field shifted towards more computer drafting.[41]

The conversation would continue in a 2020 article authored by Fortenberry and Leifeste in which they performed an experiment comparing the results of analog or traditional hand measuring versus laser scanning in the classroom. Their results found that analog measurements had a higher level of precision than digital recording and higher accuracy when depicting details such as window frames and door jambs, but that digital had better accuracy for less accessible elements and for irregular and non-orthogonal elements of the building envelope. As a result, the authors suggested that the best approach to measurements was one that used a combination of both analog and digital techniques, noting that analog measurement should still be taught in academic programs in order to encourage deeper understanding of buildings.[42] By taking this more middle-of-the-road stance, the authors align with themes that had been flowing as an undercurrent within the preservation field for a few years.

Established academics publishing in journals about their projects and their classes were not the only individuals to add to this conversation, however. A number of theses from emerging professionals contribute to the discussion, showing the conversation regarding the usage of design and documentation software occurring at all levels of academia. In 2015, Laura Lee Worrell's thesis continued earlier conversations about BIM

[41] Carter L. Hudgins and Amalia Leifeste, "The Documentation Course: Beyond Drawing," *Preservation Education and Research* 9 (2017): 47-61, https://www.ncpe.us/wp-content/uploads/2017/09/PER2016-v9-offprint-03-Hudgins-Leifeste.pdf.
[42] Brent R. Fortenberry, and Amalia Leifeste, "Querying the Products of Two Recording Techniques: Analog and Digital," *APT Bulletin: The Journal of Preservation Technology* 51, no. 2/3 (2020): 47–56, https://www.jstor.org/stable/26943427.

in the field. She aimed to build a case for integrating the use of BIM in preservation as Kapp had done earlier. She cites case studies such as the creation of a BIM model for Mount Vernon and creates her own BIM model using Revit and Autodesk Navisworks in order to advocate for the usage of BIM to help manage the storage and interpretation of building records.[43] Recent anecdotal evidence has hypothesized that despite efforts of Worrell and Kapp to advocate for the use of BIM models, the integration of the software has yet to catch on. The surveys conducted for this thesis help determine whether or not BIM models are becoming a more accepted and utilized tool by preservationists (at least in the museum field).

Other theses contribute to the conversation with different software and types of technology. Amanda Brown's 2016 thesis discusses the increased interest in digitizing cultural heritage sites and historic structures, noting some of the trends Fortenberry had discussed earlier such as the increase in affordability leading to greater use of technology to undertake this work. She compared four different techniques of technological documentation tools (laser scanning, photogrammetry, multimedia geographic information systems (GIS) and three-dimensional modeling), noting that one technique was not stronger than the other, rather the tools used should be whichever best fits the objectives of the project. Citing trends academics had noted such as the speed, high level of accuracy, and 'nonintrusive character' of such technology, Brown predicted that digital documentation would play an increasing role in understanding, appreciating, and

[43] Laura Lee Worrell, "Building Information Modeling (BIM): The Untapped Potential for Preservation Documentation and Management," Order No. 1591152, Clemson University, 2015.

managing heritage sites.[44] Once again, the survey for this thesis helps examine just how great a role digital documentation plays in these objectives at historic sites.

Use by Preservation Practitioners

While the vast conversation occurring in preservation academia certainly shows similar work being done within museums and preservation, a more well-rounded conversation also includes digital documentation technologies usage by preservation practitioners for projects in real-world settings. Similar to Worrell and Kapp, Elisavet Tsilimantou et. al. discuss their work in the field and make the argument that BIM technology is essential for managing construction phasing, materials, and other important building components within one location: a BIM model.[45] Two other case studies include similar projects to those done in museums, but they are included in this section of the literature review because they have a less explicit museum connection and are more rooted in preservation usage. The first, "Impact of Virtual Reality Experience on Accessibility of Cultural Heritage," discusses how accessibility to a piece of heritage is important in the creation of value, and uses virtual reality (VR) to provide accessibility to a Buddhist temple in Myanmar that can no longer be accessed by the public.[46] This case

[44] Amanda Brown, "City-Scaled Digital Documentation: A Comparative Analysis of Digital Documentation Technologies for Recording Architectural Heritage" Clemson University, 2016, https://tigerprints.clemson.edu/all_theses/2405.
[45] Elisavet Tsilimantou, Ekaterini T. Delegou, Ioannis A. Nikitakos, Charalabos Ioannidis, and Antonia Moropoulou, "GIS and BIM as Integrated Digital Environments for Modeling and Monitoring of Historic Buildings," *Applied Sciences* 10, no. 3 (2020): 1078, https://doi.org/10.3390/app10031078.
[46] A. Paladini, A. Dhanda, M. Reina Ortiz, A. Weigert, E. Nofal, A. Min, M. Gyi, S. Su, K. Van Balen, and M. Santana Quintero, "Impact of Virtual Reality Experience on Accessibility of Cultural Heritage," *The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences* 42 (May 5, 2019): 929-936, https://doi.org/10.5194/isprs-archives-XLII-2-W11-929-2019.

study is included here as it was published in a photogrammetry journal, and yet it includes many of the same themes found in publications focused on museum project themes, such as creating value and providing accessibility to objects or spaces using digital tools such as VR.

Similarly, Christina Pollalis et al. compare learning outcomes in a study of 61 students interacting with ancient Egyptian sculptures in "Evaluating Learning with Tangible and Virtual Representations of Archaeological Artifacts." Once again, while focused on archaeological artifacts rather than artifacts housed in a museum setting, the study is looking to achieve similar goals to studies performed in museums. The research team was concerned with learning outcomes and users' abilities to critically analyze the object presented to them through a HoloLens AR headset, a 3D model viewing website, and a plastic extrusion 3D print. In both settings, the goal of the researchers is to show that the use of the technology positively affects learning outcomes for the users of the technology. These connections between these projects in preservation and adjacent fields show that while preservation and museums are distinct endeavors, similar activities are happening in museums and in the field of preservation regarding 3D digital architecture.

There are, however, gaps in the literature revealed by the assembly of these works. The museum field lacks data on a survey level; case studies sometimes indicate which digital documentation technologies and software was used to create the products at a single museum, but the field lacks data on a larger scale. Continuing in that vein, much of the literature comes from Europe, the Middle East, and Asia. This does not mean the work is not being done in the United States—as the occasional case study and publication

from organizations such as AAM show—but it is not as widely published on. The narrow focus of many of the publications creates another gap; most literature focuses on the creation of digital products for museums and what they are intended for. However, little information is available on the satisfaction of the owners of the product and/or users, and on the background of the creators of those products. This begs questions such as: *What happens after the products are launched? Preservationists have the skills to create these projects, but are they the individuals doing the work in museums?*

The survey work of this thesis addresses some of these gaps. The survey collected data on a larger scale rather than documenting digital documentation technologies usage and project details in isolated case studies. In addition, the survey was distributed throughout the United States, addressing the lack of macro data from this country. Specific questions within the survey target the lack of information on project outcomes by measuring how museums self-determine the usefulness of the product and whether or not they would invest in it again. Other questions target the background of the individual(s) involved in creating the product to determine if they have a preservation background, helping to clear up the murkiness in the relationship between this type of work in museums and in preservation.

CHAPTER THREE

METHODOLOGY

This research employs, first, a broad survey to answer the research question: To what extent are American museums which operate historic structures using digital documentation technologies to create 3D digital architectural products to interpret and steward their historic structures? The survey was distributed broadly to 1) organizations or associations for museums 2) social media groups for individuals working in preservation and 3) email addresses linked to sites listed on state and local museum directories. The survey asked additional research questions such as:

- When museums are using digital products, what is the resulting product?
- What was the intent of the digital product?
- Are museums satisfied with that product?
- Are the products generated in house, out-of-house, or both?

The list of specific survey questions follows as the next subsection.

A second-tier survey gathered additional information on a series of case study sites which have digital products, and self-select into deeper discussion of the production and efficacy of their digital products. This survey was targeted to the producer of the digital product, and also sought to determine their educational background. The survey asked research questions such as:

- Who is involved in the creation of these products?
- Where are software skills learned?
- What software programs are being utilized to generate digital products?

- Are people with preservation education involved in this work?

Both tiers of the survey were hosted on Qualtrics, a cloud-based survey platform. Qualtrics can be used for statistical and qualitative data collection and analysis, and gives the survey creator the ability to choose from many different question types, ranging from multiple choice, to text entry, to likert scales and more. In order to make the survey simpler and more efficient for respondents, the platform also allows the use of branch logic to ensure respondents are only shown questions which pertain to their responses.[47] Examples of this branch logic can be found in the table of survey questions on the following pages.

Development of Survey

The first tier was a reconnaissance-style survey designed to collect demographic information on the institution and information museum staff or volunteers would know regarding if and how interpretive digital products are used at their site. This survey led to analysis of broad patterns such as: how common are each of the digital products surveyed for at museums operating historic structures? Does the frequency of using a certain digital product vary by institution size or geography? Does staffing size, visitation, or budget have any correlation with the use of digital products? Were most of the digital products generated in the past few years (for instance, since the COVID-19 pandemic)?

[47] Kent State University, "Statistical & Qualitative Data Analysis Software: About Qualtrics," Libguides.library.kent.edu. Kent State University Libraries, November 29, 2023, https://libguides.library.kent.edu/statconsulting/qualtrics.

The survey contained two sections; the first, a group of screening questions, and the second, a set of more focused questions about the digital product. The purpose of the screening questions (Q1-Q6) was to confirm the institution's status as a museum and determine if the museum had any digital products which capture an existing structure or recreate lost architectural or landscape features. In addition, these questions provide demographic information that can be used for comparative purposes during data analysis.

Digital project-focused questions (Q7-Q15) sought information on the intent of the digital product and the success (or lack thereof) of the product in meeting the objectives set by the museum upon its creation. In addition, this set of questions collected the contact information of those involved with the creation of the product, which was used to disseminate the second tier of the survey.

The second tier of the survey was designed to follow up with the historic sites which have staff generating their digital products in-house and the companies to which historic sites have outsourced their digital products. The second-tier survey asks respondents for information on the technicalities of production, and also for information on the educational background of the individuals who worked on creating these digital products. The primary focus of the second survey was examining the types of software used in producing digital products for museums, as well as where the respondent learned the digital tools used to create those products. Once again, the survey was broken up into two groups of questions. The first group of questions (Q1-Q6) collected data on the creator's background, including their educational background and job title. Data on

educational background is valuable to the analysis because it allows for evaluation of whether or not academically trained preservationists are doing this work.

The second set of questions (Q7-Q13) sought information about the digital product and the software used to create it. In order to ensure that they were discussing the same product referenced by the respondent to the first-tier survey, respondents to this survey were asked to describe the digital product. Responses to this set of questions were meant to answer the research sub questions of: Where are software skills learned? What software programs are being utilized to generate digital products? Are people with preservation education involved in this work?

Respondents were also asked to state whether or not they felt the product was used as intended. When compared to the satisfaction ratings provided by respondents to the first tier, the answer to this question helps build a basic understanding of how successful the implementation of these products was. These questions were designed to keep the answers simple, as a more in-depth examination of satisfaction and implementation of these products can serve as an avenue of further research.

The overarching goal of these questions is to determine how widespread the use of digital documentation technologies is to create 3D digital architectural products for the interpretation and stewardship of American historic structures operated as museums. Merely determining the scale of use, however, does not portray the full picture of digital documentation technologies usage at historic sites. Determining the demographic trends associated with such usage can suggest ways institutions who are not utilizing such programs might be supported or encouraged to use them. Learning more about the

intention of these products and the level of success in meeting those intentions can explain trends in usage and potentially uncover an issue preventing further adoption of such technologies and products. Learning about who is involved in the creation of the products and where their skills are acquired might help to suggest avenues for those interested in this work. When assembled, this data provides museums with a more holistic picture of digital program usage for interpreting and stewarding their historic structures. This benchmark can either be used to affirm the progress that has been made in the adoption of these sorts of products or suggest ways museums might work to adopt these technologies.

A full list of questions for each survey can be found in Table 3.1 and Table 3.2 below.

Survey 1 Questions			
#	**Question**	**Type**	**Branch Logic**
Screening Questions			
1	What is the name of your institution?	Fill in the blank	
2	Where is your institution located?	Fill in the blank	
3	What is the size of your institution? A. 0-5 B. 6-15 C. 16-30 D. 31-50 E. 51-70 F. 71-100 G. 101-150 H. 151-200 I. More than 200	Multiple choice	

	J. Unsure		
4	What is the average annual visitation of your site? A. Less than 500 B. 500-1,999 C. 2,000-4,999 D. 5,000-9,999 E. 10,000-24,999 F. 25,000-99,999 G. 100,000-250,000 H. Over 250,000 I. Unsure J. Prefer not to disclose	Multiple choice	
5	To your knowledge, what is the approximate annual budget of your institution? A. $350,000 and under B. $350,000-$499,999 C. $500,000-$999,999 D. $1,000,000-$2.9M E. $3M-$4.9M F. $5M-$14.9M G. $15m and over	Multiple choice	
6	Does your museum have any of the following digital products? These could be of a feature at any scale- landscape, building, architectural space or component, or an artifact. Please choose one; there will be a chance in Question 14 to provide answers about additional products. A. A 3D model B. A point cloud C. A 3d virtual tour D. A photogrammetric model E. A Building Information Model (BIM) F. A virtual and/or augmented reality experience G. A fly through video of a digital 3D product (the categories above) H. Drone footage or other immersive, digital experience I. Other (please specify)	Multiple choice	If “None of the above” is selected, the survey skips to the end with a thank you message

	J. None of the above		
Digital Product Questions			
7	When was the digital product created (please enter as YYYY)?	Fill in the blank	
8	What is the intent of the digital product (Does it recreate a lost feature? Offer interpretation of different phases of the structure? Is it a panoramic photo model or visualization of a space that is not normally accessible?)	Text entry	
9	Is the digital product meant for: interpretation (public or visitor facing), staff (museum personnel facing), or both? A. Interpretation (public or visitor facing) B. Staff (museum personnel facing) C. Both	Multiple choice	A. If "Interpretation" is selected, Q10 is asked and Q11 is skipped B. If "Staff" is selected, the survey skips to Q11 C. If "Both" is selected, both Q10 and Q11 are asked
10	On a scale of 1-5 (1 being not at all useful and 5 being extremely useful), how useful has the digital product been, over time, for interpretation of the historic resource?	Likert scale	
11	On a scale of 1-5 (1 being not at all useful and 5 being extremely useful), how useful has the digital product been, over time, for staff management of the historic resource?	Likert scale	
12	On a scale of 1-5 (1 being definitely not and 5 being definitely yes), would you invest your money and/or time creating this product again?	Likert scale	

13	Was this digital product made in-house (by a staff member, intern, or volunteer at your institution), by an outside company, or a combination of the two? A. In-house B. Outside company C. Combination of in-house and outside company	Multiple choice	A. If "In-house" is selected, Q13.A.I - Q13.A.III are displayed B. If "Outside company" is selected, Q13.B.I - Q13.B.II are displayed C. If "Combination of in-house and outside company is selected, Q13.A.I - Q13.A.III and Q13.B.I - Q13.B.II are all displayed
13.A.I	What is the job title of the person from your institution?	Fill in the blank	
13.A.II	What is the name of the person from your institution (This information will only be used for contact purposes, it will not be published as part of the analysis)?	Fill in the blank	
13.A.III	Can I contact the person from your institution about the model? A. Yes B. No	Multiple choice	A. If "Yes" is selected, Q13.A.IV is displayed
13.A.IV	What is their email address (This information will only be used for contact purposes, it will not be published as part of the analysis)?	Fill in the blank	
13.B.I	What is the name of the company at which the individual who produced your digital product works/worked?	Fill in the blank	

13.B. II	Can I contact the company about the model? A. Yes B. No	Multiple choice	A. If "Yes" is selected, Q13.B.III is displayed
13.B. III	Do you have a specific person I can contact at the company? What is their name (This information will only be used for contact purposes, it will not be published as part of the analysis)? A. Yes [Please enter name] B. No	Multiple choice (with fill in the blank)	A. If "Yes [Please enter name]" is selected, Q13.B.IV is displayed
13.B. IV	What is their email address (This information will only be used for contact purposes, it will not be published as part of the analysis)?	Fill in the blank	
14	Does your museum have any additional digital products? A. Yes B. No	Multiple choice	A. If "Yes" is selected, Q15 is asked and the survey loops back to Q7 B. If "No" is selected, the survey skips to the end with a thank you message
15	Does your museum have any of the following digital products? Please choose one; there will be a chance in Question 14 to provide answers about additional products. K. A 3D model K. A point cloud K. A 3d virtual tour K. A photogrammetric model K. A Building Information Model (BIM) K. A virtual and/or augmented reality experience K. A fly through video of a digital 3D product (the categories above)		

	K. Drone footage or other immersive, digital experience K. Other (please specify) K. None of the above		

Table 3.1: Survey 1 Questions.

Survey 2 Questions			
#	**Question**	**Type**	**Branch Logic**
Individual Questions			
1	You received this survey because you were indicated as the developer/part of the development team of the digital product(s) for the museum specified in the email with this survey link. Are you still in the same job as when you created that digital product? If not, what is your current job title? A. Yes B. No [Please enter job title]	Multiple choice (with fill in the blank)	
2	Are you a staff member at the museum/historic site (If you answered "no" to the previous question, please fill out the following questions based on your job at the time that you worked on the digital product)? A. Yes B. No	Multiple choice	A. If "Yes" is selected, Q2.A is displayed B. If "No" is selected, Q2.B is displayed
2.A	What is the name of your historic site?	Fill in the blank	
2.B	What is the name of your company?	Fill in the blank	
3	What is your job title?	Fill in the blank	
4	What is the highest degree or level of school you have completed? A. High school B. Some undergraduate coursework C. Undergraduate degree	Multiple choice	

	D. Some graduate school coursework E. Graduate degree		
5	If you attended a college or university, what was your program of study? A. History B. Historic preservation C. Museum studies D. Art history E. Architectural history F. Archaeology G. Public History H. Anthropology I. Computer science J. Nonprofit management K. Business Administration L. Other (please specify) M. Not applicable	Multiple choice	
6	Which of the following digital products were you involved in creating? These could be of a feature at any scale- landscape, building, architectural space or component, or an artifact. Please choose one; there will be a chance in Question 12 to provide answers about additional products. A. A 3D model B. A point cloud C. A 3d virtual tour D. A photogrammetric model E. A Building Information Model (BIM) F. A virtual and/or augmented reality experience G. A fly through video of a digital 3D product (the categories above) H. Drone footage or other immersive, digital experience I. Other (please specify)	Multiple choice	
Product & Software Questions			
7	Describe the digital product you created for the institution you work or worked for/with (Does it	Text entry box	

	recreate a lost feature? Offer interpretation of different phases of the structure? Is it a panoramic photo model or visualization of a space that is not normally accessible? Information about renovations to the structure?).		
8	Is the digital product meant for: interpretation (public or visitor facing), staff (museum personnel facing), or both? A. Interpretation (public or visitor facing) B. Staff (museum personnel facing) C. Both	Multiple choice	
9	From what you observed, is the digital product used as intended? A. Yes B. No	Multiple choice	B. If "No" is selected, Q9.B is displayed
9.B	If no, why not?	Text entry box	
10	What software program(s) did you use to create the digital product (ex. 3ds Max, Unity, AutoCAD, Revit, etc.)?	Fill in the blank	
11	Where did you learn the software program(s) you used to create the digital product? Choose one or more. A. Undergraduate core class B. Undergraduate elective class C. Graduate core class D. Graduate elective class E. University-sponsored workshop F. Non-university sponsored workshop G. Internship H. Post-graduation professional development (employer funded) I. Post-graduation professional development (self-sponsored) J. Other (please specify)	Multiple choice	
12	Were you involved in the creation of any additional digital products? A. Yes	Multiple choice	A. If "Yes" is selected, Q13 is asked and the

	B. No		survey loops back to Q7 B. If "No" is selected, the survey skips to the end with a thank you message
13	Which of the following digital products were you involved in creating? Please choose one; there will be a chance in Question 12 to provide answers about additional products. A. A 3D model B. A point cloud C. A 3d virtual tour D. A photogrammetric model E. A Building Information Model (BIM) F. A virtual and/or augmented reality experience G. A fly through video of a digital 3D product (the categories above) H. Drone footage or other immersive, digital experience I. Other (please specify)	Multiple choice	

Table 3.2: Survey 2 Questions.

After the draft of the questions was completed, they were sent to each member of the thesis committee for comment. Once the comments were addressed and the questionnaire was finalized with the committee, Patricia Lowe Smith, Director of Preservation at Drayton Hall Preservation Trust (a member of this thesis committee), was sent a link to pilot the survey. Her test of the survey ensured that the branch logic worked correctly, and helped refine the approximate time it takes to complete the survey.[48]

[48] It should be noted that due to her inclusion on this thesis committee, Smith would not be completing the final version of the survey; she was chosen to pilot the survey for this reason along with her expertise in preservation at a historic house museum.

An application for exempt level review was prepared for the Clemson University Institutional Review Board (IRB) to gain approval to distribute the survey. According to their website, the purpose of the IRB is to "protect the rights and welfare of human subjects recruited to participate in research activities conducted under the auspices of Clemson University (CU)."[49] As this survey was used to generalize information based on the answers of respondents, the study qualifies as research involving human subjects, necessitating IRB review. The IRB requires drafts of any material used to contact respondents and/or advertise the survey to ensure ethical solicitation of responses; thus, a blog post and email templates were drafted. All contact material explained the purpose of the survey, details about the length of the survey, and contact information for further questions.

The blog post was designed to be sent to organizations such as the American Alliance of Museums (AAM) to share on their blog. Four separate emails were drafted: 1.) an email for contacting organizations such as AAM about sharing the blog on their websites, 2.) an email for contacting individual museums directly to complete the survey, 3.) an email for contacting the individuals/companies listed by first tier respondents, and 4.) a reminder email for individuals/companies to complete the survey. The full text of each piece of contact materials (as submitted to IRB) can be found in Appendices A and B. The completed application, including the survey questions listed above, was submitted to the IRB on October 17, 2023. The application for exempt level review was approved

[49] "Institutional Review Board," Clemson.edu, Office of Research Compliance, Clemson University, 2023, https://www.clemson.edu/research/division-of-research/offices/orc/irb/index.html.

on November 3, 2023. This approval allowed for the dissemination of the survey to begin.

Selection of Respondents & Distribution

The goal of survey distribution was to get the survey to as many historic museum professionals and volunteers as possible. Inspired by the research design of Rachel Wilson's thesis, "This Is Not a Drill: A Survey of Natural Disaster Preparedness in House Museums and Historic Sites," museum organizations were determined to be a feasible avenue of disseminating the survey.[50] Several organizations, including the Association of State and Local History and the Association for Living History, Farm, and Agricultural Museums (who did not respond when contacted), have memberships made up of history museums. Other organizations, such as the American Alliance of Museums (AAM), have a broader membership base which includes history museums and other institutions such as art and science museums and zoos. AAM, which is one of the largest museum organizations in the United States, has a membership of 35,000 museums and museum professionals. The organization provides accreditation to museums, publishes standards for professionalism and best practices as well as news and research from the museum field, and crucially, provides opportunities for interaction for museum professionals.

AAM holds conferences such as the Future of Museums Summit, and also host platforms for professionals to network online such as the Museum Junction forum. A post

[50] Rachel W. Wilson, "This Is Not a Drill: A Survey of Natural Disaster Preparedness in House Museums and Historic Sites," Clemson University, 2020, https://tigerprints.clemson.edu/all_theses/3295.

with the link to the first survey was shared on both the Historic Houses & Sites Forum and Open Forum sections of the Museum Junction forum. Another post was shared with information about the project and a link to the survey on the "Historic Preservation Professionals" Facebook page.

The next phase of survey dissemination moved from the indirect method, where respondents were generated entirely through self-selection via posts on forums and social media, to the direct method, where potential respondents were contacted via email (the full text of the email can be found in Appendix A). This dissemination method was used both in Wilson's thesis and in Abby Milonas's thesis, "Physical Accessibility and Historic Preservation in Historic House Museums of the Southeast."[51] Museum directories from various museum and state tourism organizations served as the starting point for generating a list of potential respondents. Some directories were regionally based, while others were organized by individual states. By consulting all of these directories, the sample set includes a number of museums from each region in the United States. The directories consulted can be found in Table 3.3 below:

List of Directories		
Directory	**State or Regional**	**Link**
Association of Midwest Museums (AMM)	Regional	https://www.midwestmuseums.org/resources/directories/

[51] Abby Milonas, "Physical Accessibility and Historic Preservation in Historic House Museums of the Southeast," Clemson University, 2023, https://tigerprints.clemson.edu/all_theses/4098.

Mountain-Plains Museums Association (MPMA)	Regional	https://www.mpma.net/Institutional-Member-Directory
Western Museums Association (WMA)	Regional	https://westmuse.org/directory-institutional-members
PA Museums	State	https://pamuseums.org/museum-directory/
NJ Tourism New Jersey Museums	State	https://visitnj.org/nj/arts-culture/museums
I Love NY Museums in New York	State	https://www.iloveny.com/things-to-do/museums/
Alabama Museums Association	State	https://alabamamuseums.org/museums
Arkansas Museums Association	State	https://www.arkansasmuseums.org/member-directory
Florida Association of Museums	State	https://www.museumsusa.org/hosting/fam/museums/
Kentucky Museum & Heritage Alliance	State	https://kymuseums.org/directory/
Louisiana Association of Museums	State	https://lamuseums.org/resources/directory-of-louisiana-museums/
Mississippi Museums Association	State	https://msmuseums.org/museums/

North Carolina Museums Council	State	https://www.arcgis.com/apps/mapviewer/index.html?webmap=3eab98d2a8c34629b2e488da5988dbc9
South Carolina Federation of Museums	State	https://scmuseums.com/#
Virginia Association of Museums	State	https://www.vamuseums.org/our-museums?MapView=true
West Virginia Association of Museums	State	https://www.museumsofwv.org/museums
Texas Association of Museums	State	https://www.texasmuseums.org/member-directory
Explore Georgia® Discover Georgia's Museums	State	https://www.exploregeorgia.org/things-to-do/list/discover-georgias-museums
Tennessee Department of Tourist Development "Awesome Museums in Tennessee You Have to Visit"	State	https://www.tnvacation.com/articles/awesome-museums-tennessee-you-have-visit
Museums USA filtered for "Vermont"	State	https://www.museumsusa.org/museums/?k=1271400%2cState%3aVT

New Hampshire History Network	State	https://network.nhhistory.org/Participating-Organizations.aspx
Rhode Island History Online Directory Initiative	State	https://www.rihs.org/rhodi/rhodi-directory/#letter-A
Visit New England® Massachusetts Museums and Galleries	State	https://www.visit-massachusetts.com/state/museums-and-galleries/
Maine Archives & Museums	State	https://www.mainemuseums.org/Find
CT Visit History/Heritage	State	https://ctvisit.com/historyheritage

Table 3.3: List of directories consulted.

When possible, filters such as “history,” “historic house,” “historic site,” and “living history” were applied to the directory results. In both the filtered directories and those that were unable to be filtered, the resulting institutions were screened to ensure their compatibility with the goals of the survey. This was done by looking at each museum’s website to ensure that they are associated with some type of historic structure, a recreated historic structure, or a landscape on which there is evidence of features of the built environment that are no longer extant. By filtering based on this criteria, museums which use digital products simply to digitize their exhibition space were eliminated while ensuring that historic sites without extant buildings (but that still interpret the historic

built environment) could be included. This also allowed sites ranging from local historical societies to large, nationally known museums to be included in the sample set. From the directories and website searches that followed, a list of 651 contacts was generated. In addition, seven sites were added to this list due to their known usage of design and documentation programs via their connection to myself and members of this thesis committee.

Contacts were entered into a spreadsheet organized by state or region, depending on which directory they were pulled from. For each institution, the name of the museum and a contact email were collected, along with a contact name and job title when available. At the end of each entry, the date which they were first contacted was listed, along with the date of any reminders sent. The first batch of emails were sent on November 27, 2023, and a second batch on November 29. For a select few sites which fit the above criteria but did not have an email address, they were contacted via their "Contact Us" forms on their website on November 27. As responses began to come in, those who had responded were colored green to indicate that they had responded, and no further reminders were needed.

Some organizations replied to the email that they did not possess any type of product. A survey entry was filled out for each of these institutions with their name and "None of the Above" selected under Q6. This will help answer the primary research question of this thesis, which asks how widespread the use of digital documentation technologies is to create 3D digital products for the interpretation and stewardship of American historic structures operated as museums. These entries will not be used in

further demographic analysis as this information was not provided by the email respondents.

Approximately 650 sites were contacted via the direct contact method. The survey was open November 10th to December 8th, with an extension added (and publicized via email notification to potential respondents on November 29th and the "Historic Preservation Professionals" Facebook page on December 15th) until December 20th.

As responses to the first tier came in, the contact information provided by respondents was added to the spreadsheet in the same row as the museum that had provided the contact information. The second tier was distributed once contact information was entered into the spreadsheet. The second tier closed on January 15, 2024.

Methods for Analysis

The targeted response rate for the survey was based upon the precedent of the two other Clemson theses (referenced earlier in this chapter) that have addressed museum-related topics. According to *The Good Research Guide: For Small-Scale Social Research Projects,* the acceptability of a response rate is dependent on the circumstances of the survey. The book states,

> …it is more productive to gauge whether the response rate is acceptable by making a comparison with *similar* surveys. It is the response rates achieved by surveys that are similar in terms of their methods, their size, their target group,

> their topic of research, their use of prior contact and other relevant factors that provide an indication of what can be treated as an acceptable response rate.[52]

For this reason, the two precedent theses were used to set the target response rate. Abby Milonas's thesis on the Americans with Disabilities Act (ADA) in museums recorded an approximately 38% response rate and Rachel Wilson's disaster preparedness thesis recorded a 45.7% response rate.[53] Based on the similar research design for the survey in this thesis, the target response rate was around 40%.

Once the surveys closed, the data was exported to Excel directly from Qualtrics to begin analysis. Data from each question was used to address each of the research questions. The main research question, "How widespread is the use of digital documentation technologies to create 3D digital products for the interpretation and stewardship of American historic structures operated as museums?" is answered by data from Survey (S)1 Q6. The following secondary research questions are answered by the following survey questions:

- When museums are using digital products, what is the resulting product? S1 Q6, S2 Q7
- What was the intent of the digital product? S1 Q8, S2 Q8
    - Are museums satisfied with that product? S1 Q9-12, S2 Q9
- Are the products generated in house, out-of-house, or both? S1 Q13

---

[52] Martyn Denscombe, *The Good Research Guide: For Small-Scale Social Research Projects,* 6th ed. (London: McGraw-Hill Education, 2017), https://www.google.com/books/edition/EBOOK_The_Good_Research_Guide_For_Small/SMovEAAAQBAJ?hl=en&gbpv=1&dq=The%20Good%20Research%20Guide%3A%20For%20Small-Scale%20Social%20Research%20Projects&pg=PA19&printsec=frontcover, 19-20.

[53] Milonas, "Physical Accessibility and Historic Preservation in Historic House Museums," 43; Wilson, "This is Not a Drill," 61.

- How common are the digital products? S1 Q6
- Does staffing size, visitation, or budget have any correlation with the use of digital products? S1 Q2-5
- When were the digital products created? S1 Q7
- Who is involved in the creation of these products? S1 Q13
    - Where are software skills learned? S2, Q11
    - What software programs are being utilized to generate digital products? S2 Q10
    - Are people with preservation education involved in this work? S2 Q5

The analysis of data from the first survey largely concerns the extent of digital documentation technologies usage. This usage is contextualized by analyzing the demographic data collected at the beginning of the survey, which helps show if there is any correlation between museum size (in terms of staffing, visitation, and budget) and usage trends. Analyzing data from the second half of the first survey helps determine what digital product users intend those products to be used for and examines the satisfaction rate users are experiencing regarding those products. While data from the end of the first survey provides valuable information on the proportion of these products made in-house, out-of-house, or a combination of the two, the contact information collected in this section is not shared in the presentation of data in order to protect the privacy of the individuals whose information the first-tier respondents submitted.

The analysis of data from the second survey focuses on the background of the individual who contributed to the development of the digital product, comparing, for instance, how common it is for the producer to have a high school education versus an undergraduate education versus a graduate education. This section also helps illustrate what types of projects people from different backgrounds (ex. Computer science or historic preservation) have completed, which can help determine what people with training such as historic documentation might be able to contribute to the development of these digital products. Lastly, the data collected from this second survey helps determine some of the software used to generate such products and determine where those skills were acquired. This information can help those who may be interested in this work discover avenues to learn those skills.

Univariate statistics were used to define the sample set.[54] Most of the data is quantitative data. This type of data is the primary base of the comparisons listed above, which are made in the data analysis. Only a few questions collected qualitative data, and those responses are mostly used to add extra anecdotal context to the analysis. The data is presented in the next chapter, while analysis of the data is completed in Chapter 5.

[54] Univariate statistics examine each variable in a data set individually, along with the "pattern of response" for each variable. "Univariate Data Analysis," Home.csulb.edu, California State University, Long Beach, accessed March 7, 2024, https://home.csulb.edu/~msaintg/ppa696/696uni.htm.

CHAPTER FOUR

PRESENTATION OF DATA

The first tier of the survey was distributed via email to 649 museums associated with a historic structure, and of those, 632 were delivered successfully. The first tier of the survey collected 114 responses, which represents 153 museums, who either responded that they possessed one or more digital products or did not possess any.[55] The responses describe the use of 148 digital products.

In order to ensure that the products were relevant to the questions asked in this thesis, the responses needed to fit the criteria of being 3D digital architecture used to interpret and/or steward a historic structure. For the purposes of this thesis, "digital architecture" refers not to architecture that was designed with a computer, but instead refers to historic architecture that has been documented or reconstructed via digital means. The product must also have three dimensions; for the purposes of this thesis, this can come either in the form of an XYZ axis, or a two-dimensional representation that has a time sequence component as the third dimension, such as a video.

Sixteen of the 148 products do not fit these criteria. Nine of the sixteen irrelevant products had been submitted by museums that reported having other relevant products. For this reason, those nine products were removed from the dataset (with the other responses submitted by those museums left unchanged). The remaining seven products of the sixteen irrelevant products were submitted by museums that did not have any other

[55] Three responses were from an organization responding on behalf of more than one museum.

relevant products. For this reason, these seven responses were counted as "None of the above," as it is presumed that if the museum had had relevant products, they would also have disclosed those.

Five products were added to the dataset from responses to the second tier of the survey, bringing the total number of relevant products to 137. From the 114 responses submitted for the first tier, fifty unique contacts involved in the creation of those products were provided.[56] From these fifty contacts, twenty-nine individuals responded to the second tier of the survey. All identifying information has been removed from the responses presented below, as noted as a condition for answering the survey.

Response Rate

112 responses resulted from email contact. Two additional responses resulted from indirect contact (social media and forum posts), which was confirmed by cross referencing the museum names provided by respondents to the museum names found in the contact list. Together, this totals 114 responses to the first tier of the survey. In three of these responses, the parent organization that administers the museums responded on behalf of those individual museums on the contact list. In one case, the organization responded for thirty-eight individual museums, in the second instance, the organization responded for two, and in the third instance, the organization responded for four. As such,

[56] It should be noted that this number does not include contacts that were provided for individuals involved in the creation of products that did not fit the criteria of interpreting or stewarding a historic structure.

sites are counted towards the response rate rather than organizations. In total, this amounts to 153 responses, which is a 24.21% response rate.

Limitations of Data

The data recorded via these surveys is not representative of all history museums involved in the interpretation and stewardship of the built environment. According to the 2022 National Census of History Organizations, produced in collaboration with the American Association for State and Local History (AASLH), there are 21,588 history organizations in the United States. The activity area of 66% (approximately 14,248) of these organizations is historical societies and related (which encompasses historical societies that might engage in similar programming as museums, such as stewarding and exhibiting collections), and 24% (approximately 5,161) are history museums.[57]

The 632 sites contacted for the first tier of the survey consisted of both history museums and local historical societies who steward a historic structure as a museum. A response rate can only be calculated for the sites that were contacted via email; it is unclear how many individuals would have seen the forum and social media posts calling for survey respondents. The sampling method used was not designed to guarantee or target a representative sample, but instead designed on a voluntary participation base to record as much information as possible from individuals willing to respond. This sampling method does have the potential to introduce additional bias as respondents are

[57] Carole Rosenstein, PhD and Nevill Vakharia, "2022 National Census of History Organizations: A Report on the History Community in the United States," (Nashville, TN: *American Association for State and Local History,* 2022), http://download.aaslh.org/Research/2022+National+Census+of+History+Organizations.pdf, 15.

more likely to already be using digital products if they are answering the survey.[58] Since the data gathered in these surveys is not mathematically representative of the approximately 20,000 museums and local historical societies in the United States and may include some response bias, it is only used to make qualitative assessments. The data suggests why certain patterns might exist within the dataset and speculates on how those patterns could suggest new practices for other museums to adopt.

First Tier Question Responses

Question One

Question one asked for the name of the institution responding to the survey. This information was one of the data points used to link second tier responses to the first, and to track the response rate of the survey. The names of the museums are not published here in accordance with the conditions of the survey.

The following group of questions (Q2-Q6) served a dual purpose. They were both screening questions to confirm that the respondent is from a museum and possesses a 3D digital product that either interprets and/or stewards an extant or recreated historic structure, and questions to provide a basis for demographic analysis. Twenty-three individuals responded via email that their institution did not possess any of the listed digital products, and so their responses were entered into the survey with most of the

[58] This concept is explored further in "Chapter Five: Analysis," in the *Scope of Design and Documentation Program Use* section; Rebecca Medway et. al, *National Household Education Surveys Program of 2019: Qualitative Study of Nonresponding Addresses* (Washington, D.C.: U.S. Department of Education National Center for Education Statistics, 2022), https://nces.ed.gov/pubs2022/2022043.pdf, 159.

demographic information marked as “unsure” (with the exception of their locations, which could still be easily determined from their websites). The total number of museums/organizations that demographic information was provided for was 112. The organizations that provided information on behalf of the museums they steward answered the demographic questions for their organization as a whole, rather than for the individual museums.

Question Two

Question two asked respondents where their museum is located. The majority of respondents reported the city and state that their institution is located in, although a few put only the state or county that they are located in. For mapping purposes, these responses were standardized so that each response included both the city and state abbreviation where the museum is located. For the few who did not list their city, the city listed in the address on their website was used. Figure 4.1 below helps visualize the spatial distribution of the responses using the city and state listed to plot the location.

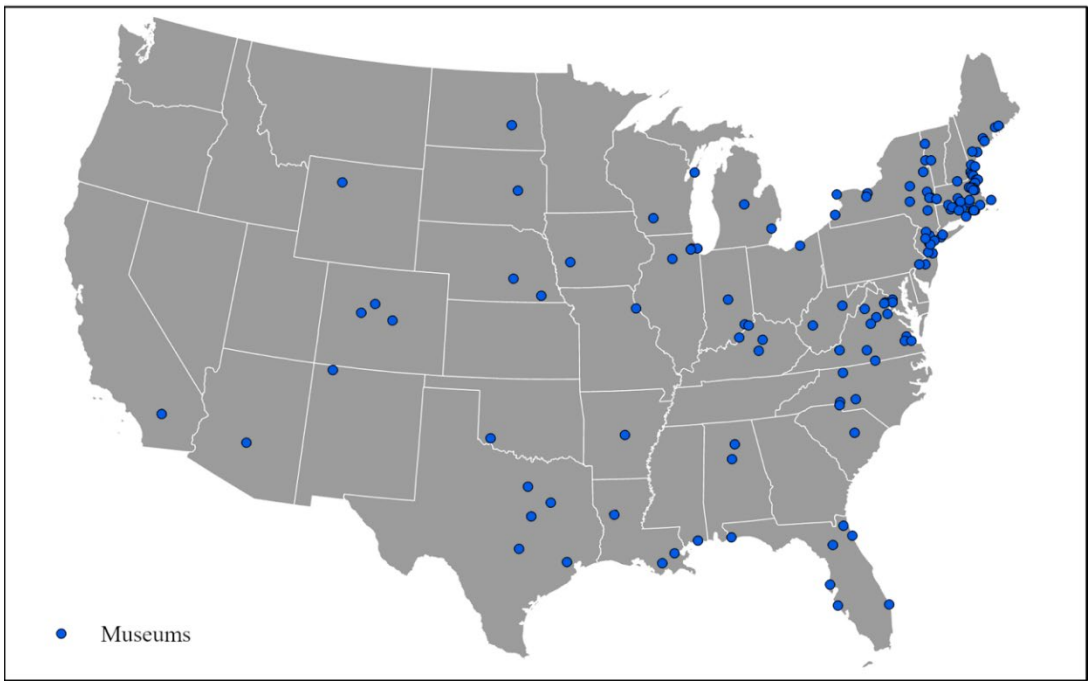


Figure 4.1: Map of first tier survey responses.

In order to comply with the privacy stipulations set up at the start of the survey, the cities listed by museums are not presented here. Table 4.1 below, however, shows the number of responses by state.

State	Count	State	Count	State	Count	State	Count
MA	25	RI	5	VT	2	ND	1
NY	19	TX	5	WI	2	NM	1
VA	13	LA	3	WV	2	OH	1
ME	10	NC	4	AR	1	OK	1
NJ	8	CO	3	AZ	1	PA	1
FL	7	AL	2	CA	1	SC	1
CT	7	IN	2	IA	1	SD	1
IL	5	MI	2	MO	1	VA	1
KY	5	NE	2	MS	1	WY	1
NH	5						

Table 4.1: Number of responses by state.

Massachusetts has the highest number of responses with twenty-five museums represented. Twenty-two of the twenty-five responses fall under a single organization which responded for thirty-eight museums, accounting for the high number of responses from this state. This is followed by New York with nineteen responses, Virginia with thirteen responses, Maine with ten responses, and New Jersey with eight responses. Like Massachusetts, a majority of the responses from Maine (seven) are from the single organization who responded for thirty-eight museums. Four of the responses from Virginia are personal connections, which likely contributed to the higher response rate from that state.[59] The fewest responses come from the west coast, which was poorly represented by the museum directories used to compile the list of contacts in comparison to directories in the central and eastern United States. For this reason, the qualitative assessments in this thesis can only suggest current practices in the field, especially on the east coast where the response rate was higher.

Question Three

Question three asked respondents about the size of their museum in terms of the number of full-time staff who are employed there. For the four organizations that responded on behalf of multiple museums, the respondent answered this question with the number of full-time staff in their organization as a whole.

[59] These personal connections include an alumni from the same undergraduate program as the author, a former internship supervisor of the author, and two connections made via the author's graduate program.

- Over half of the sites (50.9%, n=112) responded that they have no more than five full-time staff [60]
- 13.4% of respondents have six to fifteen full-time employees
- 7.1% have sixteen to thirty full-time employees
- 2.7% have thirty-one to fifty
- 0% have fifty-one to seventy
- 1.8% have seventy-one to one hundred
- 0.9% have 101-150
- 2.7% have 151-200
- 1.8% have more than 200 employees
- 18.8% of respondents are either unsure or do not have demographic information available.

See Figure 4.2 for the count of institution size.

[60] N equals the number of responses used in the calculation of the percentage. This number will vary based on the question as some respondents were only asked certain questions based on their responses. The branch logic used can be found in Chapter Three.

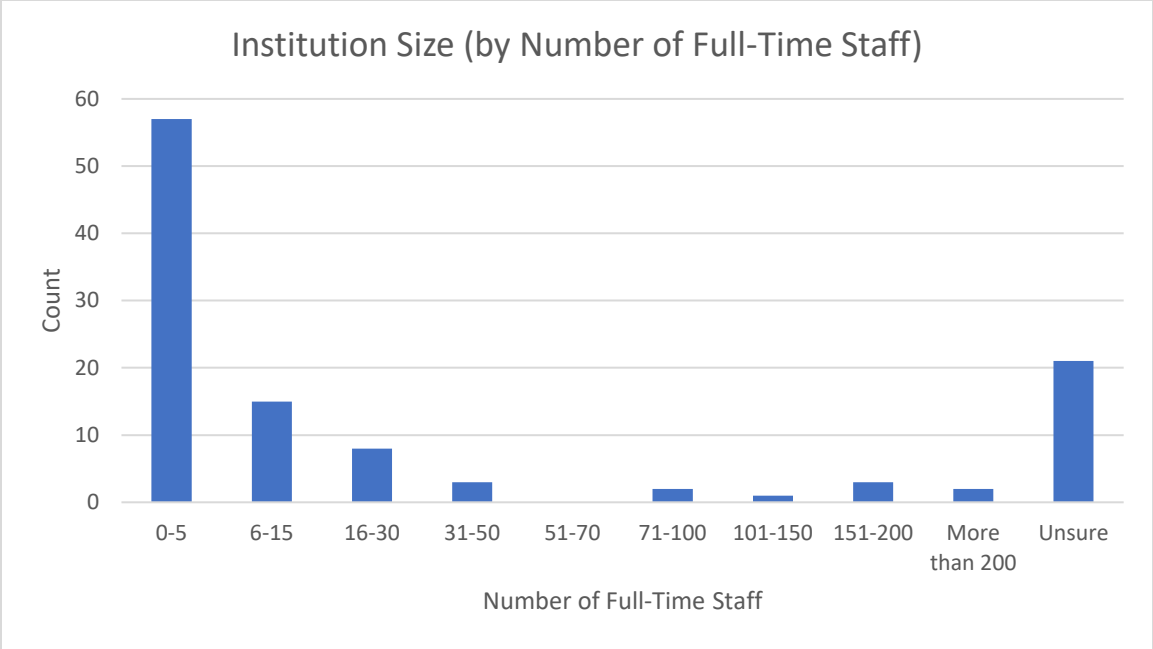


Figure 4.2: Institution Size (by Number of Full-time Staff)

Question Four

Question four asked for the average annual visitation of the respondent's museum. Unlike the number of full-time staff which is skewed towards an extremely small staff, the range of visitation is spread more evenly across the dataset. For the four organizations that responded on behalf of multiple museums, the respondent answered this question with the average annual visitation for their organization as a whole.

- 5.4% of respondents have less than 500 visitors annually (n=112)
- 11.6% have between 500 to 1,999 visitors
- 12.5% have between 2,000 to 4,999 visitors
- 13.4% have between 5,000 to 9,999 visitors
- 9.8% have between 10,000 to 24,999

- The largest percentage of sites, 15.2%, have between 25,000 to 99,999 visitors annually
- Fewer sites have greater visitation than this; 6.3% have between 100,000 to 250,000 visitors, and only 4.5% of respondents have over 250,000 visitors annually
- 21.4% of respondents are either unsure or do not have demographic information available.

See Figure 4.3 for the count of average annual visitation.

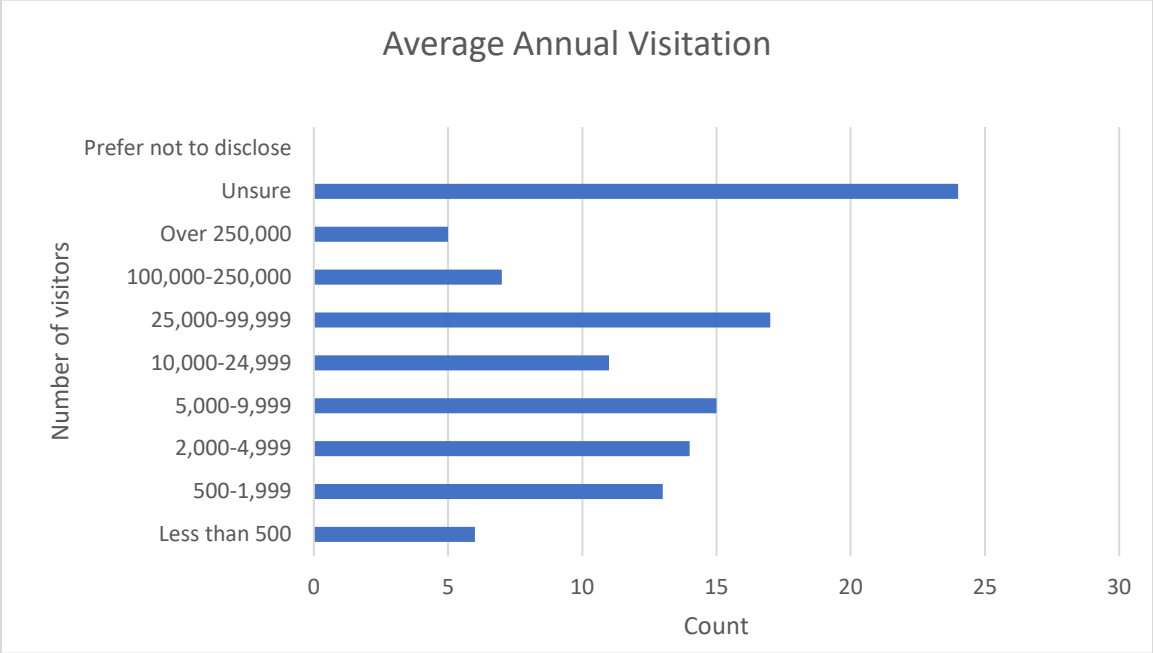


Figure 4.3: Average annual visitation.

Question Five

Question five asked respondents for the approximate annual budget of their institution. This question was made optional so that individuals who either did not know or were not able to share such information could continue the survey. For the four

organizations that responded on behalf of multiple museums, the respondent answered this question with the approximate annual budget for their organization as a whole. As with the number of full-time employees, the largest percentage of respondents have smaller budgets. 34.8% of respondents (n=112) have an approximate annual budget of $350,000 and under. This is followed by 8.0% of respondents with a budget of about $350,000 to $499,999, and 8.9% of respondents with a budget of about $500,000 to $999,999. Another significant group of respondents (17.0%) have a budget of approximately $1,000,000 to $2.9M. After this group, fewer institutions have larger budgets, with only 2.7% having a budget of about $3M to $4.9M, 4.5% with a budget of $5M to $14.9M, and 1.8% with $15M and over. 22.3% of respondents did not answer the question. See Figure 4.4 for the count of approximate annual budget.

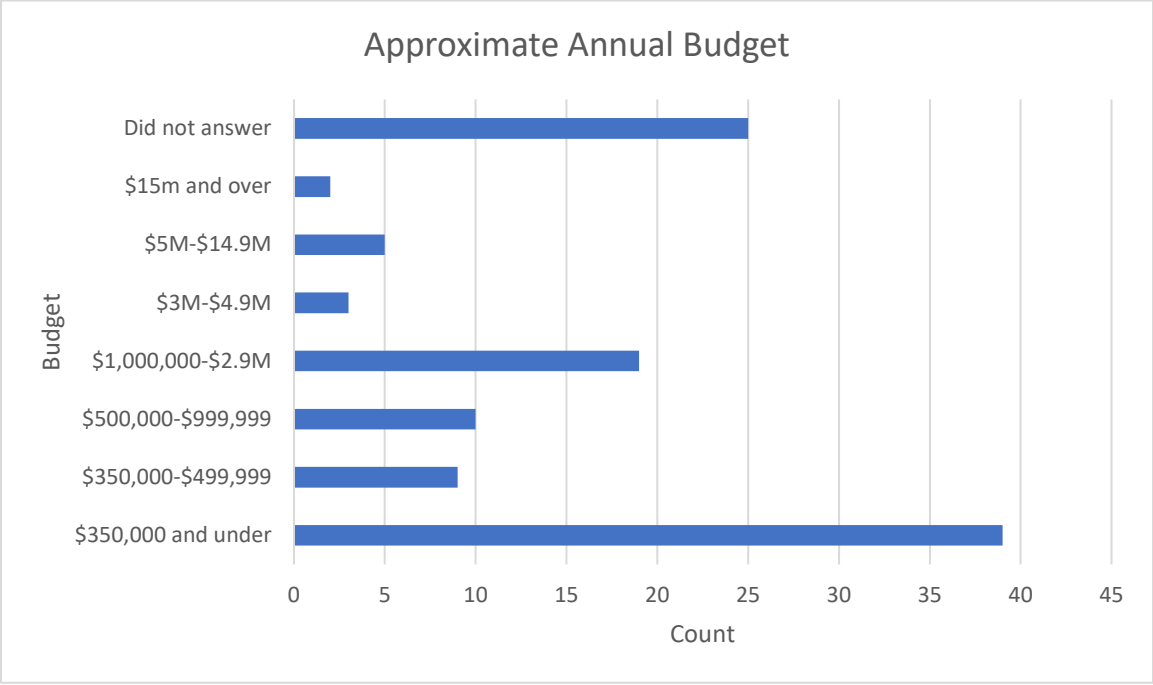


Figure 4.4: Approximate annual budget.

Question Six

Question six is key to determining whether or not the respondent's museum possesses a digital product. Respondents were asked to select from a list of three-dimensional or pseudo-three-dimensional digital products, with a "None of the above" option for museums who are not in possession of any of the listed products. The responses listed below account for the 137 relevant products (which were determined to be so from the responses to question eight). There is a tie for the largest percentage of respondents, with 32.2% (n=199) possessing no digital product, and 30.2% possessing a 3D virtual tour (such as a Matterport scan). This is followed by 13.1% of respondents who possess drone footage or other immersive digital experiences, and 6.5% of respondents who have some sort of other 3D digital product.[61] 4.5% of respondents have a 3D model, 4.5% of respondents have a photogrammetric model, and 4.5% of respondents have a virtual and/or augmented reality experience. Only 3.0% of sites possess a (laser documented) point cloud and 1.5% a Building Information Model (BIM). No institutions responded that they possessed a fly through video of a digital 3D product.

It is possible (based on the descriptions in question eight) that a few respondents misrepresented their digital products. Two respondents who had defined their product as "Other" described a product that fit under another category, and so their response was overridden and changed to the category. In addition, five products were added to the total list of 3D digital products after consulting the dataset from the second tier of the survey.

[61] Examples of "Other" responses include a digital interactive of a historic home, a Clio tour and StoryMaps, and a touch table with an interactive map of a city.

In these instances, the second-tier respondent (who had contributed to the development of the product) described an additional product which had been made for the museum but which had not been submitted by the first-tier respondent. Given the familiarity of the creator of the product with it, these products were added to the total product count. See **Error! Reference source not found.** for the count of 3D digital products.

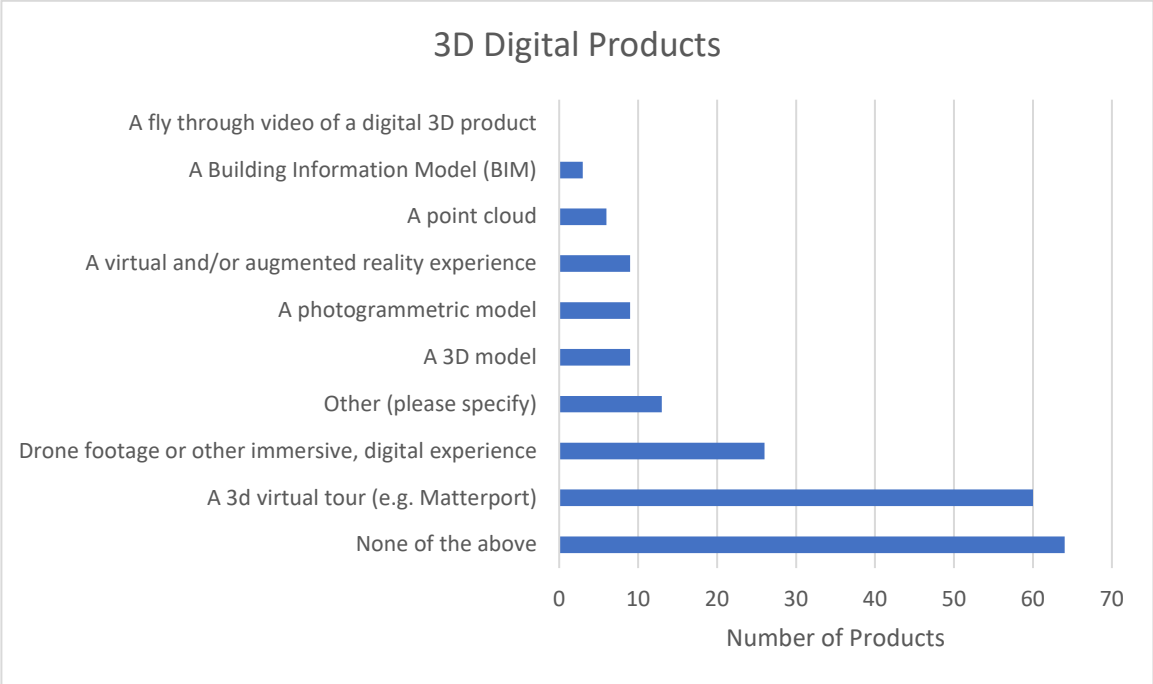


Figure 4.5: 3D digital products.

Questions seven through fifteen focus on the digital project itself. They seek information on the intent of the digital product and the level of success the respondent feels the product had in meeting the objectives set by the museum for the product. This set of questions ends with questions to collect contact information for the second tier of the survey, which is not be shared.

Question Seven

Question seven asked respondents when the digital product was created. Aside from one outlier (which may be a typo from the respondent; they said their product was made in 2000, which would be surprising given the product they described: a touch table which shows the evolution of maps from 1880 to 2021), all of the products which had date information available (n=131) were created no earlier than 2010. Only 0.8% of the products described were created in 2010, 0.8% in 2011, 0.8% in 2012, 0% in 2013, 0.8% in 2014, and 0.8% in 2015. A slight uptick began in 2016, with 1.5% of the products created in that year, followed by 8.4% in 2017, and 2.3% in 2018. 2019 saw an increase back to 7.6% of the products created in that year, followed by a significant jump in 2020, with 44.3% of the described products being created in that year. While there was a drop in the number of new products created in 2021 with 8.4% of the products in the dataset being created in that year, the rates remained around where they were after 2018. 6.9% of the products were created in 2022, 13.7% in 2023, and 0.8% in 2024 (this date was given by a respondent who is planning to create a BIM in 2024; as the first-tier survey was disseminated and closed in 2023, the data available for 2024 is incomplete and therefore not represented Figure 4.6 below). Two products are not represented in Figure 4.6 because they were described as “continuously” produced with no start date given.

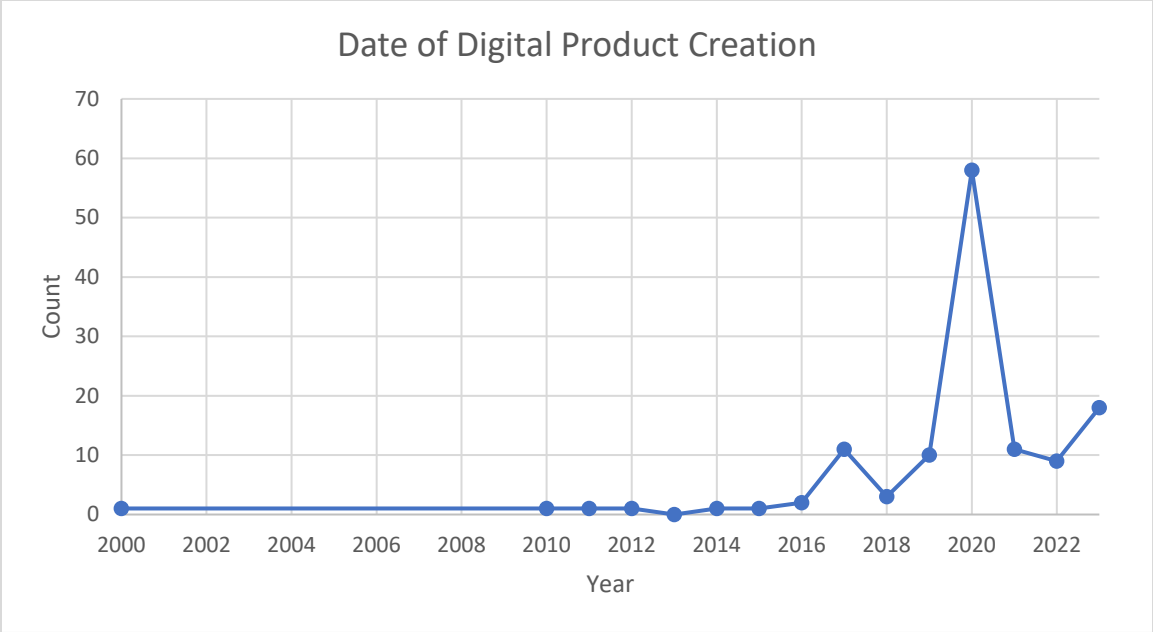


Figure 4.6: Date of digital product creation.

Question Eight

Question eight asked the respondent to describe the intent and goals of the digital product. This question helped ensure that the responses given in question six actually help to interpret or steward a historic structure at the museum. Based on the responses to this question, fourteen products were deemed not to meet these criteria. As a result, they were removed from the analysis of questions nine through thirteen. Table 4.2 below includes a sample of the responses that were counted for this question.

Product	Description of Product
A 3d virtual tour (e.g. Matterport)	Originally it was to provide access to our sites during COVID and now provides access for people who live too far away to visit or cannot navigate the many physical impediments at our sites like stairs, thresholds, and narrow doorways.
A 3D model	We have a growing 3D model of the [redacted] Landscape that includes a 3D model of the main house along with about 20 other historic structures on property. This allows the public to experience and explore the landscape from anywhere. It is also used as an access point for our archival records related to each structure. When a structure is clicked on a pop up window appears with all the archive material tagged to it. This allows the public and staff to search for records using visual means instead of a search engine. This also gives the public access to buildings that are typically not physically accessible from the main visitor pathways or provides representations of structures that have been demolished. This landscape is constructed with the use of GIS mapping software combined with 3D models built in either Sketchup or 3DsMax.
A virtual and/or augmented reality experience	To provide the widest public access to the museum without boundaries or limitations. It both augmented and virtually projects through [redacted]. There are over a dozen student partnership projects.
A Building Information Model (BIM)	It is used to manage care of our 18th-century dwelling
Drone footage or other immersive, digital experience	The panoramic photo model helps put the built environment in context to the topographic features of the site and also identifies locations of previously existing support structures, including winter kitchens and potential domiciles for sharecroppers and enslaved individuals.

Table 4.2: Example descriptions for each product type.

Question Nine

Question nine asked respondents whether the intention of their digital product is for "interpretation of the resource (public or visitor facing)," "staff [stewardship] of the resource (museum personnel facing)," or for both. A vast majority of the products are intended for interpretation of the resource (63.0%, n=135) or for both interpretation and staff (stewardship) purposes (31.1%). Only 5.9% of the products are meant only for staff use. Table 4.3 includes a breakdown of this data.

Audience	**Count**	**Percentage**
Interpretation (public or visitor facing)	85	63.0%
Staff (museum personnel facing)	8	5.9%
Both	42	31.1%

Table 4.3: Intention of digital products.

Question Ten

Question ten asked the respondent to rate the usefulness of the product over time for the interpretation of the resource on a scale of one to five (one being not at all useful and five being extremely useful). This question was only asked to respondents who had indicated that their digital product is intended for interpretation or both interpretation and staff purposes. As a result, 126 products are counted in this question (n=126). Overall, the feelings towards the usefulness of the products for interpretive purposes trends in the positive direction. A majority of the products are rated as "extremely useful" (56.3%), followed by 23.8% rated as "very useful", and 17.5% as "moderately useful." Only 2.4% of products are rated as "slightly useful," and no products are rated as "not at all useful." See Figure 4.7 for the count of usefulness of digital products for interpretive purposes.

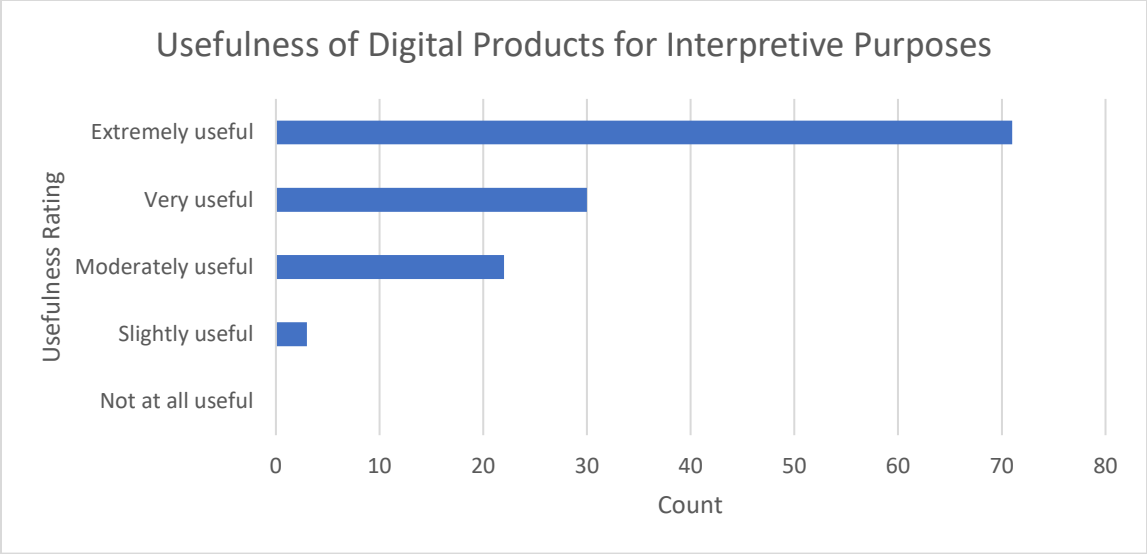


Figure 4.7: Usefulness of digital products for interpretive purposes.

Question Eleven

Question eleven asked the respondent to rate the usefulness of the product over time for stewardship and staff management of the resource on a scale of one to five (one being not at all useful and five being extremely useful). This question was only asked to respondents who had indicated that their digital product was intended for staff purposes or both interpretation and staff purposes. As a result, 47 products are counted in this question (n=47). Like the responses to question ten, the feeling towards staff-facing products is generally positive, although slightly less so than the feeling towards interpretive products. 34.0% of the products are rated as "extremely useful," 38.3% as "very useful," 17.0% as "moderately useful," 8.5% as "slightly useful," and 2.1% as "not at all useful." See Figure 4.8 for the count of usefulness of digital products for staff-facing purposes.

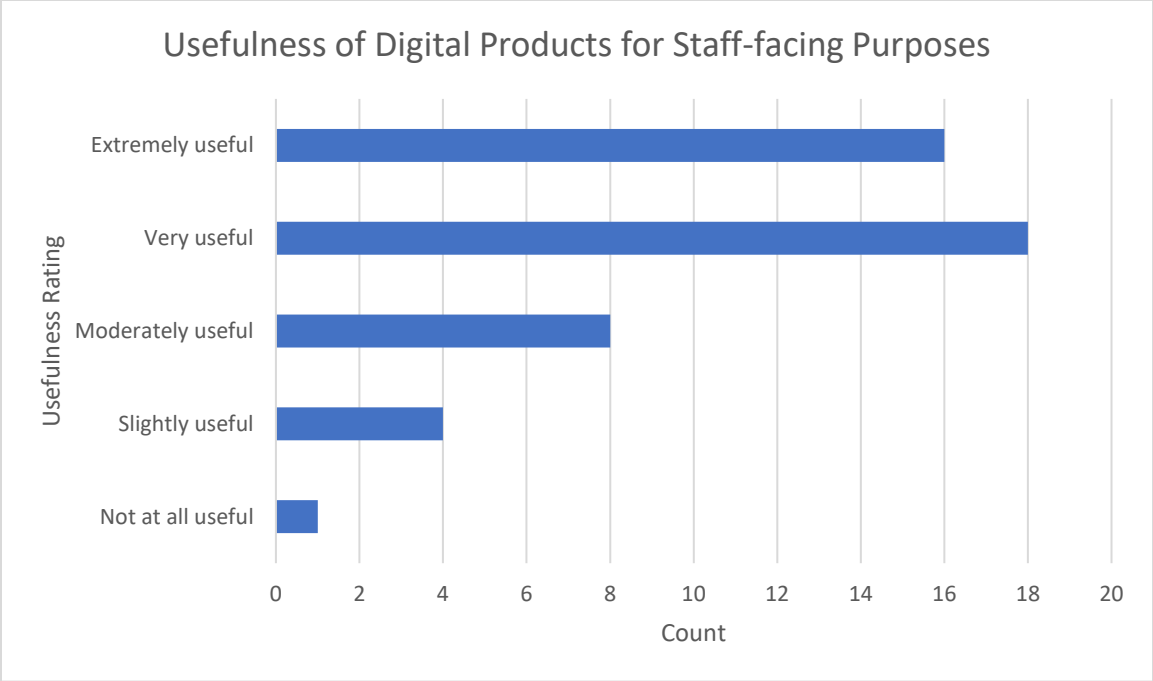


Figure 4.8: Usefulness of digital products for staff-facing purposes.

Question Twelve

Question twelve asked respondents if they would invest their money and/or time creating this product again on a scale of one to five (one being definitely not and five being definitely yes). This question was asked for 130 products (n=130). Once again, the response was mostly positive. For 75.4% of the products, the respondent indicated "definitely yes" when asked if they would invest in the product again. For 14.6% of the products, the response was "probably yes," for 6.9%, "might or might not," and for 3.1%, "probably not." No respondents stated that they would "definitely not" invest in the product again. See Figure 4.9 for the count of respondents who indicated each level of likelihood of reinvesting in the digital product.

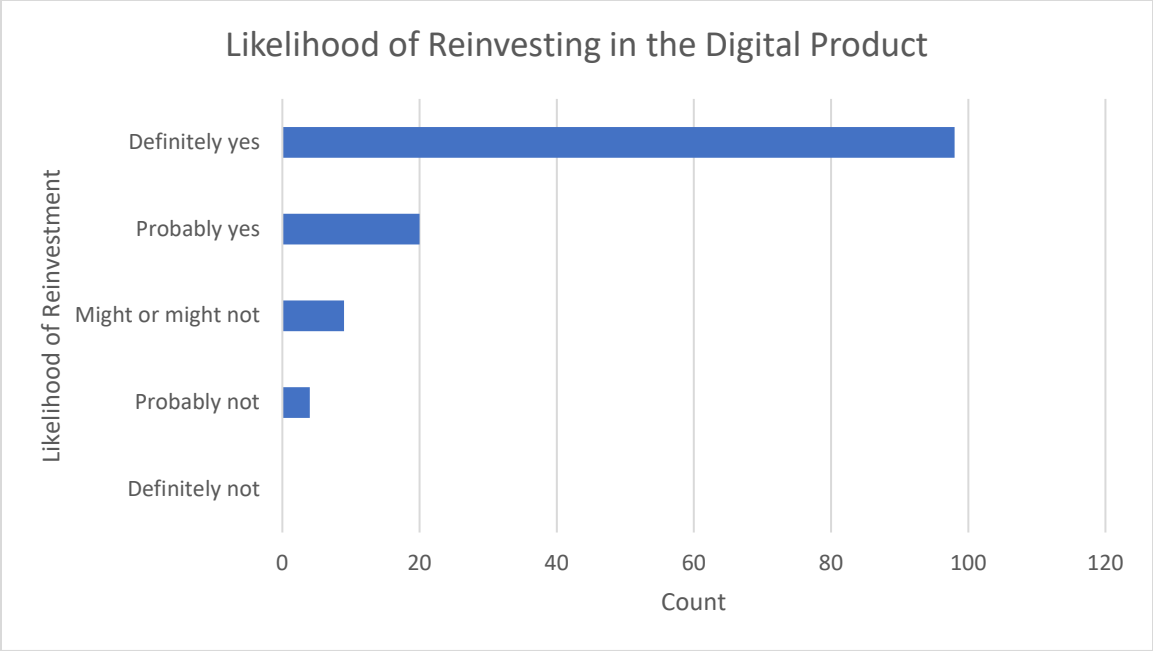


Figure 4.9: Likelihood of reinvesting in the digital product.

Question Thirteen

The first part of question thirteen asked respondents if their digital product was made in-house, by an outside company, or a combination of the two. Roughly half of the products were made by someone working in-house (49.3%, n=134), 33.6% produced by an outside company or organization, and 17.2% by a combination of individuals working in-house and at outside companies. See Figure 4.10 for a count of in-house versus out-of-house production.

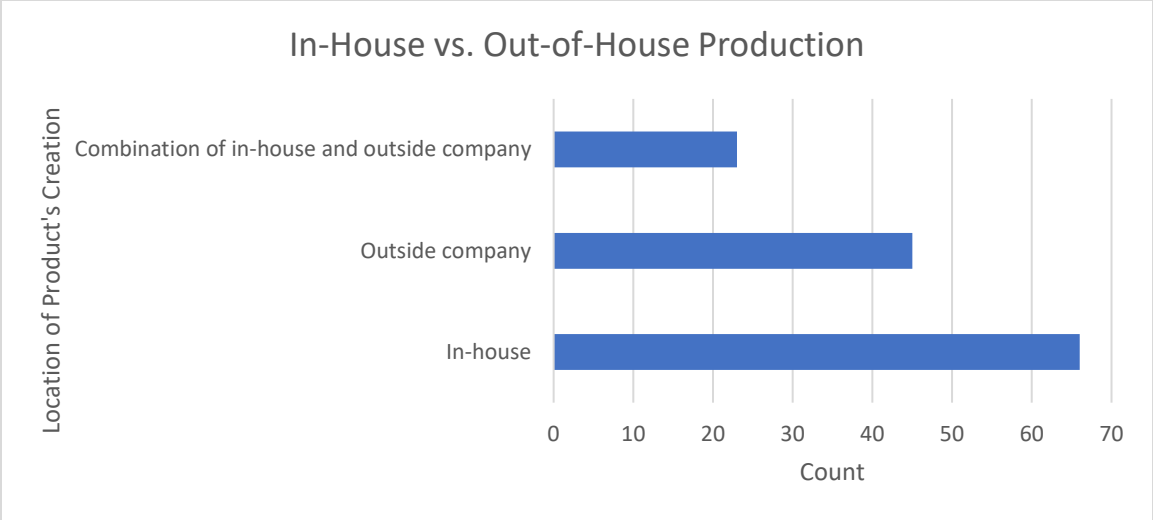


Figure 4.10: In-house vs. out-of-house production.

Parts A through C of the question sought contact information for the individuals who were involved in the creation of the products. In accordance with the conditions of the survey, the names and email addresses collected in these parts of question thirteen are not published here.

Questions Fourteen and Fifteen

Question fourteen asked if the respondent's museum has any additional products. The purpose of this question was purely to determine whether or not the survey would end or restart for a new product. Similarly, question fifteen asked the respondent to indicate what the additional product was from the list provided in question six. This question gave the same options as question six and was used to loop the survey. As such, all responses to question fifteen are reported as responses to question six for ease of reporting.

Second Tier Question Responses

Questions one through six of the second tier seek information on the creator's background, including their educational background and job title. Twenty-nine individuals responded to this tier of the survey detailing the creation of forty-nine digital products. Two products were eliminated from the analysis because they do not fit the criteria of being 3D digital architecture. Fifteen of the products were eliminated from the analysis because they do not correspond to a digital product counted in the analysis of data collected in the first tier of the survey; however, these products are still discussed in the analysis as additional examples of what 3D digital products can be used for.

Question One

Question one asked respondents if they hold the same job as when they created the digital product described in the email they received with the survey link. If they responded no, they were asked for their current job title, and instructed to fill out the following questions based on the job that they worked at the time the product was created.

Question Two

Question two asked if the respondent is a staff member at the museum the product was created for. Their answer determined which set of questions they were next asked: 2.A or 2.B. The only difference between the two was that 2.A. asked for the name of the historic site the individual works at, whereas 2.B. asked for the name of the company

they work for. These answer are not shared in accordance with confidentiality of the survey; however, they were used to match responses from the second tier to the first tier.

Question Three

Question three asked respondents what their job title is. This was used to match responses between the two tiers and will not be shared in accordance with the anonymity laid out in the survey.

Question Four

Question four asked respondents to indicate the highest degree or level of school that they have completed. The majority of respondents (58.3%, n=24) have completed a graduate degree. 8.3% of the respondents have completed some graduate school coursework, 20.8% have an undergraduate degree, 12.5% have some undergraduate coursework, and 0% listed high school as their highest level of education. See Figure 4.11 for a count of the highest level of education completed.

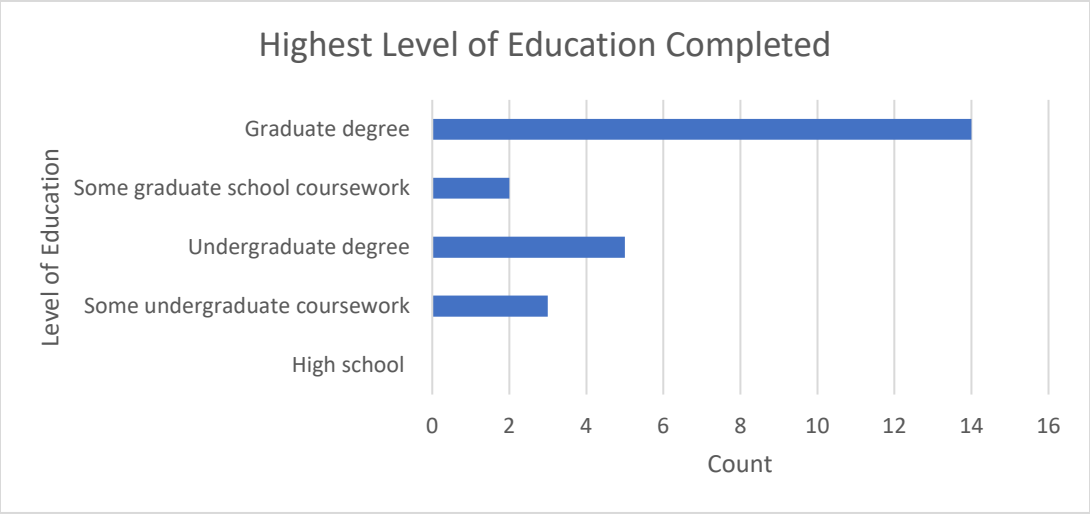


Figure 4.11: Highest level of education completed.

Question Five

Question five asked respondents what their program(s) of study was if they attended a college or university. They were able to select one or more of the listed options so that individuals with multiple degrees could indicate all areas of study represented by their degrees. The most common area of study selected was the "other" option, with 31.0% of the selection of possible areas of study consisting of this option (n=42). The additional areas of study respondents filled in for "other" were "Classics," "architectural design and build," "philosophy," "education," "architecture," "Fine Art - Photography," "criminal justice," "computer graphics" "POLI and Public Policy," "English," "chemistry," and "Master in Information Systems." The next highest percentage indicated was "history" at 21.4%, then "historic preservation" at 9.5%, "museum studies" at 9.5%, "architectural history" at 7.1%, "archaeology" at 7.1%, "anthropology" at 4.8%, "public history" at 4.8%, and "art history" at 4.8%. No respondents selected "computer science," "nonprofit management," business administration" or "not applicable." See Figure 4.12 for the count of respondent areas of study.

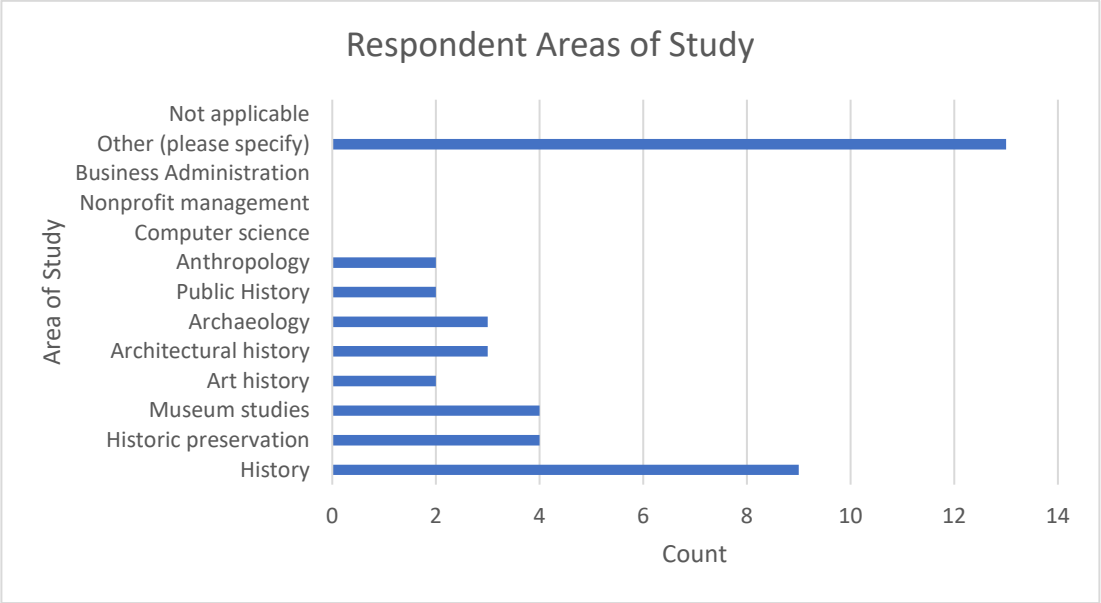


Figure 4.12: Respondent areas of study.

Question Six

Question six asked respondents to indicate which digital product they helped to create from the same list of three-dimensional digital products provided to respondents in the first survey. This question was primarily used for matching responses to the first tier rather than counting the number of products; however, some of these responses are used as case studies in the next chapter. Out of forty-nine total products submitted, twenty-eight were products that appeared in the first-tier survey data, and five were added to the first tier data based on their descriptions. Two products were eliminated from the dataset as they do not fit the criteria of being 3D digital architecture.[62] There were also fifteen

[62] The two products eliminated for not fitting the criteria of being 3D digital architecture were "simple QR Coded signage to create a digitally enhanced self-guided walking tour" (which was described as the respondent as "Not a 3D digital product."), and "photographic digitization of all objects and archives" in the collection of the respondent's organization.

products submitted which do not correspond to any of the products counted in the first tier of the survey, but these extra products help provide additional insight into the possibilities of using digital products to interpret and steward the historic built environment in the next chapter.

Question Seven

Question seven asked the respondent to describe the digital product they helped create. While responses to this question assist in matching responses between the two tiers like the responses to question six, these responses also provide a different perspective of the product if the two surveys were answered by different individuals. These responses are used to create additional context in the next chapter.

Question Eight

Question eight asked the respondent if the product was meant for interpretation, staff, or both interpretation and staff purposes. Like the previous two questions, this question helps link the two surveys together. In two instances, the second tier respondent indicated that a product was only used for interpretation, while the first tier respondent indicated that the product was used for both interpretation and staff purposes. In another five instances, the second tier respondent indicated that it was used for both purposes, whereas the first tier respondent indicated that it was used for only one purpose (either interpretation or staff-facing). In these cases, the first tier respondents' responses was privileged over the second tier respondents'. Presumably, the person answering the first

tier has more experience with the product's use as a staff member or volunteer at the museum in which the product is used, therefore their answer is preferred in this instance.

Question Nine

Question nine asked if the respondent believed that the product they helped create was used as intended based on their observations. If they responded no, they were asked to indicate why it was not used as intended. For the thirty-two responses relevant to the first survey, respondents felt 90.6% of the products were used as intended (n=32), while only 9.4% felt that they had not been used as intended. One of the respondents that felt it had not been used as intended stated the reasoning was that the product had not yet been released. The second stated, "The level of effort to complete the platform exceeded the museum's budget. In addition, the technology available at the time required far more effort to develop the platform that [sic.] what is available today (and continues to develop)." The third respondent stated, "We are challenged to train staff to be fluent in Revit (which created the model)." See Table 4.4 for the breakdown of respondents' determination of whether or not products were used as intended.

Respondents' Determination of Whether or Not Products Were Used as Intended	**Count**	**Percentage**
Yes	29	90.6%
No	3	9.4%

Table 4.4: Respondents' determination of whether or not products were used as intended.

Question Ten

Question ten asked what software program(s) the respondent used to create the digital product. This was asked as an open-ended question to account for the many different types of software that may have been used to build the products. The thirty-two responses that are tied to museums from the first tier are listed below as they were reported by the respondents. They are further categorized in Chapter Five.

- Revit
- Various scanners
- AutoCAD, 3ds Max (with v-ray for rendering), Unity
- As noted on the prior page, the original program was developed in AIR, and the new version is Unity. The new CMS is custom-programmed and hosted on our web servers.
- Recap and Revit
- Recap and Revit
- Not sure
- Matterport
- Matterport
- ZBrush, Tinkercad, DAZ Studio, Meshmixer, Blender, Nomad Sculpt
- 3DF Zephyr
- 3DF Zephyr, Luma AI, Polycam
- MicMac

- just digital cameras or ipad.
- Matterport
- Microsoft PowerPoint, and Keynote for an accessible version for people who are blind or have low vision.
- Matterport
- scan data processed with FARO Scene (architectural data) or 3D Systems Geomagic (artifact data) - derivatives of data may be primarily authored with 3D Studio Max, Autodesk ReCap, Rhino 3D
- Metashape
- Photoshop
- Matterport
- SketchUp, ArcGIS Pro, ArcGIS Online, AutoCAD
- Drone Phantom
- ArcGIS Storymap, Clio
- SketchUp
- not sure
- DJI Fly for DJI Mini 2 drone; iMovie
- Just the DJI drone software
- Matterport
- Matterport
- Revit
- Revit, ArcGIS, CityEngine, FME, Excel

Question Eleven

Question eleven asked the respondent where they learned the software program(s) they used to create the digital product. They were able to select one or more of the listed options. The results below reflect the responses of individuals who worked on products reflected in the first tier survey results.

Despite the majority of respondents having undergraduate and graduate degrees, most of the software programs were learned outside of academic settings. The most common location that respondents learned the software was somewhere other than the options provided in the survey (44.2%, n=43). Common responses under "Other (please specify) were variations of 'self taught' and 'on the job training.' These responses are further categorized in Chapter Five (see Appendix E for full list of locations). The next most common location for learning the software was in post-graduation professional development (self-sponsored) (20.9%), followed by post-graduation professional development (employer funded) (9.3%), undergraduate core class (7.0%), graduate core class (4.7%), graduate elective class (4.7%), undergraduate elective class (2.3%), university-sponsored workshop (2.3%), non-university sponsored workshop (2.3%), and an internship (2.3%). See Figure 4.13 for the count of where respondents learned the software.

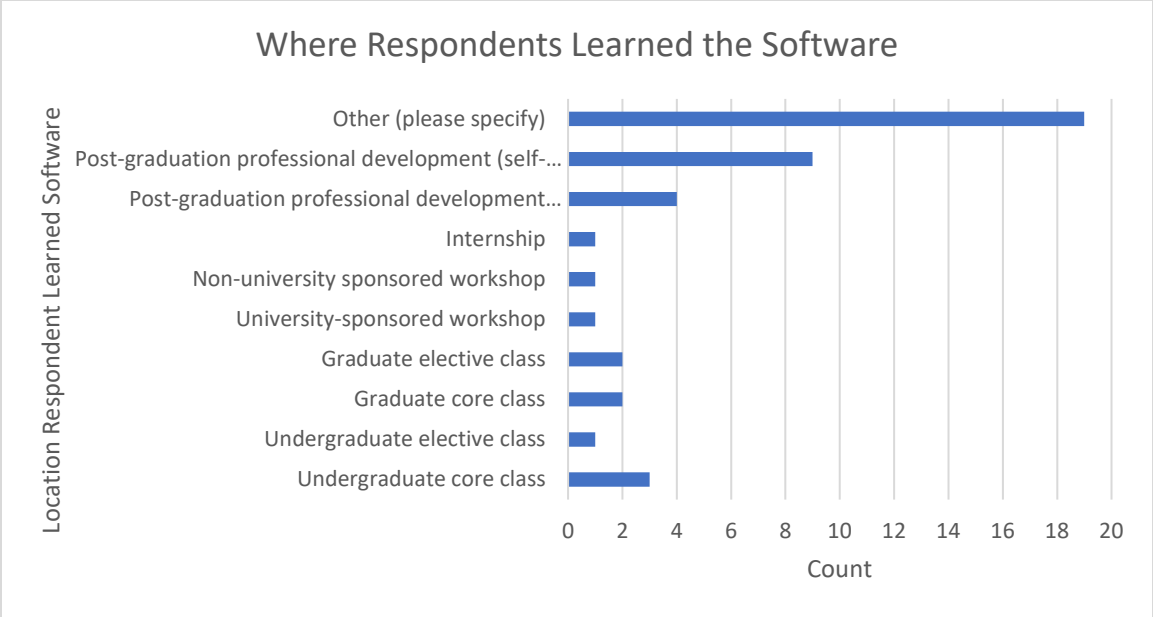


Figure 4.13: Where respondents learned the software.

Questions Twelve and Thirteen

Question twelve asked respondents if they were involved in the creation of any additional projects. If they selected "No," the survey ended. If they chose "Yes," they were shown question thirteen, which asked them to select an additional product from the list of three-dimensional digital products. Like the responses to question fifteen from survey one, the primary goal of this question was to loop the survey, therefore the responses to this question are reported as responses to question six for ease of reporting.

CHAPTER FIVE

ANALYSIS

Using the Data

The goal of this survey was to develop a representation of digital program usage for interpreting and stewarding the historic buildings and landscapes at museums in the United States. The data can be used to trace patterns among respondent museums that can be compared to themes within the literature review. While the data can be used to identify patterns, suggest why certain trends are present, and make suggestions for museums looking to adopt these technologies, the results of this survey do not represent all history museums involved in the interpretation and stewardship of the built environment. Instead, it presents a snapshot of digital program usage at the museums who opted in to participation in the survey. This study can be used as a benchmark for museums who either already possess or are looking to develop these types of digital products, and those watching the field to see how digital interpretation and documentation might be changing across the field.

Analysis at a Glance

- Given a response rate of 24.21% and approximately one third of responses selecting “None of the above” when asked if they possessed a 3D digital product, the data suggests the use of digital documentation technologies in the United

States to interpret and steward historic structures in a museum setting is not widespread.

- 3D virtual tours (i.e. Matterport) are by far the most common digital products in use across the responding organizations, accounting for one-third of the total products.
- In addition to the interpretive and/or stewardship and staff management uses assigned to the products by the respondents, the products are further broken down into six categories of additional uses: visualization (re-creation), visualization (accessibility), information storage, documentation, building maintenance, and marketing/fundraising.
    - For products intended for interpretive or visitor facing purposes, 76.5% fall under the visualization (accessibility) category.
    - For products intended for both interpretive and stewardship and staff management purposes, 40.5% fall under the visualization (accessibility) category.
    - These high percentages suggest that the most common secondary use for digital products in museums is to improve accessibility, both for those physically accessing the site and unable to visit certain parts, and for those who are not able to visit the site at all.
- The level of satisfaction is very high across all recorded responses, although it is slightly lower for stewardship and staff management products.

    - For products used for interpretive purposes, 56.3% rated the products as extremely useful and 23.8% rated them very useful.
    - For products used for stewardship and staff management purposes, 34.0% rated the products as extremely useful and 38.3% rated them very useful.
- Roughly half of all products reported on were made in-house at the museum.
    - 49.3% were created by staff or volunteers working in the museum.
    - 17.2% were created through the collaboration of an individual or group working in the museum with an outside company.
    - 33.6% of products were created out-of-house (by an outside company).
    - For the most common digital product, 3D virtual tours, 71.2% (42) of the products were made in-house, whereas only 22.0% (13) were made out-of-house and only 6.8% (4) were created through a combination of the two.
- The use of digital products has been on the rise since about 2016, with a significant increase in 2020 likely due to COVID-19, as well as increased affordability of the tools needed to make the products.

Scope of Design and Documentation Program Use

The primary question guiding the development of this survey was, "How widespread is the use of digital documentation technologies to create 3D digital architectural products for the interpretation and stewardship of American historic structures operated as museums?" The data collected in this survey suggests that the answer to this question is: not very widespread. A number of factors contribute to this

conclusion. The first is that nearly one third of all responses to question six, which asked respondents which digital products they possessed, are "None of the above." This response is tied for the largest percentage of responses (32.2%) to question six.

In addition, the response rate to the survey may also suggest a lack of digital product usage. In the informed consent document that appeared at the start of the first survey, the exclusion/inclusion requirements states, "Participants in the survey must be directly associated with a museum in the United States and have knowledge of the museum's creation and/or use of a digital product." This likely served as a deterrent for museums who did not possess a digital product, meaning that the percentage of "None of the above" responses could have been higher had the language been less exclusionary. Additionally, individuals are generally less likely to respond to a survey that does not apply to them.[63]

While it is not possible to determine how many potential respondents were deterred from answering this survey by the language of the exclusion/inclusion requirements and the language within the forum and social media posts, a comparison of the response rates to similar surveys supports this conclusion. The two surveys from Milonas and Wilson (mentioned in Chapter Three) had response rates of 38% and 45.7% respectively. Despite running this survey with a similar timeline and distribution

[63] In a study conducted by the American Institutes for Research to determine why the response rate for the screener phase of the National Household Education Surveys Program decreased between 2012 and 2019, nonrespondents were broken down into seven typologies. One of these typologies was "Not relevant to me," which consisted of nonrespondents who believed the survey was not relevant to them. The researchers found that one in six nonrespondents to the NHES fell into this group, suggesting it is a valid reason for potential respondents to choose not to respond to a survey; Rebecca Medway et. al, *National Household Education Surveys Program of 2019: Qualitative Study of Nonresponding Addresses*.

methodology, this survey recorded a notably lower 24.21% response rate.[64] Comparing the topics of the surveys, Wilson's survey examined disaster preparedness planning in museums, and Milonas' survey examined accessibility in historic house museums. With the increase in natural disasters and the Americans with Disabilities Act mandating the accessibility of publicly used historic structures, the topics covered by Wilson's and Milonas' surveys are much more likely to be at the forefront of a museum's list of priorities than the creation of digital products. The low response rate to this survey, with similar variables of timeline and distribution methodology, therefore suggests that the creation of digital products is less common than disaster planning and accessibility concerns, supporting the claim that the use of digital products to interpret and steward the historic built environment in United States museums is not very widespread.

Products in Use at United States Museums

Despite the limited scope of 3D digital product use, there are still some museums utilizing these products to interpret and steward the historic built environment. When museums are using these products, the first tier survey found that of the options listed in question six, 3D virtual tours (e.g. Matterport), drone footage or other immersive, digital experiences, 3D models, virtual and/or augmented reality experiences, photogrammetric models, (laser documented) point clouds and Building Information Models are among the

[64] This survey and the two precedent surveys were open for a similar period of time. However, while Wilson's survey ran at nearly the same point in the school year (November into mid-December), Milonas' survey ran later in the school year, from February to March. Wilson's had the higher response rate of the two, which supports the conclusion that the timeframe of this survey was not the leading factor of the lower response rate.

products in use. By far, the most common of these products in use is 3D virtual tours. Nearly one-third of responses to question six, which collected data on the 3D digital products possessed by museums, indicate the use of "3D virtual tours." The next most common response, drone footage or other immersive digital experiences, accounts for over one-tenth of responses. The next highest product, those that fell under the 'other' category, accounts for only 6.5% of the data. The most uncommon of the products among the surveyed museums are (laser documented) point clouds and Building Information Models, which account for only 3.0% and 1.5% of responses, respectively. A fly through of a virtual 3D product is the only option that no respondents are in possession of. The potential reasoning for these patterns is examined in the "Reflections on Digital Product Satisfaction" and "Patterns in the Development of Digital Products" sections.

Intention of Digital Products

The vast majority of 3D digital products recorded in this survey are intended for interpretive uses, with 63.0% intended for only interpretive use and 31.1% intended for both interpretive and staff-facing uses. While these responses indicate the basic intention of the product, the open-ended responses to question eight help determine how the products are intended to perform such roles. The open-ended responses generally fall into at least one of six categories: visualization (re-creation), visualization (accessibility), information storage, documentation, building maintenance, and marketing/fundraising.

Products that fall into the visualization (re-creation) category generally involve re-creation of lost elements so that visitors can experience non-extant buildings, landscapes, or processes that are difficult to visualize, such as historic methods or systems. The products are often being used to help visitors form empathetic connections to the built environment, similar to the case study from Romania, “Virtual Museums: Dealing with Cultural Identity in the Digital Age,” which is explored in the literature review. In this example, the team created the virtual reconstruction to help visitors engage with life in the past at a site called Vădastra (see Figure 5.1).

Figure 5.1: An example of a digital product falling in the "Visualization (re-creation)" category, photo from Gheorghiu and Ştefan, "Virtual Museums: Dealing with Cultural Identity in the Digital Age."

Products that fall into the visualization (accessibility) category are generally used to provide access to the historic structure for people who cannot physically access the building while visiting the site and/or those who cannot visit the site. An example of this

is the VR experience created by a team for the purpose of providing access to a Buddhist temple in Myanmar that was rendered structurally unsound by an earthquake (see Figure 5.2).

Figure 5.2: An example of a product which falls into the "Visualization (accessibility)" category, photo from A. Paladini et al., "Impact of Virtual Reality Experience on Accessibility of Cultural Heritage."

Products in the information storage category have archival records linked to the product to make them searchable and organized so that visitors and/or staff can access the information. One of the first tier respondents described an example which falls into this category. They wrote, “It [a 3D model] is also used as an access point for our archival

records related to each structure. When a structure is clicked on a pop up window appears with all the archive material tagged to it." Those in the documentation category record the current conditions of the historic resource. A respondent to the first tier of the survey described the use of a point cloud which serves as "documentation of [an] extant building interior," providing an example of the use of a digital product to document the current condition of a portion of a historic structure.

Products falling into the building maintenance category are used to help manage the care of the historic structure. An example of this type of product is the Historic Building Information Management (HBIM) model created by Quinn Evans, which links documentation and a 3D model of the structure and preservation planning into one interface.[65] The interface is shown in Figure 5.3.

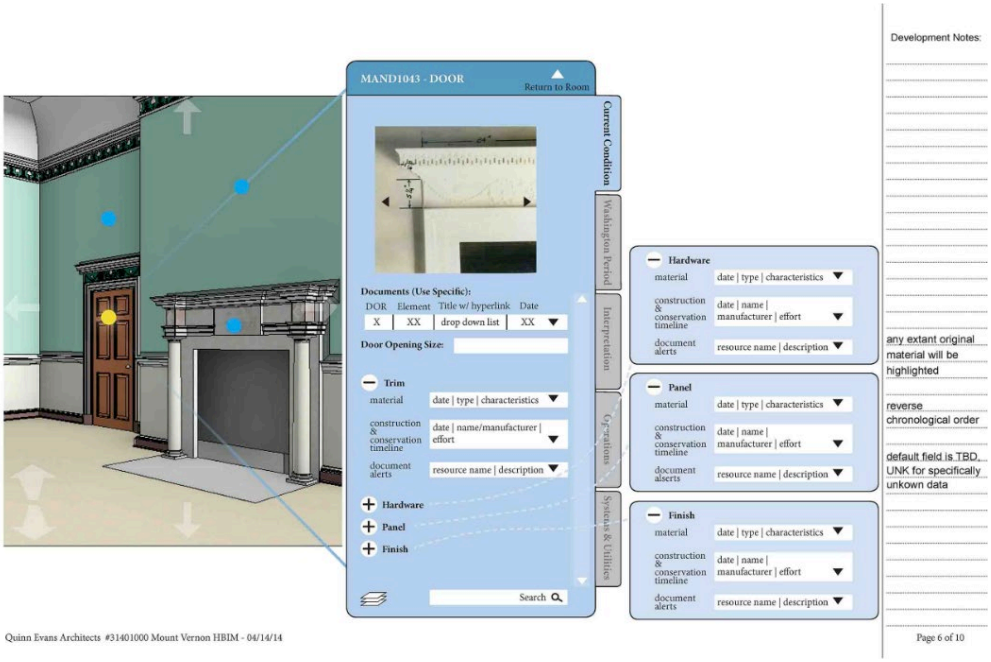


Figure 5.3: An example of a product falling into the information storage category, photo from "Preserving George Washington's Home," Quinn Evans.

[65] "Preserving George Washington's Home," Quinn Evans, accessed February 26, 2024, https://www.quinnevans.com/projects/mount-vernon.

The final category, marketing/fundraising, includes products used to solicit donations and/or increase traffic to the site and/or their web resources. A respondent to the first tier of the survey provided an example of a product which falls into this category. They described a 3D virtual tour of a historic site that "serves to promote a capital campaign," indicating that the intention of the product is to help raise funds for that campaign.

When sufficient information was available, products were placed into at least one of the above categories (products could fall into more than one category). They are categorized only by the response provided by the respondent, not assumptions made about the products. These categories exist as supplements to the main intention of each product: interpretation and/or staff-facing purposes.

For the products reported to be intended for interpretation purposes:

- 76.5% of the products fall into the visualization (accessibility) category
- 10.6% fall into the documentation category
- 5.9% fall into the marketing/fundraising category
- 4.7% fall into the visualization (re-creation) category
- 1.2% fall into the information storage category
- 0% fall into the building maintenance category

For the products intended for staff-facing purposes:

- 28.6% of the products fall into the visualization (accessibility) category
- 28.6% fall into the building maintenance category

- 14.3% fall into the marketing/fundraising category
- 14.3% fall into the visualization (re-creation) category
- 14.3% fall into the documentation category
- 0% fall into the information storage category

Finally, for the products respondents indicated to be intended for both interpretive and staff-facing purposes:

- 40.5% fall into the visualization (accessibility) category
- 38.1% fall into the documentation category
- 21.4% fall into the visualization (re-creation) category
- 9.5% fall into the building maintenance category
- 9.5% fall into the information storage category
- 2.4% fall into the marketing/fundraising category

See Table 5.1 for the breakdown of additional use categorization by main use.

Additional Use Categorization by Major Use						
Product	**Visualization (Re-creation)**	**Visualization (Accessibility)**	**Information Storage**	**Documentation**	**Building Maintenance**	**Marketing/ fundraising**
Both	21.4%	40.5%	9.5%	38.1%	9.5%	2.4%
Interpretation	4.7%	76.5%	1.2%	10.6%	0%	5.9%
Staff	14.3%	28.6%	0%	14.3%	28.6%	14.3%

Table 5.1: Additional use categorization by main use.

By far, the most prevalent category of secondary intended uses is visualization (accessibility), which is the most common category across all three options of primary intended uses. One intriguing point in this category is the occurrence of museums who developed their product(s) to allow access to the site despite COVID-related restrictions, and later realized that those products could improve physical accessibility once the site reopened. Of the 73 products which fall into the visualization (accessibility) category, four museums explicitly state that the pandemic spurred the creation of their product. An organization representing 38 individual museums stated that the 3D virtual tours made for each of those museums were created for this reason as well. This organization stated, "Originally it was to provide access to our sites during COVID and now provides access for people who live too far away to visit or cannot navigate the many physical impediments at our sites like stairs, thresholds, and narrow doorways."

A similar sentiment was echoed by another museum, who stated, "The 360 tour was created during COVID when we were closed, in order to continue to connect with the public. We then adapted it to a stable, permanent tour after COVID, in particular for visitors who are unable to navigate stairs to our second floor." While this idea was only explicitly stated by two museums, it does suggest one of the many reasons why satisfaction rates with these digital products are as high as they are; museums create the product for one reason but discover other uses for the product once it has been made.

Another popular category of secondary intended uses is visualization (re-creation), which 14.3% of staff-facing products, 5.9% of interpretive products, and 21.4% of products that were intended for both interpretive and staff-facing purposes fall under.

Often, these products are used to create experiences where the visitor can engage more deeply with lost elements of the historic built environment or historic methods that allow them to form a more empathetic connection with the history. One museum reported that their virtual and/or augmented reality experience was intended "To bring history to life in our historic slave quarter and to bridge the gap between our past (history) and today with the use of technology." This response indicates an important asset that such products can offer to museums; the chance to bring history to life.

In one of the foundational texts on museum interpretation, Freeman Tilden writes "...the purpose of interpretation is to stimulate the reader or hearer toward a desire to widen his horizon of interests and knowledge, and to gain an understanding of the greater truths that lie behind any statements of fact."[66] By visually recreating lost aspects of the built environment that may be difficult for visitors to picture, these 3D products can help these lost features feel more lifelike and tangible for visitors. Breathing life into features that no longer exist can help a visitor connect to those lost aspects of heritage, which in turn can lead to the provocation and increased understanding that Tilden cites as a goal of interpretation.

Reflections on Digital Product Satisfaction

Overall, the level of satisfaction is very high across all of the recorded responses. Of the products listed as being used for interpretive purposes, 56.3% rated the products as

[66] Freeman Tilden, *Interpreting Our Heritage,* 4th ed. (Chapel Hill: The University of North Carolina Press, 2007), 59, https://ebookcentral.proquest.com/lib/clemson/reader.action?docID=4322102&ppg=5.

extremely useful, 23.8% rated them very useful, 17.5% rated them moderately useful, 2.4% rated them as slightly useful, and 0% of people rated them as not at all useful. Of the products listed as being used for stewardship and staff management purposes, 34.0% rated the products as extremely useful, 38.3% rated them very useful, 17.0% rated them moderately useful, 8.5% rated them as slightly useful, and 2.1% of people rated them as not at all useful. While the overall satisfaction rate with management products is slightly less high than with interpretive products, the data still indicates that by and large, museums are highly satisfied with the products that they possess.

This data is also broken down by the level of satisfaction museums have reported by individual product. Table 5.2 and Table 5.3 below demonstrate how respondents rated the usefulness by product.

Usefulness of Interpretive Products by Type									
	Extremely useful		Very useful		Moderately useful		Slightly useful		Total Count
Product	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	
A 3d virtual tour (e.g. Matterport)	42	72.4%	7	12.1%	8	13.8%	1	1.7%	58
Drone footage or other immersive, digital experience	12	46.2%	6	23.1%	8	30.8%		0.0%	26
Other (please specify)	9	64.3%	3	21.4%	1	7.1%	1	7.1%	14
A photogrammetric model	3	33.3%	6	66.7%		0.0%		0.0%	9
A virtual and/or augmented reality experience	1	14.3%	3	42.9%	3	42.9%		0.0%	7
A 3D model	3	50.0%	3	50.0%		0.0%		0.0%	6
A point cloud	1	33.3%	2	66.7%		0.0%		0.0%	3
A Building Information Model (BIM)		0.0%		0.0%	1	50.0%	1	50.0%	2
Grand Total	**71**	**56.8%**	**30**	**24.0%**	**21**	**16.8%**	**3**	**2.4%**	**125**

Table 5.2: Usefulness of interpretive products by type.

Usefulness of Staff-Facing Products by Type											
	Extremely useful		Very useful		Moderately useful		Slightly useful		Not at all useful		Total Count
Product	**Count**	**Percentage**	**Count**	**Percentage**	**Count**	**Percentage**	**Count**	**Percentage**	**Count**	**Percentage**	
A 3d virtual tour (e.g. Matterport)	3	37.5%	4	50.0%	1	12.5%		0.0%		0.0%	8
Drone footage or other immersive, digital experience	4	40.0%	3	30.0%	3	30.0%		0.0%		0.0%	10
Other (please specify)		0.0%	2	100.0%		0.0%		0.0%		0.0%	2
A photogrammetric model	2	22.2%	2	22.2%	1	11.1%	4	44.4%		0.0%	9
A virtual and/or augmented reality experience	1	50.0%		0.0%	1	50.0%		0.0%		0.0%	2
A 3D model	3	37.5%	5	62.5%		0.0%		0.0%		0.0%	8
A point cloud	2	40.0%	1	20.0%	1	20.0%		0.0%	1	20.0%	5
A Building Information Model (BIM)		0.0%	1	50.0%	1	50.0%		0.0%		0.0%	2
Grand Total	**15**	**32.6%**	**18**	**39.1%**	**8**	**17.4%**	**4**	**8.7%**	**1**	**2.2%**	**46**

Table 5.3: Usefulness of staff-facing products by type.

Particularly of note, 3D virtual tours, the most common digital product, have the highest percentage of "extremely useful" ratings amongst the products used for interpretive purposes. This is one of only three interpretive products (the other two being drone footage or other immersive digital experience and those in the "Other" category) which more than half of respondents in possession of those products indicated is extremely useful. In the interpretive category, the majority of photogrammetric models and (laser documented) point clouds are both rated "very useful." 3D models have a similarly high satisfaction rate, which is tied between "extremely useful" and "very useful." With a slightly lower satisfaction rate, augmented and/or virtual reality experiences have a tie between "very useful" and "moderately useful." The product with the lowest satisfaction rate is Building Information Modeling (BIM), which has a tie between "moderately useful" and "slightly useful." With the exception of BIM, which is rated on the lower end of the usefulness spectrum for interpretive purposes, each of the different product types are generally rated at least "moderately useful" if not more so. This indicates that even when broken down by product type, most interpretive products still follow the pattern of very high satisfaction indicated in the overall data.

Management products are mostly rated with a high rate of satisfaction, although there is a slightly greater variation in this group. The majority of drone footage or other immersive, digital experiences and (laser documented) point clouds are rated "extremely useful." The majority of 3D models, 3D virtual tours, and products classified as "other" are rated "very useful." Virtual and/or augmented reality experiences are tied between "extremely useful" and "moderately useful," and Building Information Modeling (BIM)

is tied between “very useful” and “moderately useful.” On the other hand, the majority of photogrammetric models are rated as “slightly useful,” which is a noticeably lower rate of satisfaction than the other products. Despite these variations, management products are generally regarded favorably when broken down by type, similar to the breakdown of interpretive products.

Along with these favorable ratings for usefulness, respondents answered “definitely yes” when asked if they would invest in the product again for three quarters (75.4%) of the products. Like the ratings for usefulness, the data collected on the likelihood of reinvesting in the digital product can be broken down by type. Table 5.4 illustrates this data divided by product type.

Likelihood of Reinvesting in Product by Type									
	Definitely yes		Probably yes		Might or might not		Probably not		Total Count
Product	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	
A 3d virtual tour (e.g. Matterport)	49	83.1%	5	8.5%	3	5.1%	2	3.4%	59
Drone footage or other immersive, digital experience	19	73.1%	5	19.2%	2	7.7%		0.0%	26
Other (please specify)	10	71.4%	1	7.1%	2	14.3%	1	7.1%	14
A photogrammetric model	9	100.0%		0.0%		0.0%		0.0%	9
A 3D model	6	75.0%	2	25.0%		0.0%		0.0%	8
A virtual and/or augmented reality experience	2	28.6%	4	57.1%		0.0%	1	14.3%	7
A point cloud	2	40.0%	2	40.0%	1	20.0%		0.0%	5
A Building Information Model (BIM)	1	50.0%		0.0%	1	50.0%		0.0%	2
Grand Total	**98**	**75.4%**	**19**	**14.6%**	**9**	**6.9%**	**4**	**3.1%**	**130**

Table 5.4: Likelihood of reinvesting in product by type.

For 3D virtual tours, drone footage or other immersive, digital experiences, photogrammetric models, 3D models, and products classified as "Other," respondents would 'definitely' reinvest in the majority of products. In the case of (laser documented) point clouds, there is a tie between the response of definitely would reinvest in and probably would reinvest in. Reflecting a slightly lower rate of satisfaction, respondents reported that they would probably reinvest in the majority of virtual and/or augmented reality experiences. Respondents had the greatest uncertainty about reinvesting in Building Information Modeling (BIM), which has a tie between "Definitely yes" and "Might or might not." Of particular note, despite mixed levels of usefulness, respondents would reinvest in 100% of the reported photogrammetric models again. Additionally, in the case of the 3D virtual tours (the most popular digital product), respondents were willing to reinvest in 83.1% of the products again. This data indicates that amongst a host of digital products that respondents are quite content with and would reinvest in, 3D virtual tours are amongst the most useful and the most likely for museums who responded to the survey to reinvest in.

The likelihood of reinvestment is also comparable to the variable of public-facing versus staff-facing use. For both interpretive products and those that were both interpretive and staff-facing, there are similarly high likelihoods of definite reinvestment in products, with 76.2% and 75.6% respectively. For staff-facing products, however, respondents would only definitely reinvest in 60.0% of the products. This supports the correlation between a slightly higher overall rate of satisfaction with public-facing

products. The complete breakdown of the likelihood of reinvestment in products versus their use is found in Table 5.5 below.

Likelihood of Reinvestment by Use								
	Interpretation (public or visitor facing)		Staff (museum personnel facing)		Both			
Likelihood of Reinvesting in the Software	Count	Percentage	Count	Percentage	Count	Percentage	Total Count	Total Percentage
Definitely yes	64	76.2%	3	60.0%	31	75.6%	98	75.4%
Probably yes	11	13.1%	1	20.0%	7	17.1%	19	14.6%
Might or might not	5	6.0%	1	20.0%	3	7.3%	9	6.9%
Probably not	4	4.8%	3	0.0%	31	0.0%	4	3.1%
Definitely yes	64	76.2%	1	60.0%	7	75.6%	98	75.4%

Table 5.5: Likelihood of reinvestment by use.

Patterns in the Development of Digital Products

In-House vs. Out-of-House

One observable pattern in the development of these 3D digital products is the significant number of products being developed in-house. Of the 134 products reported on, 49.3% were created by staff or volunteers working in the museum. An extra 17.2% were created through the collaboration of an individual or group working in the museum with an outside company. 33.6% of products were created out-of-house, by an outside company. This rate suggests that individuals who work within museums often have the skills to create such products. However, more insight is gained by breaking the rates of in-house versus out-of-house creation down by product. Table 5.6 below presents the data in this manner:

In-House vs. Out-of-House by Product							
	In-house		Outside company		Combination of in-house and outside company		Total Count
Product	**Count**	**Percentage**	**Count**	**Percentage**	**Count**	**Percentage**	
A 3d virtual tour (e.g. Matterport)	42	71.2%	13	22.0%	4	6.8%	59
Drone footage or other immersive, digital experience	4	15.4%	16	61.5%	6	23.1%	26
Other (please specify)	4	28.6%	3	21.4%	7	50.0%	14
A photogrammetric model	8	88.9%	1	11.1%		0.0%	9
A virtual and/or augmented reality experience	1	14.3%	4	57.1%	2	28.6%	7
A 3D model	4	40.0%	4	40.0%	2	20.0%	10
A point cloud	2	33.3%	3	50.0%	1	16.7%	6
A Building Information Model (BIM)		0.0%	2	66.7%	1	33.3%	3
Grand Total	**65**	**48.5%**	**46**	**34.3%**	**23**	**17.2%**	**134**

Table 5.6: In-house vs. out-of-house by product.

There are a few patterns in this data which may indicate general trends amongst these products. The vast majority of 3D virtual tours are made in-house (71.2%), which might suggest a reason why this particular product is so popular; it is more easily attainable by museums since people working in-house have the skills to make these tours, or if they do not already have the skills, they are relatively easy to learn by oneself.[67] The majority of drone footage, the second most popular product at historic sites, is produced out-of-house. However, there may be a different reason for this product's popularity. The majority of sites may not have the equipment (i.e. a drone) needed to produce this product as they require a license which is expensive and time consuming to acquire.[68] Unlike some of the other 3D products which are more time consuming to produce and are therefore more expensive to contract out, drone footage can be collected in one site visit, making it more economical to have this product created out-of-house.

Similarly, other products that require more advanced knowledge to produce and/or more expensive equipment, such as virtual and/or augmented reality experiences, (laser documented) point clouds, 3D models, and Building Information Models (BIMs) are more likely to be created by outside companies.[69] These products are also much less common than 3D virtual tours (accounting for 5.2%, 4.5%, 7.5%, and 2.2% of relevant

[67] Matterport (a prominent company which both sells the tools needed to create 3D virtual tours and provides services where their technicians create the tour) has a help center on their website with free resources such as a "New User Walkthrough" for new users of their cameras and "Matterport Academy," which offers training videos to teach new users how to create scans, edit models, and more. These resources allow users to learn at their own pace. "Help Center," Matterport.com, Matterport, 2024, https://support.matterport.com/s/?language=en_US.
[68] Federal Aviation Administration, "Certified Remote Pilots Including Commercial Operators," FAA.gov, Department of Transportation, August 8, 2023, https://www.faa.gov/uas/commercial_operators.
[69] For more information on how these products are created, see the "Who's Who of Digital Product Development" and "Potential Software for Developing Digital Products" sections of this chapter.

products, respectively). While the cost of these products relative to their popularity will be discussed more in the "Demographic Patterns" section, it is likely that the cost of having to outsource such complicated products to produce contributes to their decreased popularity in comparison to 3D virtual tours and other products that can be produced more easily in-house.

Demographic Patterns

Museums and organizations responding to the survey provided demographic information for their respective institutions. The original hypothesis for this thesis was that institutions with a small number of full-time staff, low annual budgets, and low visitation would have less resources to devote to the development of digital products and would therefore be less likely to possess them. Largely, the data indicates that these variables are not the driving force in determining whether or not a museum will possess a 3D digital product. It is important to note that less data was available for organizations that had responded that they do not possess a digital product, as several institutions responded via email and did not provide additional information. Nevertheless, there are a few patterns visible amongst the data.

There is little correlation between the likelihood of possessing a digital product and the first of these variables: full-time staff size. Amongst responding organizations that did possess one of these products, 51.9% have a full-time staff of 0-5 individuals. Amongst those that did not possess a product, 49.1% have a full-time staff of 0-5

individuals.[70] This similar rate suggests that the number of full-time staff is not the primary driving factor behind 3D digital product possession.

On the other hand, there is a larger range of staff size amongst organizations that do possess a digital product. Of the organizations who do not possess digital products, none reported having more than 50 full-time staff, whereas amongst organizations that had a product, 3.8% of respondents reported having 101-150 full-time staff, 5.8% reported having 151-200 full-time staff, and 1.9% reported having more than 200 full-time staff. While only a minority of respondents who possess a digital product have a staff size at this end of the spectrum, the larger range of staff size may imply that a larger staff size is a helpful factor in the creation of digital products. However, as no correlation is seen on the low end of the spectrum, this data does not support the hypothesis that institutions with smaller staff sizes are less likely to possess a digital product than those with a larger staff size. Table 5.7 below breaks down the percentage of organizations that fall into each category of staff size by whether or not they possess a 3D digital product.

[70] 36.8% of respondents who do not possess a digital product were either unsure or did not provide data for this question.

Digital Product Possession vs. Staff Size					
	Does not possess a digital product		Possess a digital product		Total Count
Staff Size	**Count**	**Percentage**	**Count**	**Percentage**	
0-5	28	50.9%	27	49.1%	55
6-15	4	26.7%	11	73.3%	15
16-30	3	37.5%	5	62.5%	8
31-50	1	33.3%	2	66.7%	3
71-100		0.0%	2	100.0%	2
101-150		0.0%	1	100.0%	1
151-200		0.0%	3	100.0%	3
More than 200		0.0%	1	100.0%	1
Unsure	21	100.0%		0.0%	21
Grand Total	**57**	**52.3%**	**52**	**47.7%**	**109**

Table 5.7: Digital product possession vs. staff size.

There is a correlation between average annual visitation and possession of digital products. Only 1.9% of organizations that possess a digital product have an average annual visitation amount at the lowest level (less than 500), whereas 7.0% of organizations that do not possess a digital product fall into this category.[71] At the next two levels (500-1,999 and 2,000-4,999), however, the rates for both groups generally fall between 11% to 13%. As visitation grows past this point, the percentages of organizations who possess a digital product tend to increase in the high-level visitation categories, while a smaller percentage of organizations that do not possess a digital product fall into these high-level visitation categories. Similar to the pattern seen with staff size, the range of visitation also extends further amongst organizations that possess a

[71] 42.1% of respondents who do not possess a digital product were either unsure or did not provide data for this question.

digital product, with 13.5% of organizations having between 100,000-250,000 visitors a year, and 7.7% of organizations experiencing visitation over 250,000. As with staff size, this pattern does not fully support the hypothesis that institutions with lower visitation are less likely to possess a digital product than those with higher visitation. It does, however, suggest that higher visitation may be a contributing, but not significant, factor in the likelihood of a museum possessing a digital product. Table 5.8 below breaks down the percentage of organizations that fall into each category of annual visitation by whether or not they possess a 3D digital product.[72]

Digital Product Possession vs. Visitation					
	Does not possess a digital product		**Possess a digital product**		**Total Count**
Visitation	**Count**	**Percentage**	**Count**	**Percentage**	
10,000-24,999	2	16.7%	10	83.3%	12
100,000-250,000		0.0%	7	100.0%	7
2,000-4,999	7	53.8%	6	46.2%	13
25,000-99,999	7	41.2%	10	58.8%	17
5,000-9,999	6	42.9%	8	57.1%	14
500-1,999	7	53.8%	6	46.2%	13
Less than 500	4	80.0%	1	20.0%	5
Over 250,000		0.0%	4	100.0%	4
Unsure	24	100.0%		0.0%	24
Grand Total	**57**	**52.3%**	**52**	**47.7%**	**109**

Table 5.8: Digital product possession vs. visitation.

The data linked to an institution's approximate annual budget follows similar patterns to the other categories of demographic data. 32.7% of responding organizations

[72] It should be noted that museums with a larger visitation have a larger audience for their digital products, which would make the scope of product usage more widespread on a viewership basis. This thesis, however, explores the scope of product usage on a institutional basis. An additional survey, aimed at viewer reception of digital products, is discussed in the "Areas of Further Research" section of this chapter.

that have a digital product have an approximate annual budget of $350,000 or less, while 35.1% of organizations that do not have a digital product fall into this budget category.[73] For both groups, the next largest percentage of organizations falls under the $1,000,000 to $2.9M category (26.9% for those that do possess a digital product and 8.8% of those that do not possess a digital product). As with the other demographic categories, there is a larger range of budgets for those organizations that did possess a digital product than those that did not, with 9.6% of respondents who possessed a product falling into the $5M to $14.9M budget range, and 1.9% falling into the $15M and over range.

As with the other demographic categories, the pattern as it appears here does not fully support the hypothesis that institutions with smaller budgets are less likely to possess a digital product than those with higher budgets. However, due to the high level of uncertainty (43.9%) in the budgets of institutions who do not possess a digital product, it is difficult to use this data to determine whether or not budget is a significant factor in determining whether or not an institution possesses a digital product. As museums with budgets over $5 million appear among those having a digital product but not among those without digital products, it could suggest that budget is a factor in digital product possession. Table 5.9 below breaks down the percentage of organizations that fall into each category of approximate annual budgets by whether or not they possess a 3D digital product.

[73] 43.9% of respondents who do not possess a digital product were either unsure or did not provide data for this question.

Digital Product Possession vs. Average Annual Budget					
	Does not possess a digital product		Possess a digital product		Total Count
Budget	**Count**	**Percentage**	**Count**	**Percentage**	
$1,000,000-$2.9M	5	26.3%	14	73.7%	19
$15m and over		0.0%	1	100.0%	1
$350,000 and under	20	54.1%	17	45.9%	37
$350,000-$499,999	2	25.0%	6	75.0%	8
$3M-$4.9M	2	66.7%	1	33.3%	3
$500,000-$999,999	3	27.3%	8	72.7%	11
$5M-$14.9M		0.0%	5	100.0%	5
Unsure	25	100.0%		0.0%	25
Grand Total	**57**	**52.3%**	**52**	**47.7%**	**109**

Table 5.9: Digital product possession vs. average annual budget.

Timeline of Development

As described in "Chapter Four: Data Collection," there has undeniably been an increase in the creation of digital products amongst the responding museums since 2010. With the exception of the outlier product that was said to be created in 2000 (and is likely a typo), all of the reported products were created no earlier than 2010. From 2010 until about 2015, growth in digital product creation was slow. It began to increase in 2016, with the largest spike happening in 2020. Part of this spike can be attributed to a response from a single parent organization, whose museums were responsible for the creation of 38 3D virtual tours in that year. However, even adjusted to account for response bias,

2020 saw notable growth in digital product creation.[74] Figure 5.5 and Figure 5.4 below illustrate these trends.

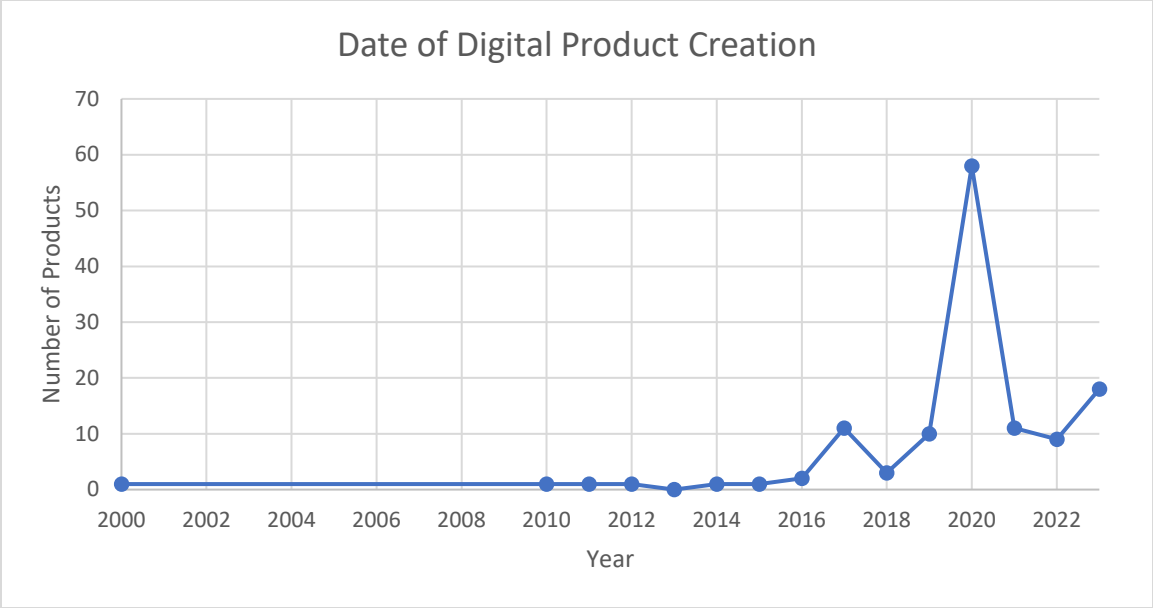


Figure 5.5: Date of digital product creation.

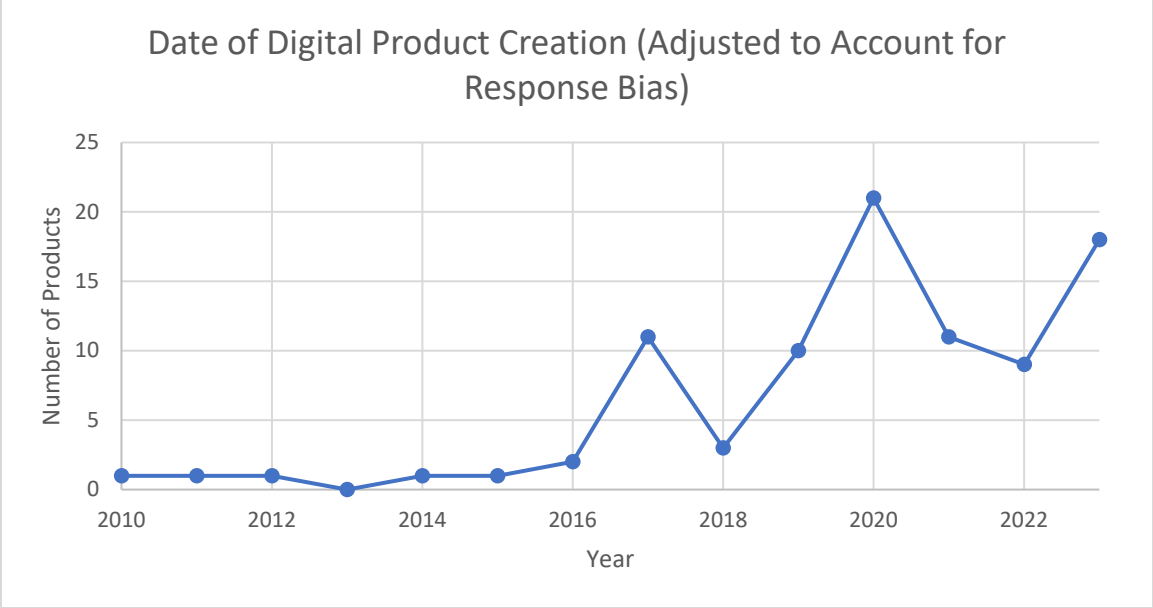


Figure 5.4: Date of digital product creation (adjusted to account for response bias).

[74] To account for response bias, responses from organizations who responded on behalf of multiple museums were removed from the dataset for the graph "Date of Digital Product Creation (Adjusted to Account for Response Bias."

A number of factors contribute to the increase in the creation of digital products around this time. In mid-March of 2020, states began enacting shutdowns, encouraging social distancing measures, and discouraging travel in response to the COVID-19 pandemic.[75] For museums that relied on engagement with visitors at the physical museum, the shutdowns essentially rewrote the script for how museums could accomplish their missions of engaging with and educating the public. According to a 2022 report from the American Alliance of Museums (AAM), "museums had been closed to the public for an average of twenty-eight weeks due to the pandemic." In addition, the report indicated that of the 710 respondents to their survey (which was used to create the report), 76% would "continue the virtual/online practices they implemented for programming…" and that "Many respondents indicated they would continue with virtual practices they adopted during the pandemic, which proved to have benefits for broadening engagement…"[76]

It is important to note that AAM includes museums from all areas of the museum field, such as science centers, zoos, and art museums, and the patterns they observe are therefore derived from a much larger sample than just museums associated with the historic built environment. On the other hand, these statistics still suggest an increase in digital products in response to the pandemic, as well as a desire for museums to continue the use of their pandemic-era digital products (a result very much reflected by the

[75] "CDC Museum COVID-19 Timeline," CDC.gov, David J. Sencer CDC Museum: In Association with the Smithsonian Institution, Centers for Disease Control and Prevention, March 15, 2023, https://www.cdc.gov/museum/timeline/covid19.html.
[76] American Alliance of Museums and Wilkening Consulting, *National Snapshot of COVID-19 Impact on United States Museums* (American Alliance of Museums, February 8, 2022) 6, https://www.aam-us.org/wp-content/uploads/2022/02/COVID-19-Snapshot-of-the-Museum-Field-Dec-Jan.pdf.

satisfaction data described earlier in this chapter). As mentioned in the "Intention of Digital Products" section, several of museums who responded to this survey explicitly stated that their products had been created to meet the challenge of engaging the public when their buildings were inaccessible due to these pandemic-related closures. Given the trend highlighted by the AAM, these responses to this survey, and the spike in products created in 2020, this data strongly suggests that the pandemic played a significant role in the growth of virtual product creation around this time.

This is, however, only one factor that could have contributed to the growth in 3D digital product creation during this time. While a significant spike occurred in 2020, growth was already accelerating in 2019. An additional factor that may have encouraged this growth was the increase in financial accessibility of the equipment and software needed to create these 3D products. In a 2019 article on the use of terrestrial laser scanning for studying forest canopies, the researchers remarked that financials were a likely barrier for users as the equipment needed to capture laser scans could cost upwards of $100,000. They noted, however, that recently, compact, lightweight, and lower-cost laser scanners (costing closer to $20,000) had come onto the market.[77] These newer, more cost-effective equipment options may also have contributed to the uptick in digital product creation in the late 2010s and early 2020s.

[77] M. Disney, A. Burt, K. Calders, C. Schaaf, and A. Stovall. "Innovations in Ground and Airborne Technologies as Reference and for Training and Validation: Terrestrial Laser Scanning (TLS)." *Surveys in Geophysics* 40, no. 4 (July 2019): 937-958, https://doi.org/10.1007/s10712-019-09527-x.

Who's Who of Digital Product Development

Data collected in the second tier of the survey indicates that nearly all of the second tier respondents hold at least one higher education degree. The majority of respondents counted in the second tier of the survey hold a graduate degree (58.3%), 8.3% have completed some graduate school coursework, 20.8% hold an undergraduate degree, and 12.5% have completed some undergraduate coursework. No respondents hold only a high school diploma without completing at least some undergraduate coursework. This data suggests a high degree of professionalism amongst individuals completing this work in museums.

Despite the high degree of professionalism, the respondents to this survey largely learned the software used to create these 3D digital products outside of the classroom. In addition to the categories of "Undergraduate core class," "Undergraduate elective class," "Graduate core class," "Graduate elective class," "University-sponsored workshop," "Non-university sponsored workshop," "Internship," "Post-graduation professional development (employer funded)," and "Post-graduation professional development (self-sponsored)," respondents were given the choice of "Other (please specify)." From these responses, three additional categories were added based on the descriptions respondents provided: "Other (on the job)," "Other (self-taught)," and "Other (worked with a third party)." Table 5.10 below indicates the breakdown of where the respondent learned the software used to create the digital product(s) with the additional categories included.

Where Respondents Learned the Software	Count	Percentage
Post-graduation professional development (self-sponsored)	9	20.9%
Other (worked with a third party)	8	18.6%
Other (self-taught)	7	16.3%
Post-graduation professional development (employer funded)	4	9.3%
Other (on the job)	4	9.3%
Undergraduate core class	3	7.0%
Graduate core class	2	4.7%
Graduate elective class	2	4.7%
Undergraduate elective class	1	2.3%
University-sponsored workshop	1	2.3%
Non-university sponsored workshop	1	2.3%
Internship	1	2.3%

Table 5.10: Where respondents learned the software.

Based on this data, over three quarters of the avenues respondents sought to learn the software were outside of a school setting (79.1%). Respondents most commonly sought out post-graduation professional development (self-sponsored) (20.9%). This was followed by instances where the respondent worked with a third party (18.6%), then by instances where the software was self-taught (16.3%).[78] Post-graduation professional development (employer funded) and other (on the job) were tied for the next most common scenario for learning the software (each at 9.3%). For those respondents who

[78] Two respondents mentioned using internet tutorials to teach themselves to use the software, including one respondent who had sought out tutorials on YouTube in order to learn the software. See Appendix for the full list of responses.

did learn the software in school, undergraduates were more likely to learn it in a core class than in an elective, whereas graduate students were equally as likely to learn it as part of a core class as they were to learn it in an elective. It is also important to note that despite being exposed to the software in an academic setting, respondents who indicated that they learned the software in an academic setting often sought out additional training after graduation (see Table 5.11 below).

Respondents Who Learned the Software in an Academic Setting	
Area of Study	**Where the Respondent Learned the Software**
Historic preservation Architectural Design & Build	Undergraduate core class Other (please specify)
Art history Philosophy	Undergraduate core class Post-graduation professional development (self-sponsored) Other (please specify)
Historic preservation Archaeology Anthropology	Graduate elective class University-sponsored workshop Post-graduation professional development (self-sponsored)
History Museum studies	Undergraduate core class
Historic preservation Museum studies	Undergraduate elective class Post-graduation professional development (employer funded)
History Museum studies Public History	Graduate core class Graduate elective class Internship

Table 5.11: Respondents who learned the software in an academic setting.

The breakdown of areas of study could suggest the reasoning behind this pattern. The most common area of study indicated among respondents was "Other (please specify)," which included "Classics," "architectural design and build," "philosophy," "education," "architecture," "Fine Art - Photography," "criminal justice," "computer graphics" "POLI and Public Policy," "English," "chemistry," and "Master in Information

Systems." "Architectural design and build" and "architecture" were grouped under "architecture" to provide more consistency when analyzing the data. Table 5.12 below indicates the breakdown of the data by grouping similar responses and representing "Other (please specify)" responses as the area of study indicated by the respondent.

Areas of Study with Grouping		
Area of Study	**Count**	**Percentage**
History	9	21.4%
Historic preservation	4	9.5%
Museum studies	4	9.5%
Archaeology	3	7.1%
Architecture	3	7.1%
Architectural history	3	7.1%
Education	3	7.1%
Anthropology	2	4.8%
Public History	2	4.8%
Art history	2	4.8%
Criminal justice	1	2.4%
POLI and Public Policy	1	2.4%
Philosophy	1	2.4%
Fine Art - Photography	1	2.4%
Master in Information Systems	1	2.4%
Classics	1	2.4%
English	1	2.4%

Table 5.12: Areas of study with grouping.

Broken down in this manner, history remains the most common area of study indicated by responses at 21.4%. This is followed by historic preservation and museums studies, which are tied as the second most common area of study at 9.5%. It is not entirely surprising that these three are the most common areas of study in the dataset given that the target audience for the survey was American museums who steward and/or interpret the historic built environment. However, this breakdown may suggest why the

majority of respondents learned the software outside of the academic setting. Among the top three areas of study, it is unlikely that history and museum studies would typically include documentation technologies and software in their curriculum.

In terms of which areas of study were most likely to prepare graduates with the skills to utilize these software, the data is a bit unclear but suggests some general trends. Since respondents could choose multiple areas of study and multiple locations for learning the software at once, it is not possible to say which area of study the respondent learned the software in. However, among the six responses where the respondent indicated that they had at least partially learned the software in an education setting, three listed historic preservation as one of their areas of study, three listed museum studies, two listed history, and architecture, public history, art history, philosophy, archaeology, anthropology, and computer graphics were all listed once.

With historic preservation tied for the most responses of individuals who learned the software in an academic setting, there may be a correlation between the area of study and graduates who enter the field at least partially knowledgeable in and prepared to utilize the software used to generate 3D virtual products. As discussed in the literature review, there are some academic programs who are teaching software such as AutoCAD, along with preservation practitioners working in academia who are utilizing the software for projects. The presence of such software in academic preservation settings does strengthen this correlation. However, the inability to match the area of study to the location where the respondent learned the software makes it impossible to definitively prove that there is a link between the two, in particular because museum studies appears

the same number of times as historic preservation among respondents who learned the software in an academic setting.

For a full breakdown of where respondents learned the software versus their area of study, please see Appendix F. This table represents how many respondents indicated a specific location for learning the software, with a count for each of the areas of study that the respondent reported. It is not possible, however, to determine if the respondent truly learned the software in the area noted as the survey question was not asked in a way that allows the direct connection to be made between area of study and the location.

Who's Who of Digital Product Development – With Additional Examples

The dataset used in the "Who's Who of Digital Product Development) section, (hereafter referred to as Dataset 1) had fifteen products eliminated as they did not correspond to products that had been counted in the analysis of the first tier survey data. When these fifteen additional products are added back into the dataset (hereafter referred to as Dataset 2) for reanalysis, many of the patterns observed in Dataset 1 are still present. The majority of respondents in both datasets hold a higher education degree (Dataset 1: 58.3%, Dataset 2: 59.3%), and there is a similar breakdown of degree levels in both, as seen in **Error! Reference source not found.** below.

Level of Education Comparison				
	Dataset 1		**Dataset 2**	
Level	**Count**	**Percentage**	**Count**	**Percentage**
High school	0	0.0%	0	0.0%
Some undergraduate coursework	3	12.5%	3	10.7%
Undergraduate degree	5	20.8%	6	21.4%
Some graduate school coursework	2	8.3%	2	7.1%
Graduate degree	14	58.3%	17	60.7%

Table 5.13: Level of education comparison.

Similarly to Dataset 1, over three-quarters of respondents learned the software outside of a school setting (Dataset 1: 79.1%; Dataset 2: 77.4%). The breakdown of Dataset 2 locations, however, differs slightly from Dataset 1. Notably, respondents were most commonly self-taught (19.4%). The most common location from Dataset 1, learning from post-graduation professional development, was the second most common response in Dataset 2 (17.7%). It was also slightly more common for respondents to learn the software in an undergraduate core class (Dataset 1: 7.0%; Dataset 2: 9.7%) and an undergraduate elective class (Dataset 1: 2.3%; Dataset 2: 4.8%). Also of note, no respondents from Dataset 1 reported learning the software from manufacturer, but two respondents from Dataset 2 reported attending manufacturer training. The full comparison of locations can be found in Table 5.14 below.

Where Respondents Learned the Software Comparison				
	Dataset 1		**Dataset 2**	
Where Respondents Learned the Software	**Count**	**Percentage**	**Count**	**Percentage**
Post-graduation professional development (self-sponsored)	9	20.9%	11	17.7%
Other (worked with a third party)	8	18.6%	10	16.1%
Other (self-taught)	7	16.3%	12	19.4%
Post-graduation professional development (employer funded)	4	9.3%	6	9.7%
Other (on the job)	4	9.3%	5	8.1%
Undergraduate core class	3	7.0%	6	9.7%
Graduate core class	2	4.7%	2	3.2%
Graduate elective class	2	4.7%	2	3.2%
Undergraduate elective class	1	2.3%	3	4.8%
University-sponsored workshop	1	2.3%	1	1.6%
Non-university sponsored workshop	1	2.3%	1	1.6%
Internship	1	2.3%	1	1.6%
Other (manufacturer training)	0	0.0%	2	3.2%

Table 5.14: Where respondents learned the software comparison.

As with Dataset 1, it was common for individuals who learned the software in an academic setting to seek out additional training post-graduation. Three additional respondents were added to Dataset 2 who indicated learning the software in an academic setting. For two of the responses, it is unclear which area of study is associated with the academic setting the respondent learned the software in as the respondent indicated multiple areas of study. One respondent, however, indicated that have only a computer graphics background, which indicates they definitely learned the software in their undergraduate education. Table 5.15 below includes all respondents who reported learning the software in an academic setting.

Respondents Who Learned the Software in an Academic Setting (Updated)	
Area of Study	**Where the Respondent Learned the Software**
Historic preservation Architectural Design & Build	Undergraduate core class Other (please specify)
Historic preservation Building Science	Undergraduate core class Other (please specify)
Art history Philosophy	Undergraduate core class Post-graduation professional development (self-sponsored) Other (please specify)
Historic preservation Archaeology Anthropology	Graduate elective class University-sponsored workshop Post-graduation professional development (self-sponsored)
History Museum studies	Undergraduate core class
Historic preservation Museum studies	Undergraduate elective class Post-graduation professional development (employer funded)
History Museum studies Public History	Graduate core class Graduate elective class Internship
History Museum studies Public History	Graduate core class
Computer Graphics	Undergraduate core class Undergraduate elective class

Table 5.15: Respondents who learned the software in an academic setting (updated).

Among the nine respondents in Dataset 2 who indicated learning the software in an academic setting, four listed historic preservation as one of their areas of study, three listed history, three listed museum studies, two listed an architecture-related program, two listed public history, and art history, philosophy, archaeology, anthropology, and computer graphics were all listed once. Historic preservation appearing the most among individuals who learned the software in an academic setting supports the correlation between this area of study and graduates who enter the field at least partially knowledgeable in and prepared to utilize the software used to generate 3D virtual products. As with the Dataset 1 analysis, however, the inability to connect the area of study directly to the location where the respondent learned the software makes it impossible to definitively prove that there is a link between the two.

Potential Software for Developing Digital Products

Respondents to the second tier reported using 35 different software programs to generate the corresponding 3D digital products described in the first tier. Responses were standardized in order to streamline analysis, as respondents occasionally entered the names of software inconsistently (ex. “Autodesk ReCap” versus “Recap”). The top three most common software used by the second tier respondents were Matterport (13.2%), Autodesk Revit and (9.4%) and Autodesk ReCap (5.7%). It is unsurprising that Matterport was the most common software, as it is a well-known company whose

products can be used to make the most common digital product described in the Tier 1 survey, 3D virtual tours.[79]

Of the top three software, none are open source, which would allow users to create projects at typically little to no cost.[80] Instead, respondents were using proprietary software. For instance, a significant number of Autodesk products are in use across the responses. 22.6% of all the software used by respondents to generate 3D digital products consisted of Autodesk products, including Autodesk Revit, a Building Information Modeling (BIM) tool, Autodesk 3ds Max, a modeling and rendering software, and Autodesk ReCap, a software used for reality capture and 3D scanning.[81] In addition, 7.5% of products are software available through Esri, which is a prominent producer of proprietary geographic information system (GIS) software.[82] Additional information on the software can be found in Table 5.16 and Table 5.17 below.

[79] "About Us," Matterport.com, Matterport, 2024, https://matterport.com/about-us.
[80] "What is Open Source Software?"
[81] "Autodesk Products," Autodesk.com, Autodesk, 2024, https://www.autodesk.com/products?page=2.
[82] "About Esri: Overview," Esri.com, Esri, accessed March 8, 2024, https://www.esri.com/en-us/about/about-esri/overview.

Software Used by Second Tier Respondents		
Software in Use	**Count**	**Percentage**
Matterport	7	13.2%
Autodesk Revit	5	9.4%
Autodesk ReCap	3	5.7%
SketchUp	2	3.8%
Autodesk 3ds Max	2	3.8%
3DF Zephyr	2	3.8%
Unity	2	3.8%
Autodesk AutoCAD	2	3.8%
DJI drone software	2	3.8%
MicMac	1	1.9%
Luma AI	1	1.9%
Photoshop	1	1.9%
Blender	1	1.9%
Meshmixer	1	1.9%
CityEngine	1	1.9%
Microsoft PowerPoint	1	1.9%
Clio	1	1.9%
ArcGIS Storymap	1	1.9%
DAZ Studio	1	1.9%
ArcGIS Pro	1	1.9%
Rhino 3D	1	1.9%
Metashape	1	1.9%
ArcGIS	1	1.9%
Microsoft Excel	1	1.9%
ArcGIS Online	1	1.9%
Nomad Sculpt	1	1.9%
3D Systems Geomagic	1	1.9%
Polycam	1	1.9%
iMovie	1	1.9%
Keynote	1	1.9%
Tinkercad	1	1.9%
Drone Phantom	1	1.9%
ZBrush	1	1.9%
FARO Scene	1	1.9%
FME	1	1.9%

Table 5.16: Software used by second tier respondents.

Software Used by Second Tier Respondents by 3D Digital Products		
Software by 3D Digital Products	**Count**	**Percentage**
A 3d virtual tour	**7**	**13.2%**
Matterport	6	85.7%
Autodesk Revit	1	14.3%
Drone footage or other immersive, digital experience	**6**	**11.3%**
DJI drone software	2	33.3%
MicMac	1	16.7%
Photoshop	1	16.7%
Drone Phantom	1	16.7%
iMovie	1	16.7%
Other (please specify)	**5**	**9.4%**
Microsoft PowerPoint	1	20.0%
ArcGIS Storymap	1	20.0%
Unity	1	20.0%
Clio	1	20.0%
Keynote	1	20.0%
A 3D model	**15**	**28.3%**
SketchUp	2	13.3%
Autodesk AutoCAD	2	13.3%
Unity	1	6.7%
Meshmixer	1	6.7%
ArcGIS Online	1	6.7%
Nomad Sculpt	1	6.7%
Autodesk 3ds Max	1	6.7%
ArcGIS Pro	1	6.7%
Tinkercad	1	6.7%
Autodesk Revit	1	6.7%
ZBrush	1	6.7%
Blender	1	6.7%
DAZ Studio	1	6.7%
A photogrammetric model	**5**	**9.4%**
Metashape	1	20.0%
3DF Zephyr	1	20.0%
Polycam	1	20.0%
Luma AI	1	20.0%
Matterport	1	20.0%
A point cloud	**8**	**15.1%**

Autodesk ReCap	2	25.0%
Autodesk Revit	1	12.5%
Rhino 3D	1	12.5%
FARO Scene	1	12.5%
Autodesk 3ds Max	1	12.5%
3DF Zephyr	1	12.5%
3D Systems Geomagic	1	12.5%
A Building Information Model (BIM)	**7**	**13.2%**
Autodesk Revit	2	28.6%
FME	1	14.3%
Autodesk ReCap	1	14.3%
Microsoft Excel	1	14.3%
ArcGIS	1	14.3%
CityEngine	1	14.3%
Grand Total	**53**	**100.0%**

Table 5.17: Software used by second tier respondents by 3D digital products.

Recategorization of Products

The analysis above utilizes the data as it was reported by respondents to the survey. Respondents were asked to choose from eight different products (not including "Other" or "None of the above"; the options were "A 3D virtual tour (i.e. Matterport)," "Drone footage or other immersive, digital experience," "A 3D model," "A photogrammetric model," "A virtual reality and/or augmented reality experience," "A point cloud," "A Building Information Model (BIM)," and "A fly through video of a digital 3D product." The first tier of the survey was designed to be disseminated to museums with the knowledge that the creator of the product may not be the individual responding to the survey. For this reason, these categories were designed so that respondents who may not know much about technology or the nature of capturing 3D data could likely answer the survey.

This, however, created some overlap between some of the categories. To determine if recategorizing the data to eliminate overlapping data would change the prevalence of products, five alternative categories were created: "3D model (points- or surface-based)," "3D model (massing- or solids-based)," "Immersive digital experience (passive user experience with respect to duration)," "Immersive digital experience (user-driven time interval)," and "Building Information Model (BIM)." It should be noted that BIM models are massing- or solids-based 3D models, but they are separated into a different category because they include additional construction information that typical 3D models do not. This method of recategorization does require a significant level of author interpretation, which is why it follows the analysis of the data as provided by respondents. Table 5.18 below indicates which of the products from the original survey fall into the five alternative categories.

Alternative Category	**Original Category**
3D model (points- or surface-based)	• A photogrammetric model • A point cloud
3D model (massing- or solids-based)	• A 3D model
Immersive digital experience (passive user experience with respect to duration)	• Drone footage or other immersive, digital experience • A fly through video of a digital 3D product
Immersive digital experience (user-driven time interval)	• A 3D virtual tour • A virtual reality and/or augmented reality experience
Building Information Model (BIM)	• Building Information Model (BIM)

Table 5.18: Comparison of recategorized products.

Recategorizing the data in this way had little impact on the breakdown of products. The category with the greatest overlap, 3D model (points- or surface-based), combined to account for 7.0% of responses. Originally, photogrammetric models accounted for 4.5% of responses and (laser documented) point clouds for 3.0% of responses. In comparison, immersive digital experience (user-driven time interval), which includes 3D virtual tours, accounts for 34.7% of responses. Therefore, the negligible difference when accounting for overlapping products indicates that the original analysis is still valid. Table 5.19 below indicates the breakdown of the original categories in comparison to the alternative categories.

Original Breakdown		
Product	**Count**	**Percentage**
A 3D virtual tour	60	30.2%
A virtual and/or augmented reality experience	9	4.5%
None of the above	64	32.2%
Drone footage or other immersive digital experience	26	13.1%
A fly through video of digital 3D product	0	0%
A photogrammetric model	9	4.5%
A point cloud	6	3.0%
Other (please specify)	13	6.5%
A 3D model	9	4.5%
A Building Information Model (BIM)	3	1.5%

Recategorization Breakdown		
Product	**Count**	**Percentage**
Immersive digital experience (user-driven time interval)	69	34.7%
None of the above	64	32.2%
Immersive digital experience (passive user experience with respect to duration)	26	13.1%
3D model (points- or surface-based)	15	7.5%
Other (please specify)	13	6.5%
3D model (massing- or solids-based)	9	4.5%
A Building Information Model (BIM)	3	1.5%

Table 5.19: Breakdown of original product categories vs. recategorized product types.

Areas of Further Research

The data collected and analyzed in this thesis can serve as a benchmark for comparison with data collected in future studies. A museum organization such as AAM could conduct this survey again in a decade's time in order to determine how the use of digital documentation technologies to create 3D digital architectural products has evolved. The data can be used to determine if the use of digital products has grown, if producers of digital products still have similar backgrounds and learn the necessary skills through similar methods, and if the breakdown of product type remains similar.

If this survey is recreated, the organization conducting it might consider making a few minor changes and additions to the survey. This includes streamlining the categories of digital products, perhaps using those in the "Recategorization of Products" section, in order to avoid overlap between categories. In addition, this study focused on the products that resulted from the use of digital documentation technologies but did not collect information on the equipment used to capture data. An extended survey could ask questions to fill this gap. Along with the extended survey, a supplemental survey looking at the satisfaction of visitors using the different 3D digital products could provide additional insights into how successful these products are.

The methodology for survey distribution could also be adjusted slightly. Given the relatively low response rate, an extended survey with more clear inclusion/exclusion language could be distributed to additional sites across the United States. It would be especially helpful to identify additional sites in the western part of the country as this area was poorly represented by the respondents. Even if the response rate remains relatively

similar after this effort, a larger sample size could help affirm the observations made using this data.

To add an additional layer to the data, work could be completed outside of the survey. Interviews could be conducted with the organizations who have found significant success with their digital products in order to determine how they developed their digital products. This information could be used to create a workflow for creating such products. These workflows could then be used by other institutions looking to adopt the use of 3D digital products.

Another area of further research beyond the scope of the survey would be examining the differences between how museums are funded in Europe versus the United States. As discussed in the literature review, many of the case studies describing the use of 3D digital products in museums feature European institutions. Examining the funding structure of museums in this region could potentially explain why technology adoption is more prevalent in Europe than in the United States. In addition, it might provide a model for a better funding base from which digital models can be created in United States museums.

CHAPTER SIX

CONCLUSION

Preservation and museums have long gone hand-in-hand, but the extent of the use of digital documentation technologies for preservation purposes in museums has mostly been documented in publicly available literature as lone case studies. A comprehensive view of the prevalence of these digital interpretive and management tools benefits managers of individual historic sites, and also establishes a benchmark for the field of museum studies and historic preservation to compare changing patterns over time. The repetition of this survey in a decade's time by an organization such as the American Alliance of Museums (AAM) or the American Association for State and Local History (AASLH) could be compared to this benchmark to determine how trends have either continued or shifted.

Case studies suggest that such software is used in museums, yet the case studies focus on isolated instances of the use of such technologies. This thesis uncovered the likely reason for such sporadic publications: the use of such technology is not yet widespread in United States historic sites.

This thesis provides relevant conclusions for three different audiences. The first of these audiences is the individual historic sites which interpret and steward historic structures. This thesis provides a snapshot of the current usage of digital products in these types of museums, which in turn provides a growth trajectory relevant to these institutions. At this time, a few very passionate individuals are excited to share this type of work at their institutions, but actual widespread adoption is not the current reality. The

low response rate to this survey (24.21%) and the approximately one-third of respondents who do not possess a digital product illustrate this current state of 3D architectural product use. Yet, the use of digital products has been rising since about 2016, with a significant increase in 2020 due to the COVID-19 pandemic and the increased affordability of tools to create the products (see Figure 6.1).

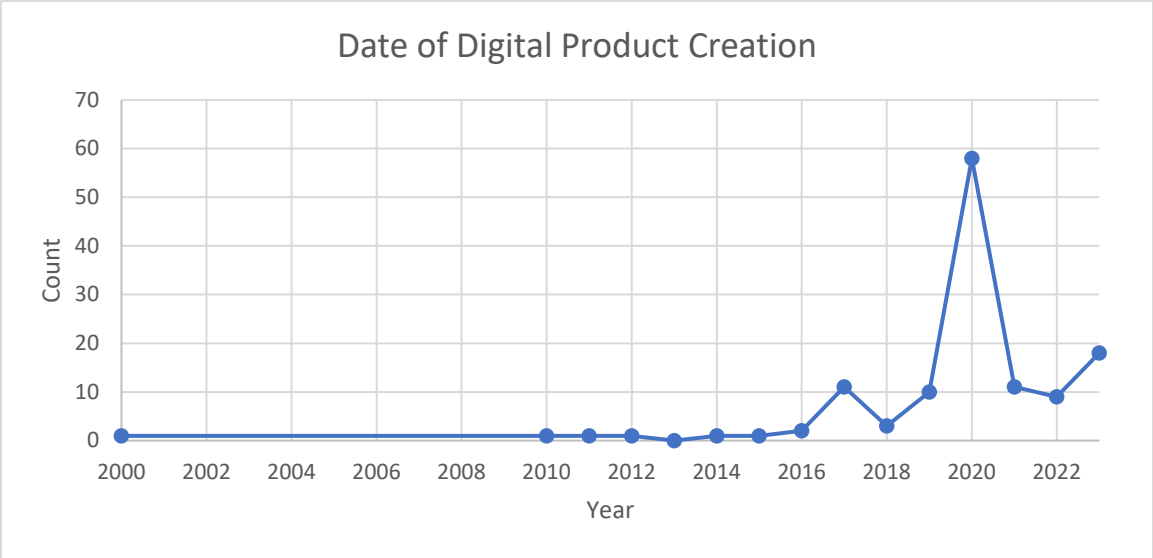


Figure 6.1: Date of digital product creation.

For museums, this growth trajectory might inspire institutions to follow the trend and create a digital product. For those who might wish to begin using a product, there are a range of options, but some have proved more popular with survey respondents than others. By and large, for museums that do possess a digital product (92 museums out of the 153 surveyed), 3D virtual tours such as Matterport are currently the most common product (of 134 digital products, 60 were classified as a "3D virtual tour [i.e. Matterport]"; see Figure 6.2). In comparison to 3D virtual reconstructions and BIMs which require the use of more complicated software and longer periods of time to create,

3D virtual tours provide museums with a quick, affordable, and relatively simple alternative to document and interpret historic spaces.

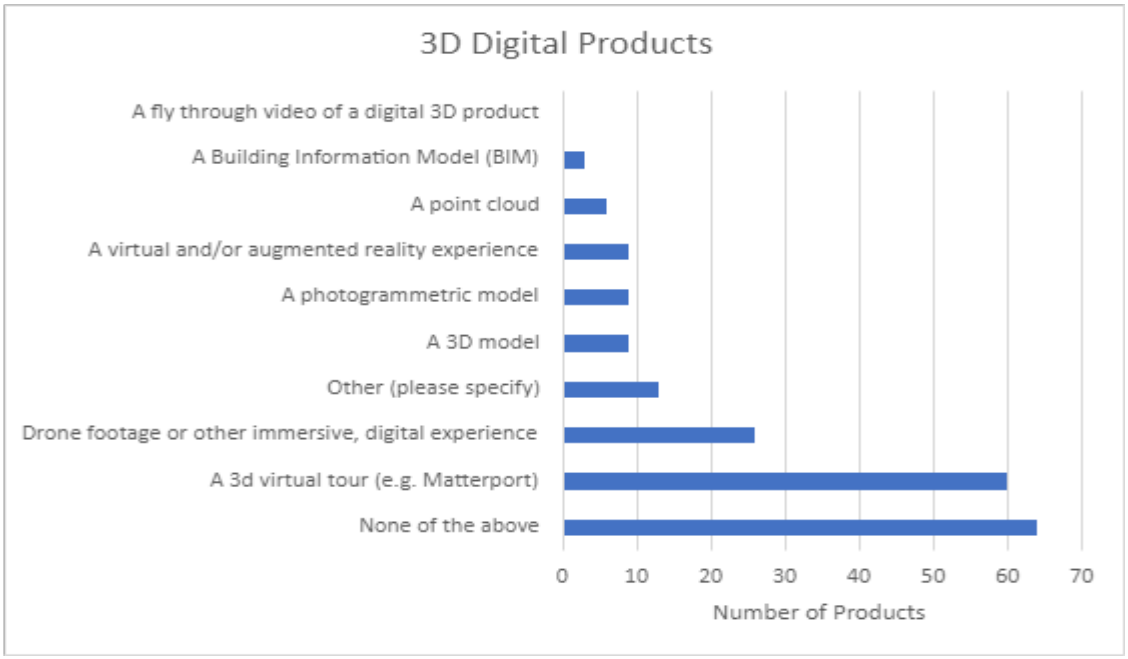


Figure 6.2: 3D digital products.

For museums looking for a product as their first foray into the digital realm, survey responses have shown that there is a high level of satisfaction with 3D virtual tours. The majority (83.1%) of respondents in possession of this type of product would "definitely" undertake the project again given the choice in the future. This is especially the case for small museums with limited resources. One museum which fell into the categories of 0-5 full time staff members and a budget under $350,000 summarizes the potential for this type of product: "It's a virtual tour so that people can visit the site without being in [their city]. It is a one-of-a-kind site and we wanted to share it with the world!" This quote from a small museum with few full-time staff (0-5) and a limited

budget ($350,000 and under) reflects their strong satisfaction with their product and its impact, aligning with the trends seen across the dataset.

While the satisfaction with 3D virtual tours is of particular note, the level of satisfaction across all of the recorded responses is generally very high. With the exception of BIM, which has a lower usefulness rating than the other products intended for interpretive purposes, each of the different product types are generally rated at least "moderately useful" if not more so. This indicates that most interpretive products follow the pattern of very high satisfaction indicated in the overall data. While there is a slightly greater variation in the satisfaction ratings for staff-facing products, they are still generally regarded favorably. Figure 6.3 and Figure 6.4 illustrate the breakdown of usefulness ratings by type.

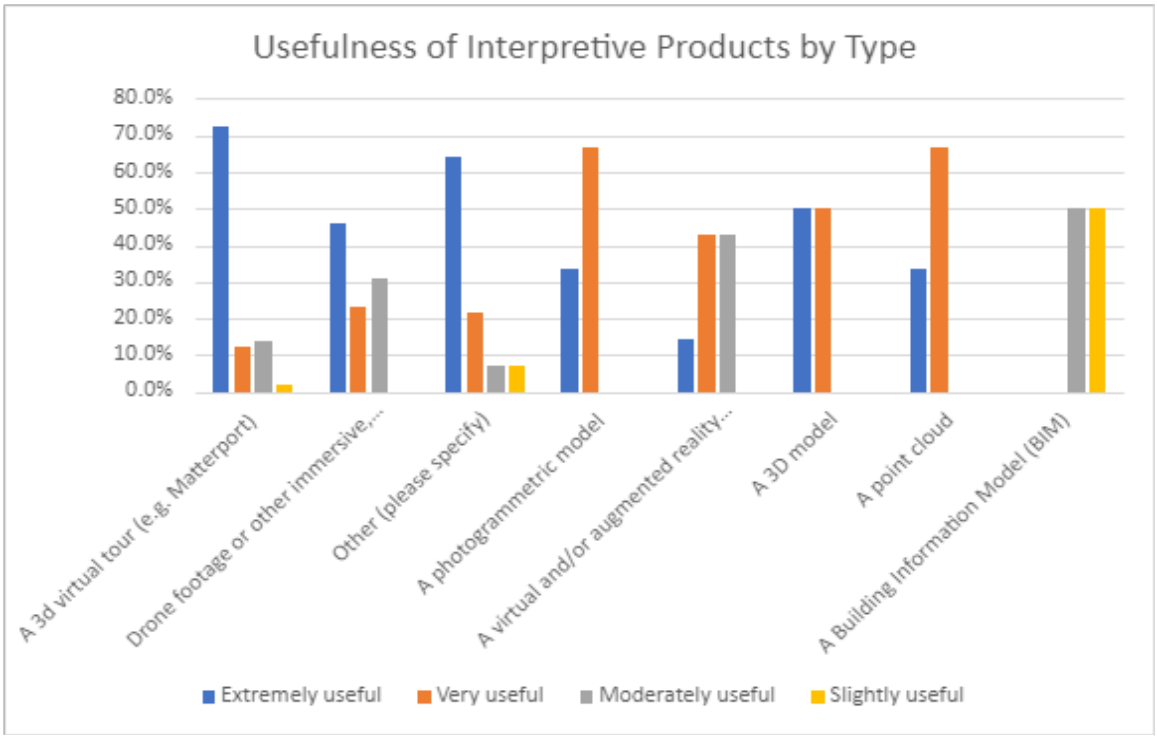


Figure 6.3: Usefulness of interpretive products by type (in percentages).

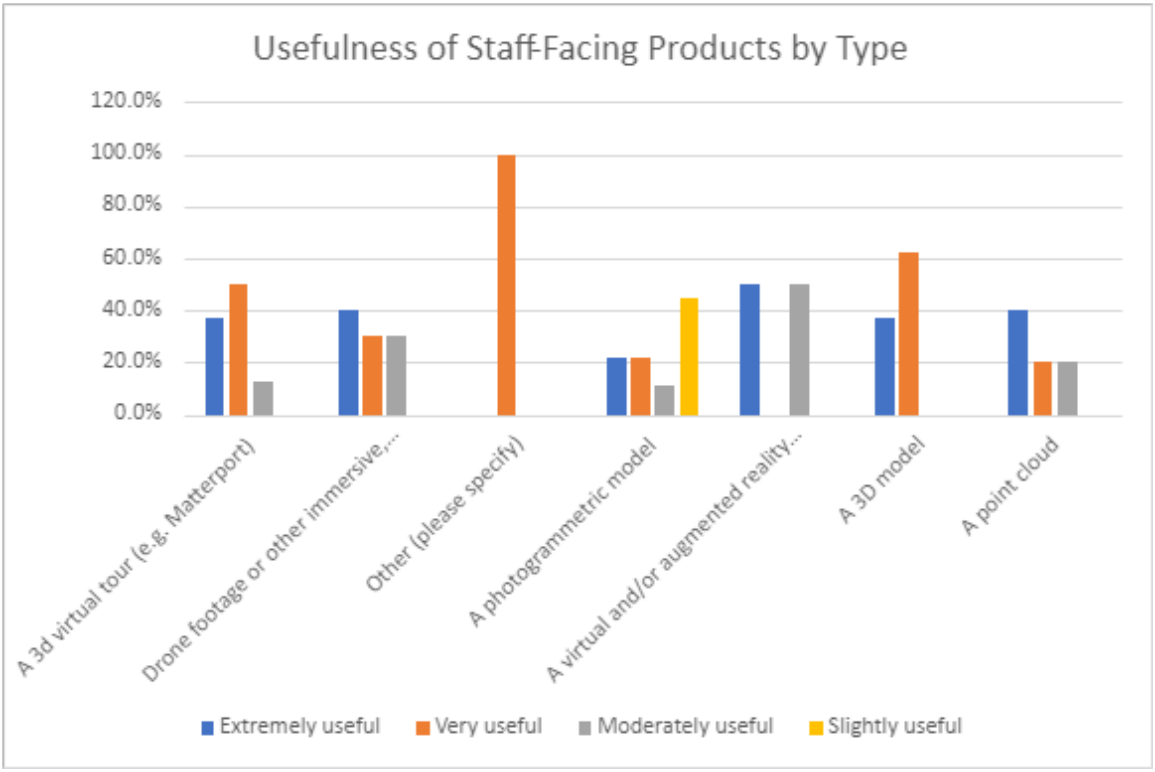


Figure 6.4: Usefulness of staff-facing products by type (in percentages).

For the museums that elect to dedicate resources to creating more complex products, there are several other prominent 3D digital architecture products that are being pioneered by a few of the museums who responded to the survey. 4.5% of the products in use by respondents are virtual and/or augmented reality experiences. One example is a museum using their AR/VR experience, accessed via a QR code, to make their grounds more accessible by allowing users to translate content to other languages within the digital experience. Another 4.5% of the products described are 3D models, including one used to "show how a building used to look or how it will look," and features both extant structures and virtual reconstructions. These types of projects can create immersive and

more accessible experiences, which can help facilitate connections that some visitors may not be able to make on a standard tour of the museum.

Data collected in question eight of the first tier of the survey also indicate some of the other uses museums are finding for their digital products (categorization of the responses was performed in the "Intention of Digital Products" section of Chapter Five).[83] Plenty of the respondents are using their products for accessibility and documentation purposes, but far fewer indicated that they are using their products for fundraising or publicity purposes. One small museum in the northeast, with five or fewer full-time staff and a budget ranging from $500,000 to $999,999, reported that they were using their 3D virtual tour to promote a capital campaign, while another museum from the same region with five or fewer full-time staff and a budget under $350,000 uses their drone footage as an "eyecatcher" on the home page of their website.

In both cases, the digital products are bringing attention to something the museum wishes to be highlighted—be it a capital campaign or their site—which raises awareness about the museum and/or a particular challenge it is facing. This increased awareness can help encourage people to visit the museum or donate to help address those challenges. In the face of the decreased visitation and financial hardships brought upon museums by COVID-19, getting creative with digital products (i.e. viewing them as a marketing tool) might help address some of these challenges.[84]

---

[83] Question Eight asked, ""What is the intent of the digital product (Does it recreate a lost feature? Offer interpretation of different phases of the structure? Is it a panoramic photo model or visualization of a space that is not normally accessible?"

[84] American Alliance of Museums and Wilkening Consulting, *National Snapshot of COVID-19 Impact on United States Museums.*

Educators preparing students to enter this field are an additional audience for the results of this thesis research. These results show that there will likely be a growing demand for the skills used to create these products in the coming years. The growth trajectory of these products, which has been on the rise since 2016, indicates that the number of products being created is likely to continue to increase (see Figure 6.1). Additionally, respondents are overwhelmingly willing to reinvest in the creation of digital products. For three quarters (75.4%) of products, respondents would "definitely" reinvest in the product again (see Figure 6.5). This significant level of satisfaction and willingness to reinvest likely signals increased demand for individuals with the skills to create these products in the coming years.

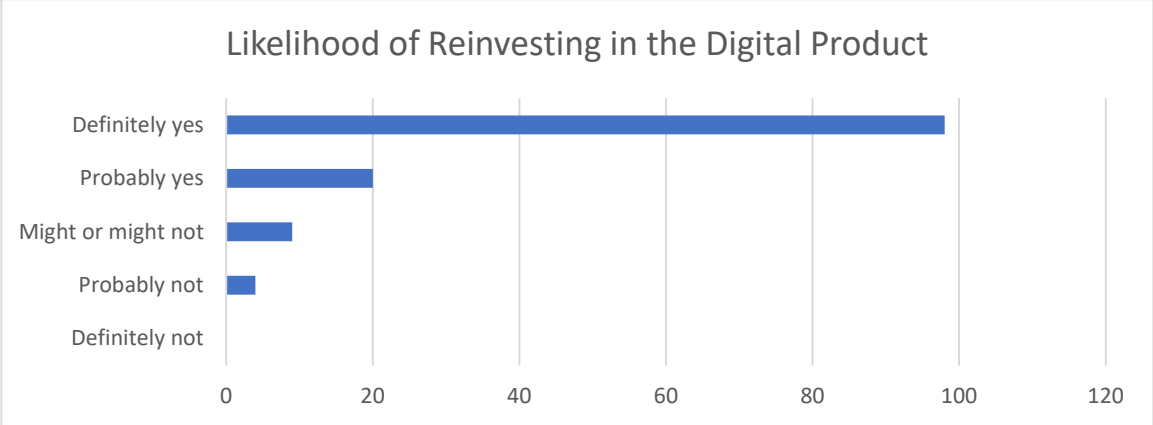


Figure 6.5: Likelihood of reinvesting in the digital product.

Despite the growing demand for digital products, the survey data suggests that the various fields whose graduates often pursue museum work are not meeting the demand for the skills needed to produce such products. Despite the majority of respondents possessing a graduate degree as their terminal degree, 79.1% of the respondents from

Dataset 1 and 77.4% of respondents from Dataset 2 learned the software used to create the digital product from a location outside of the school setting (see Figure 6.6)[85]

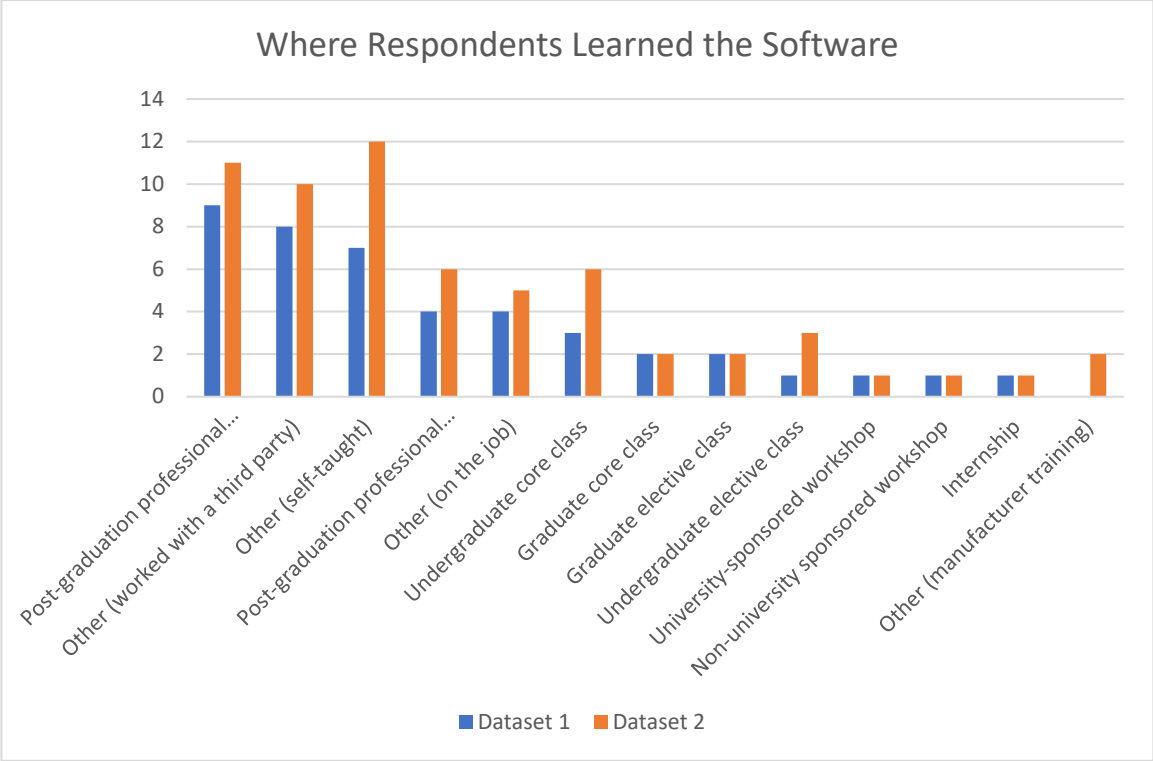


Figure 6.6: Where respondents learned the software.

While this indicates that academia is largely not preparing graduates with the skills needed to create these products, some academic programs have launched efforts to incorporate these skills and software into their curricula. As discussed in the literature review, some preservation programs are teaching the software and skills graduates need to succeed in jobs where they would be creating such products. While a handful of the

[85] Dataset 1 includes only respondents who described the creation of digital products which correspond to those counted in the analysis of the first tier survey data. Dataset 2 includes fifteen additional products which are examples of 3D digital architecture, but do not correspond to products counted in the analysis of the first tier survey data.

respondents who learned these skills in school come from preservation backgrounds, many other backgrounds are represented in the dataset, including history, museum studies, and architecture. While some preservation programs are leading the way in teaching these types of software as discussed in the literature review, more may want to consider adding digital documentation technology into their curriculums. Additionally, other areas of study such as history and museum studies might also consider adding digital documentation technologies in their curriculums or finding opportunities for their students to take classes in other disciplines to learn these skills. This can help address the current gap in academia, which will better prepare graduates to meet the growing demand for individuals able to create these products.

For individuals who do graduate with a foundational knowledge of digital documentation technologies, the creation of 3D digital products for museums is an avenue they may want to consider when looking for work. With 33.6% of the surveyed products being produced by outside companies and 17.2% produced through a collaboration with outside companies, individuals expand the field where they can work if they have these skills. While the connection between museums and preservation has long been well established, as more museums hope to interpret and steward the historic built environment with 3D digital products, individuals with these skills, including preservationists, might be able to help fill the need for individuals able to create such products.

No matter who is creating the digital products, what their use is, or the type of product, the high rates of satisfaction reported by the respondents to this survey suggest

that 3D digital products have a place in interpreting and stewarding the historic built environment in museums. It appears that those passionate few who described the use of digital products at their institutions are ahead of the digital curve; despite the place these technologies have in this section of museum work, they have yet to become widespread. However, the data shows that since 2016, and especially since 2020, the creation of digital products has increased. As these technologies become more accessible, both financially and more user-friendly, it is likely that the United States will continue to see growth in the development of these products. Those who have already implemented these digital products at their institutions provide examples of how they can be successfully utilized by the museum community to interpret and steward the historic built environment.

APPENDICES

Appendix A

Design and Documentation Survey Emails and Blog Posts

Organizations Email Script

To whom it may concern,

My name is Hannah St. Onge and I am a graduate student pursuing my M.S. in Historic Preservation at Clemson University. As part of my thesis, I am conducting a survey to determine which design and/or documentation software programs are used to generate digital products such as 3D models, 3D virtual tours, photogrammetric models, augmented and/or virtual reality experiences, or building information models (BIM) for museums, and to see if individuals with a preservation degree are part of producing these digital products.

I will be conducting a two tiered approach to the survey; the first tier is a reconnaissance-style survey to generate a list of respondents for the second tier. The primary focus of this tier is to collect data about historic sites that possess some sort of digital product, and determine whether or not that product was made in-house. The second tier of the survey will follow up with the historic sites who have staff generating their digital products in-house and the companies to whom historic sites have outsourced their digital products. The primary focus of the second survey will be examining the types of software used in producing digital products for museums, as well as where the respondent learned the digital tools used to create those products.

I am reaching out to your organization due to your connections to a large network of museums. Would you be willing to share the blog post that I have drafted and attached to this email on your organization's blog? Anyone contacted about the survey is not obligated to participate if they do not wish to do so; there will be no penalty for abstention or compensation for involvement.

The first tier of the survey consists of 16 to 22 questions, depending on the respondent's answers, and should take about 10-20 minutes to complete. All personal information will be stored securely and not made available to the public without express permission. Any identifying information will be deleted from digital storage once the project has been completed.

My goal with this survey is to provide the museum and preservation fields with a better understanding of software use in the museum field and help preservationists understand their role (or potential role) in the development of such products. Completion of this survey will contribute to this goal.

I ask that any respondents to the first tier of the survey please complete it before 5:00pm EST on Friday, December 8, 2023. If you have any questions, please contact me at hstonge@g.clemson.edu or my advisor, Amalia Leifeste, at aleifes@clemson.edu.

Thank you for your help!

Best regards,

Hannah St. Onge

Museum Email Script

To whom it may concern,

My name is Hannah St. Onge and I am a graduate student pursuing my M.S. in Historic Preservation at Clemson University. As part of my thesis, I am conducting a survey to determine which design and/or documentation software programs are used to generate digital products such as 3D models, 3D virtual tours, photogrammetric models, augmented and/or virtual reality experiences, or building information models (BIM) for the museum, and to see if individuals with a preservation degree are part of producing these digital products.

I will be conducting a two tiered approach to the survey; the first tier is a reconnaissance-style survey to generate a list of respondents for the second tier. The primary focus of this tier is to collect data about historic sites that possess some sort of digital product, and determine whether or not that product was made in-house. The second tier of the survey will follow up with the historic sites who have staff generating their digital products in-house and the companies to whom historic sites have outsourced their digital products. The primary focus of the second survey will be examining the types of software used in producing digital products for museums, as well as where the respondent learned the digital tools used to create those products.

I have selected you as a potential participant because of your association with a museum which may possess a digital product. You are not obligated to participate if they do not wish to do so; there will be no penalty for abstention or compensation for involvement.

The first tier of the survey consists of 16 to 22 questions, depending on your answers, and should take about 10-20 minutes to complete. All personal information will be stored securely and not made available to the public without express permission. Any identifying information will be deleted from digital storage once the project has been completed.

My goal with this survey is to provide the museum and preservation fields with a better understanding of software use in the museum field and help preservationists understand their role (or potential role) in the development of such products. Completion of this survey will contribute to this goal.

Please complete the first tier of the survey before 5:00pm EST on Friday, December 8, 2023. If you have any questions or experience any difficulties accessing the survey, please contact me at hstonge@g.clemson.edu or my advisor, Amalia Leifeste, at aleifes@clemson.edu. Thank you for your help!

Link to the survey: https://clemson.ca1.qualtrics.com/jfe/form/SV_7PvUwL2cHLmDz7g

Best regards,

Hannah St. Onge

Tier Two Follow Up Script

To whom it may concern,

My name is Hannah St. Onge and I am a graduate student pursuing my M.S. in Historic Preservation at Clemson University. As part of my thesis, I am conducting a survey to determine which design and/or documentation software programs are used to generate digital products such as 3D models, 3D virtual tours, photogrammetric models, augmented and/or virtual reality experiences, or building information models (BIM) for museums, and to see if individuals with a preservation degree are part of producing these digital products.

I will be conducting a two tiered approach to the survey; the first tier is a reconnaissance-style survey to generate a list of respondents for the second tier. The primary focus of this tier is to collect data about historic sites that possess some sort of digital product, and determine whether or not that product was made in-house. The second tier of the survey will follow up with the historic sites who have staff generating their digital products in-house and the companies to whom historic sites have outsourced their digital products. The primary focus of the second survey will be examining the types of software used in producing digital products for museums, as well as where the respondent learned the digital tools used to create those products.

I have selected you as a potential participant because a first tier survey respondent indicated that you contributed to the development of *[brief description of digital product(s)]* for *[name of museum]* and submitted your contact information.

The second tier of the survey consists of 7 to 15 questions, depending on your answers, and should take about 5-15 minutes to complete. All personal information will be stored securely and not made available to the public without express permission. Any identifying information will be deleted from digital storage once the project has been completed.

My goal with this survey is to provide the museum and preservation fields with a better understanding of software use in the museum field and help preservationists understand their role (or potential role) in the development of such products. Completion of this survey will contribute to this goal.

Please complete the second tier of the survey before 5:00pm EST on Monday, January 15, 2024. If you have any questions or experience any difficulties accessing the survey, please contact me at hstonge@g.clemson.edu or my advisor, Amalia Leifeste, at aleifes@clemson.edu. Thank you for your help!

Best regards,

Hannah St. Onge

Link to survey: https://clemson.ca1.qualtrics.com/jfe/form/SV_81jRm2eGMwq3D94

Revised version:

To whom it may concern,

My name is Hannah St. Onge and I am a graduate student pursuing my M.S. in Historic Preservation at Clemson University. As part of my thesis, I am conducting a survey to determine which design and/or documentation software programs are used to generate digital products such as 3D models, 3D virtual tours, photogrammetric models, augmented and/or virtual reality experiences, or building information models (BIM) for museums, and to see if individuals with a preservation degree are part of producing these digital products.

I have selected you as a potential participant because a first tier survey respondent indicated that you contributed to the development of *[brief description of digital product(s)]* for *[name of museum]* and submitted your contact information.

If you are interested, please complete the second tier of the survey before 5:00pm EST on Monday, January 15, 2024. It should take no more than 5-15 minutes to complete. If you have any questions or experience any difficulties accessing the survey, please contact me at hstonge@g.clemson.edu or my advisor, Amalia Leifeste, at aleifes@clemson.edu. Thank you for your help!

Best regards,

Hannah St. Onge

Link to survey: https://clemson.ca1.qualtrics.com/jfe/form/SV_81jRm2eGMwq3D94

Tier Two Reminder Script

To whom it may concern,

I hope all is well. On [*date of email distribution*], a survey was sent to you because a first tier survey respondent indicated that you contributed to the development of *[brief description of digital product(s)]* for *[name of museum]* and submitted your contact information. If you are able, please complete the survey before 5:00pm EST on Monday, January 15, 2024. It consists of 7 to 15 questions, depending on your answers, and should take about 5-15 minutes to complete.

Through this survey, I hope to provide the museum and preservation fields with a better understanding of software use in the museum field and help preservationists understand their role (or potential role) in the development of digital products for museums. If you have any questions or experience any difficulties accessing the survey, please contact me at hstonge@g.clemson.edu or my advisor, Amalia Leifeste, at aleifes@clemson.edu. Thank you for your help!

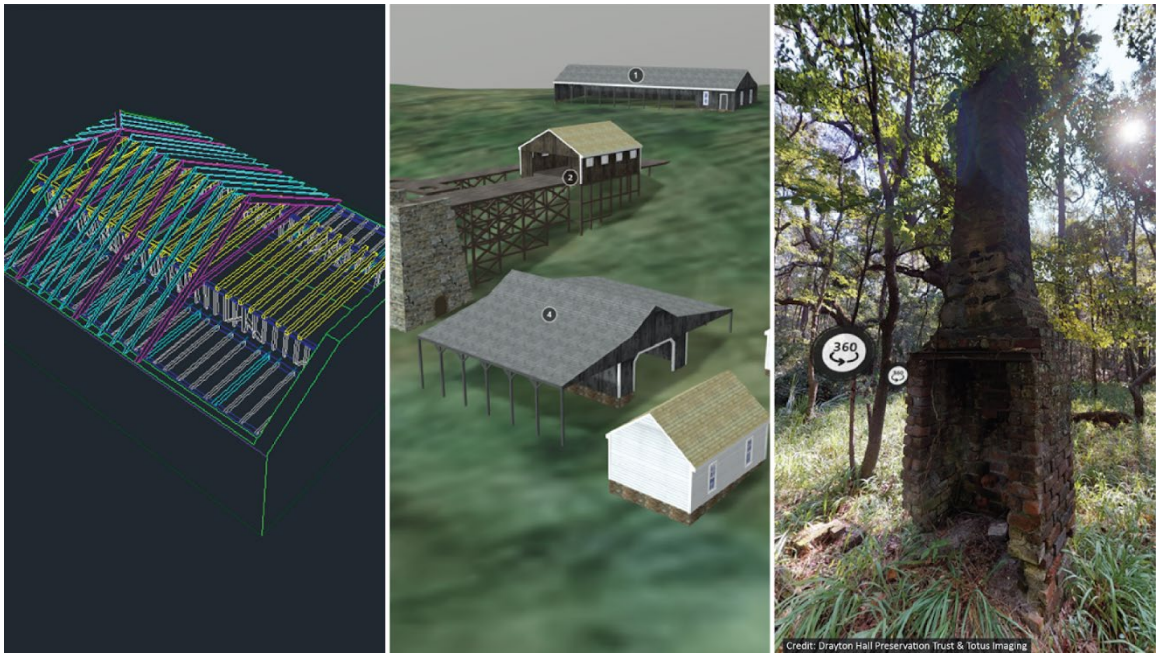
Link to survey: https://clemson.ca1.qualtrics.com/jfe/form/SV_81jRm2eGMwq3D94

Best regards,

Hannah St. Onge

Blog Post

Design and Documentation Software in Museums: Call For Museum Survey Participants In The United States



Interpreting the historic built environment using design and documentation software; photo by author, with chimney 3d space capture courtesy of Drayton Hall Preservation Trust & Totus Imaging.

As part of my thesis for the Clemson University Graduate Program in Historic Preservation, I am conducting a survey on the usage of design and documentation software in museums. I am looking to determine which software programs are used to generate digital products such as 3D models, 3D virtual tours, photogrammetric models, augmented and/or virtual reality experiences, or building information models (BIM) for museums, and to see if individuals with a preservation degree are part of producing these digital products.

If your museum has any of the above digital products or a similar product, I would appreciate your participation in the survey. I am currently seeking respondents to

the first tier of my survey, which aims to collect data about historic sites that possess some variety of digital product, and determine whether or not that product was made in-house. From this first survey, I plan to generate a list of respondents for the second tier of my survey, which will focus on examining the types of software used in producing digital products for museums, as well as where the respondent learned the digital tools used to create them.

The first tier of this survey consists of 16 to 22 questions, depending on the respondent's answers, and should take 10-20 minutes to complete. It should be completed by someone at your institution who is familiar with the development and/or use of the digital product(s), even if they were not directly involved in its creation (the second tier will follow up with those who directly participated in its development). If you are not familiar with your museum's digital products but know another individual at your institution who is, or know of another institution who possesses digital products like those listed above, it would be a great help if you could share this link with them. The survey will involve the release of identifiable information such as full names, job titles, and contact information of participants; however, none of these details will be included within the final report without explicit written consent from the individuals therein, and all non-publicly available information will be deleted from all digital records at the conclusion of the project. Through this survey, I hope to provide the museum and preservation fields with a better understanding of software use in the museum field and help preservationists understand their role (or potential role) in the development of such products.

The use of software to generate digital products for museums has been widely published about. Projects completed for museums in the United States, Europe, and Asia have utilized software ranging from Unity3D, to Autodesk 3ds Max, to Agisoft Metashape. They have produced products to help visualize missing elements of artifacts and buildings, recreate lost landscapes, and build experiences for visitors to interact with past landscapes and artifacts. This conversation has occurred largely on a case study level, with developers sharing their experience in creating a project for a single museum. Thus, it is my hope that my research can look more broadly at software usage in U.S. museums.

As an extension of this software usage question, I would also like to generate a better understanding of who is involved in the creation of such products. Is it common for the product to be made in-house? Or are museums outsourcing such work to other companies? Do people involved in the development of digital products for museums come from a museum background, a preservation background, or an entirely different field such as computer science? I am especially interested in determining the level of involvement (if any), of individuals with preservation backgrounds in this work. Current preservation practice sometimes involves the use of digital programs which, based upon the aforementioned case studies, might be encountered in U.S. museums. Examples from current preservation practice include the use of Autodesk AutoCAD for documenting structures and Reality Capture to generate photogrammetric models of objects relating to the built environment. Given the similarities in software usage, it would be intriguing to determine whether or not preservationists are involved in this work in museums, and if

not, can suggest a role in which preservationists who wish to work in museums might want to explore. This research should help both museum professionals and preservationists generate a better understanding of software usage in museums, which can help inform the decision making process around them.

I have designed this survey with the supervision of the Principle Investigator, Amalia Leifeste, Associate Professor of Historic Preservation at Clemson University. If you have any questions or concerns about the survey, please contact me at hstonge@g.clemson.edu.

Please click here to complete the survey:
https://clemson.ca1.qualtrics.com/jfe/form/SV_7PvUwL2cHLmDz7g

Thank you for your participation,

Hannah St. Onge

Appendix B

Informed Consent Documents

Information about the Research Study
Clemson University

Design and Documentation Software in Museums Survey (Tier 1)

KEY INFORMATION ABOUT THE RESEARCH STUDY

Hannah St. Onge is inviting you to volunteer for a research study. Hannah St. Onge is a graduate student at Clemson University conducting the study with the supervision of Amalia Leifeste, Associate Professor of Historic Preservation.

Study Purpose: The purpose of this research is to determine which software programs are used to produce digital products such as 3D models, 3D virtual tours, photogrammetric models, augmented and/or virtual reality experiences, or building information models (BIM) for museums. It also aims to determine if individuals with a preservation degree are part of producing these digital products. This study will help provide the museum and preservation fields with a better understanding of software use in the museum field and help preservationists understand their role (or potential role) in the development of such products.

Voluntary Consent: Participation is voluntary, and you have the option to not participate.

Activities and Procedures: Your part in the study will be to complete the survey. It contains 16 to 22 questions depending on your answers.

Participation Time: It will take you about 10-20 minutes to be in this study.

Risks and Discomforts: There are certain risks or discomforts that you might expect if you take part in this research. They include the release of full names, job titles, and contact information of participants. None of these details will be included within the final report without explicit written consent from the individuals therein, and all non-publicly available information will be deleted from all digital records at the conclusion of the project.

Possible Benefits: You may not benefit directly from taking part in this study; however, your responses will benefit the fields of preservation and museum studies by providing a resource indicating which software are most commonly used in the museum field to generate such digital products. This information may help museums in the decision-

making process surrounding the development of these products and help preservationists determine what their role might be in that process.

EXCLUSION/INCLUSION REQUIREMENTS

Participants in the survey must be directly associated with a museum in the United States and have knowledge of the museum's creation and/or use of a digital product.

PROTECTION OF PRIVACY AND CONFIDENTIALITY

The results of this study may be published in scientific journals, professional publications, or educational presentations.

All information that is not publicly accessible will be shared only between Hannah St. Onge and Amalia Leifeste. Identifiable information (such as full name or place of work) will not be included in the final study without explicit written consent. All information will be kept in a private Google Drive folder until it is destroyed.

Identifiable information collected during the study will be removed and the de-identified information will not be used or distributed for future research studies.

CONTACT INFORMATION

If you have any questions or concerns about your rights in this research study, please contact the Clemson University Office of Research Compliance (ORC) at 864-656-0636 or irb@clemson.edu. The Clemson IRB will not be able to answer some study-specific questions. However, you may contact the Clemson IRB if the research staff cannot be reached or if you wish to speak with someone other than the research staff.

If you have any study related questions or if any problems arise, please contact Hannah St. Onge at hstonge@g.clemson.edu or Amalia Leifeste at aleifes@clemson.edu.

CONSENT

By participating in the study, you indicate that you have read the information written above, been allowed to ask any questions, and you are voluntarily choosing to take part in this research. You do not give up any legal rights by taking part in this research study.

Information about the Research Study
Clemson University

Design and Documentation Software in Museums Survey (Tier 2)

KEY INFORMATION ABOUT THE RESEARCH STUDY

Hannah St. Onge is inviting you to volunteer for a research study. Hannah St. Onge is a graduate student at Clemson University conducting the study with the supervision of Amalia Leifeste, Associate Professor of Historic Preservation.

Study Purpose: The purpose of this research is to determine which software programs are used by professionals working in museums to produce digital products such as 3D models, 3D virtual tours, photogrammetric models, augmented and/or virtual reality experiences, or building information models (BIM) for museums. It also aims to determine if individuals with a preservation degree are part of producing these digital products. This study will help provide the museum and preservation fields with a better understanding of software use in the museum field and help preservationists understand their role (or potential role) in the development of such products.

Voluntary Consent: Participation is voluntary, and you have the option to not participate.

Activities and Procedures: Your part in the study will be to complete the survey. It contains 7 to 15 questions depending on your answers.

Participation Time: It will take you about 5-15 minutes to be in this study.

Risks and Discomforts: There are certain risks or discomforts that you might expect if you take part in this research. They include the release of full names, job titles, and contact information of participants. None of these details will be included within the final report without explicit written consent from the individuals therein, and all non-publicly available information will be deleted from all digital records at the conclusion of the project.

Possible Benefits: You may not benefit directly from taking part in this study; however, your responses will benefit the fields of preservation and museum studies by providing a resource indicating which software are most commonly used in the museum field to generate such digital products. This information may help museums in the decision-making process surrounding the development of these products and help preservationists determine what their role might be in that process.

EXCLUSION/INCLUSION REQUIREMENTS

Participants in the survey must be directly associated with a museum in the United States or with a company that assisted a museum in the creation of a digital product and must be directly involved in the development and creation of that digital product.

PROTECTION OF PRIVACY AND CONFIDENTIALITY

The results of this study may be published in scientific journals, professional publications, or educational presentations.

All information that is not publicly accessible will be shared only between Hannah St. Onge and Amalia Leifeste. Identifiable information (such as full name or place of work) will not be included in the final study without explicit written consent. All information will be kept in a private Google Drive folder until it is destroyed.

Identifiable information collected during the study will be removed and the de-identified information will not be used or distributed for future research studies.

CONTACT INFORMATION

If you have any questions or concerns about your rights in this research study, please contact the Clemson University Office of Research Compliance (ORC) at 864-656-0636 or irb@clemson.edu. The Clemson IRB will not be able to answer some study-specific questions. However, you may contact the Clemson IRB if the research staff cannot be reached or if you wish to speak with someone other than the research staff.

If you have any study related questions or if any problems arise, please contact Hannah St. Onge at hstonge@g.clemson.edu or Amalia Leifeste at aleifes@clemson.edu.

CONSENT

By participating in the study, you indicate that you have read the information written above, been allowed to ask any questions, and you are voluntarily choosing to take part in this research. You do not give up any legal rights by taking part in this research study.

Appendix C

Museum Contacts

Contacts Emailed Survey:

- Illinois
  - Abraham Lincoln Pres Library & Museum
  - Arlington Heights Historical Museum
  - Batavia Depot Museum
  - Bishop Hill Heritage Association
  - Butterworth Center & Deere-Wiman House
  - Cahokia Mounds State Historic Site
  - Chicago Architecture Center
  - Des Plaines Historical Society
  - DuSable Museum
  - Elgin History Museum
  - Ellwood House Museum
  - Elmhurst Historical Museum
  - Erlander Swedish Home Museum
  - Evanston History Center
  - Frank Lloyd Wright Preservation Trust
  - Glen Ellyn Historical Society
  - Glessner House Museum
  - Illinois State Museum
  - Lincoln Home National Historic Site
  - Lombard Historical Society
  - Loyola University of Chicago Cuneo Mansion and Gardens
  - Macon County Historical Society
  - McLean County Museum of History
  - Mendota Museum & Historical Society
  - Museum of the Grand Prairie
  - Norwood Park Historical Society
  - Peoria Historical Society
  - St. Charles Heritage Center
  - Wilmette Historical Museum
- Indiana
  - Conner Prairie Living History Museum
  - General Lew Wallace Study & Museum
  - Historic Madison, Inc
  - Johnson County Museum of History
  - Morris-Butler House
  - President Benjamin Harrison Home

    - The History Museum
    - Samara
    - Veraestau Historic Site
    - Wylie House Museum, Indiana University
- Iowa
    - German American Heritage Center
    - Linn County Historical Society
    - Museum of Danish America
    - Salisbury House & Gardens
- Michigan
    - Alden B. Dow Home and Studio
    - Allegan County Old Jail Museum and Historical Society
    - Bay County Historical Society
    - Berrien County Historical Association
    - Edsel & Eleanor Ford House
    - Ella Sharp Museum
    - The Henry Ford Museum
    - Holland Museum
    - Mackinac State Historic Parks
    - Mason Co Historical Society, Historic White Pine Village
    - Saugatuck-Douglas Historical Society
- Minnesota
    - American Swedish Institute
    - Dakota County Historical Society - LeDuc Historic Estate
    - Dakota County Historical Society - Sibley Historic Site
    - Gammelgarden Museum
    - Historical and Cultural Society of Clay County
    - Minnesota Historical Society
    - Richfield Historical Society
    - The Ramsey County Historical Society
    - Winona County Historical Society
- Missouri
    - Campbell House Museum
    - Clay County Historic Sites
    - Mark Twain Boyhood Home & Museum
    - University of Central Missouri Archives and Museum
- Ohio
    - Oberlin Heritage Center
    - Western Reserve Historical Society
    - Buckeye Furnace
    - The Old House Guild Of Sandusky
    - Fort Meigs
    - Fort Recovery Museum & Monument

    - Hanby House
    - Harriet Beecher Stowe House
    - Hayes Presidential Library & Museums
    - Johnston Farm & Indian Agency
    - Ohio Village
    - Schoenbrunn Village
    - Shaker Historical Museum
    - Historic Zoar Village
- Wisconsin
    - Captain Frederick Pabst Mansion
    - Chippewa Valley Museum
    - Door County Maritime Museum & Lighthouse Preservation Society
    - Kenosha County Historical Society/Kenosha History
    - Outagamie County Historical Society
    - Port Washington Historical Society
    - Rock County Historical Society
    - Washington County Historical Society
- Mountains-Plains Directory
    - Aspen Historical Society
    - Aurora History Museum
    - Aztec Museum & Pioneer Village
    - Barton County Historical Society
    - Buena Vista Heritage
    - Cadoma Foundation
    - Cherokee Strip Regional Heritage Center
    - Chisholm Trail Museum
    - City of Greeley Museums
    - Crosby County Pioneer Memorial Museum
    - Dakotaland Museum
    - Deadwood History, Inc.
    - Estes Park Museum
    - Farmers Branch Historical Park
    - Fort Caspar Museum & Historic Site
    - Fort Gibson Historic Site
    - Fort Towson Historic Site
    - Frisco Historic Park & Museum
    - Gage County Historical Society and Museum
    - George M. Murrell Home/Hunter's Home
    - Georgia O'Keeffe Museum
    - Historic Sites Division - Texas Historical Commission
    - Historical Museum at Fort Missoula
    - Legacy of the Plains Museum
    - Los Alamos Historical Society
    - Mansfield Historical Museum and Heritage Center

    - Meeteetse Museums
    - Moss Mansion Museum
    - Montana Historical Society
    - Museum of The Western Prairie
    - National Mining Hall of Fame and Museum
    - Old Cowtown Museum / City of Wichita
    - Overland Trail Museum
    - Pawnee Bill Ranch and Museum
    - Rice County Historical Society
    - Riley County Historical Museum
    - Royal Gorge Regional Museum
    - Sod House Museum
    - Stanton County Museum
    - Stuhr Museum
    - Tread of Pioneers Museum
    - Chinese Joss House Museum
    - Ute Pass Historical Society & Pikes Peak
    - Wheat Ridge Historical Society
    - Fort Robinson History Center
    - Neligh Mill State Historic Site
    - Senator George Norris State Historic Site
    - Thomas P. Kennard State Historic Site
    - Kansas Historical Society Historic Sites
    - Camp Hancock State Historic Site
    - Chateau de Mores
    - Double Ditch Indian Village, Fort Clark, Huff Indian Village, Menoken Village
    - Former Governors' Mansion State Historic Site
    - Fort Abercrombie State Historic Site
    - Fort Buford State Historic Site
    - Fort Mandan State Historic Site
    - Fort Totten State Historic Site
    - Ronald Reagan Minuteman Missile Site
    - Stutsman County Courthouse State Historic Site
    - Welk Homestead State Historic Site
- Colorado
    - Anasazi Heritage Center
    - Mesa Verde National Park
- New Mexico
    - Taos Pueblo
- Western Museum Directory
    - Angel Island Immigration Station Foundation
    - Cabots Museum Foundation
    - Clackamas County Historical Society

    - Filoli Center
    - Foss Waterway Seaport
    - Minidoka National Historic Site
    - Old Idaho Penitentiary
    - Rock Creek Station/Stricker Homesite
    - Jefferson County Historical Society
    - Kittitas County Historical Museum
    - Leonis Adobe Museum
    - Limon Trail Ride and Heritage Society
    - Pratt Museum
    - Sharlot Hall Museum
    - Talkeetna Historical Society
    - Tempe History Museum
    - Iolani Palace
    - The Gamble House Conservancy
- Arizona
    - Frank Lloyd Wright Foundation
    - Montezuma Castle National Monument
- California
    - Hearst Castle
    - Alcatraz Island
- New Jersey
    - Historic Cold Spring Village
    - The Museum of Cape May County
    - American Labor Museum
    - Barclay Farmstead
    - Cornelius Low House Museum and East Jersey Old Town Village
    - Cranbury Museum
    - Dr. Wm. Robinson Plantation & Museum
    - Historical Society of Haddonfield
    - Smith Richardson History House & Museum
    - James Wilson Marshall House
    - The Jim and Mary Lee Museum
    - Lambert Castle Museum
    - Liberty Hall Museum
    - The Friends of Long Pond Ironworks
    - Macculloch Hall Historical Museum
    - Monmouth County Historical Association Museum & Library
    - Morven Museum & Garden
    - Museum of Early Trades & Crafts
    - Old Barracks Museum
    - The Readington Museums
    - Warren County Division of Cultural & Heritage Affairs
    - The Sterling Hill Mining Museum

    - The Stickley Museum at Craftsman Farms
    - Stoutsburg Sourland African American Museum
    - Tuckerton Seaport & Baymen's Museum
    - Historic Vannest-Hoff-Vannatta Farmstead
    - Atlantic Highlands Historical Society
    - Burlington County Prison Museum Association
    - Gloucester County Historical Society
    - Hopper-Goetschius House Museum
    - Kirby's Mill
    - Merchants & Drovers Tavern Museum
    - Miller-Cory House Museum
    - Rutherfurd Hall
    - Stephen Crane House
- New York
    - Frank Lloyd Wright's Martin House
    - Ganondagan State Historic Site
    - Fenton History Center
    - Dunkirk Historical Lighthouse and Veterans Park Museum
    - Sag Harbor Whaling & Historical Museum
    - Fort William Henry Museum
    - Thomas Cole National Historic Site
    - Bronck Museum
    - Fort Stanwix National Monument
    - Hanford Mills Museum
    - LeRoy Historical Society
    - Vanderbilt Museum
    - Genesee Country Village & Museum
    - Historic Richmond Town
    - Locust Grove Estate
    - The Farmers' Museum
    - Saratoga National Historical Park
    - Seward House Museum
    - Fort Ticonderoga
    - National Susan B. Anthony Museum & House
    - Senate House State Historic Site
    - Tenement Museum
    - Shaker Heritage Society
    - Oheka Castle
    - Chittenango Landing Canal Boat Museum
    - Museum At Eldridge Street
    - Clermont State Historic Site
    - Old Fort Niagara
    - Old Bethpage Village Restoration
    - Ellis Island National Museum of Immigration

- Sagamore Hill National Historic Site
- Old Fort House Museum
- Historic Palmyra
- The 1890 House Museum
- Gracie Mansion Conservancy
- Granger Homestead and Carriage Museum
- Old Fort Johnson
- Shaker Museum
- Gomez Mill House
- Bartow-Pell Mansion Museum
- Old Stone Fort Museum
- Heritage Village
- Foster Cottage Museum
- Merchant's House Museum
- Sodus Bay Historical Society/Sodus Bay Lighthouse Museum
- Morris-Jumel Mansion
- Heritage Square Museum
- Historic Huguenot Street
- Columbia County Historical Society
- Historic Saranac Lake at the Saranac Laboratory Museum
- Buffalo Niagara Heritage Village
- Raynham Hall Museum
- Richardson Bates House Museum
- Constable Hall
- Hart-Cluett House
- Skä•noñh - Great Law of Peace Center
- Van Cortlandt House Museum
- Dyckman Farmhouse Museum
- 1816 Farmington Quaker Meetinghouse Museum
- Alice T. Miner Museum
- Lewis Latimer House Museum
- Preservation Long Island
- Waterford Historical Museum
- Penfield Homestead Museum
- Octagon House of Camillus
- Mount Vernon Hotel Museum & Garden
- Rye Historical Society
- Conference House Association
- Hallockville Museum Farm
- Garibaldi Meucci Museum
- Burden Iron Works Museum
- Matthewis Persen House Museum
- Southampton History Museum
- Huntington Historical Society

    - Rock Hall Museum
    - Fort Klock Historic Restoration
    - Poe Cottage
    - King Manor
    - East Hampton Historical Society
    - John Jay Homestead
- Pennsylvania
    - Eastern State Penitentiary Historic Site
    - Gettysburg National Military Park
    - Independence National Historical Park
    - Valley Forge National Historical Park
- Maryland
    - Fort McHenry National Monument and Historic Shrine
- Washington, D.C.
    - Ford's Theatre
    - White House Historical Association
- Alabama
    - Belle Mont
    - Bellingrath Gardens and Home
    - Blountsville Historical Society
    - Bragg-Mitchell Mansion
    - Condé-Charlotte Museum
    - Jemison-Van de Graaff Mansion
    - Magnolia Grove
    - Old Alabama Town
    - Richards-DAR House Museum
    - Sloss Furnaces
    - St. Stephens Historical Park
    - Historic Tuscaloosa
    - Gorgas House Museum
    - Weeden House Museum
- Arkansas
    - Old State House Museum
    - Historic Washington State Park
    - Bella Vista Historical Museum
    - Historic Cane Hill, Inc.
    - Jacob Wolf House
    - Peel Museum & Botanical Garden
- Florida
    - Alfred B. Maclay Gardens State Park
    - Ann Norton Sculpture Gardens
    - Audubon House & Tropical Gardens
    - Art & History Museums, Maitland

- Black Archives at the Union Bank Building
- Beaches Museum & History Park
- Bok Tower Gardens
- Bonnet House Museum & Gardens
- Cape Coral Museum of History
- Castillo de San Marcos National Monument
- Cedar Key Historical Society Museum
- Cason Cottage Museum
- Colonial Spanish Quarter Museum
- Deering Estate at Cutler
- Crowley Museum and Nature Center
- Edison and Ford Winter Estates
- Flamingo Gardens, Botanical Collection and Everglades Wildlife Sanctuary
- Florida Agricultural Museum
- Gulf Islands National Seashore
- Goodwood Museum and Gardens
- Harry S Truman Little White House
- Heritage Village
- Henry Morrison Flagler Museum
- Historic Homestead Town Hall Museum
- Historic Stranahan House Museum
- Homeland Heritage Park
- History Fort Lauderdale
- House of Refuge Museum at Gilbert's Bar
- Kingsley Plantation, Timucuan Ecological & Historic Preserve
- Knott House Museum
- Loxahatchee River Historical Society
- Manatee Village Historical Park
- Mandarin Museum & Historical Society
- Marie Selby Botanical Gardens – Historic Spanish Point Campus
- Matheson History Museum
- Mound House
- Museums and Nature Center of Crane Point
- Naples Historical Society, Inc.
- Palm Harbor Museum
- Ponce De Leon Inlet Lighthouse
- Port Boca Grande Lighthouse & Museum
- Sample-McDougald House
- Silver River Museum and Environmental Education Center
- St. Augustine Lighthouse & Maritime Museum, Inc.
- Tallahassee Museum
- The Apalachicola Area Historical Society (AAHS)
- The Burroughs Home and Gardens

    - University of West Florida Historic Trust, UWFHT
    - Vizcaya Museum and Gardens
    - Ximenez-Fatio House
    - Woman's Exchange at the Historic Pena-Peck House Museum
- Kentucky
    - Ashland The Henry Clay Estate/Henry Clay Memorial Foundation
    - My Old Kentucky Home
    - Farmington Historic Plantation
    - Historic Locust Grove
    - Jack Jouett House Historic Site c/o Woodford County Heritage Committee
    - Kentucky Department of Parks
    - KMPF Mary Todd Lincoln House
    - Liberty Hall Historic Site
    - McDowell House Museum Inc.
    - South Union Shaker Village
    - Shaker Village of Pleasant Hill
    - Fort Boonesborough State Park
    - Blue Licks Battlefield State Resort Park
    - Old Mulkey Meetinghouse State Historic Site
    - Wickliffe Mounds State Historic Site
    - Waveland State Historic Site
    - Old Fort Harrod State Park
    - General Butler State Resort Park
- Louisiana
    - Destrehan Plantation
    - Evergreen Plantation
    - Hermann-Grima + Gallier Historic Houses
    - Jean Lafitte National Historical Park and Preserve
    - Longue Vue
    - Southdown Plantation House/The Terrebonne Museum
    - Historic BK House
    - LSU Rural Life Museum
    - Port Hudson State Historic Site
    - Rosedown Plantation State Historic Site
    - Larc's Acadian Village
    - St Mary Landmarks Caretaker of Grevemberg House Museum and Shadowlawn
    - Shadows-on-the-Teche
    - Melrose Plantation
    - Poverty Point World Heritage Site
- Mississippi
    - Beauvoir
    - The Grand Village of the Natchez Indians
    - Lapointe-Krebs House and Museum

    - Vicksburg National Military Park
    - Winterville Mounds
- North Carolina
    - Alamance Battleground
    - Charlotte Hawkins Brown Museum
    - City of Raleigh - Historic Resources and Museum Program
    - Classical American Homes Preservation Trust
    - Fuquay-Varina Museums
    - Historic Rosedale Foundation
    - Historic Yates Mill County Park
    - Iredell Museums
    - Kings Mountain Historical Museum
    - Biltmore
    - Tryon Palace
    - Old Salem Museums & Gardens
    - Bennett Place
    - Bentonville Battlefield
    - Brunswick Town / Fort Anderson
    - Duke Homestead
    - Fort Dobbs
    - Fort Fisher
    - Governor Charles B. Aycock Birthplace
    - Historic Bath
    - Historic Edenton
    - Historic Halifax
    - Historic Stagville
    - Horne Creek Farm
    - House in the Horseshoe
    - President James K. Polk
    - Reed Gold Mine
    - Roanoke Island Festival Park
    - Somerset Place
    - Town Creek Indian Mound
    - Vance Birthplace
- South Carolina
    - Fort Sumter and Fort Moultrie National Historical Park
- Virginia
    - George Washington’s Mount Vernon
    - James Madison’s Montpelier
    - James Monroe Museum and Memorial Library
    - Thomas Jefferson’s Monticello
    - Colonial Williamsburg
    - Arlington House, The Robert E. Lee Memorial
    - Henricus Historical Park

    - Clarke County Historical Association
    - New Market Battlefield State Historical Park
    - Aldie Mill Historic Park
    - Dumbarton House
    - Historic Newport News
    - Reynolds Homestead
    - Cape Henry Lighthouse
    - Thoroughgood House
    - Myers House
    - Chippokes State Park
    - Matthews Living History Farm Museum
    - John Marshall House
    - Bacon's Castle
    - Glen Burnie House & Gardens
    - Hunter House Victorian Museum
    - Sully Historic Site
    - Belle Grove Plantation
    - Point of Honor
    - Rippon Lodge Historic Site
    - Wilton House Museum
    - Meadow Farm Museum at Crump Park
    - Salem Museum and Historical Society
    - Red Hill - Patrick Henry Memorial Foundation
    - Historic Smithfield Plantation
    - Lee-Fendall House Museum and Garden
    - Rosewell Plantation Ruins (The Rosewell Foundation)
    - Pamplin Historical Park
    - Historic Jamestowne
    - Thomas Jefferson's Poplar Forest
    - James Monroe's Highland
    - Manassas Museum System
    - Menokin Foundation
- West Virginia
    - Adaland Mansion
    - Appalachian Forest National Heritage Area
    - Arthurdale Heritage
    - Beverly Heritage Center
    - Craik-Patton House
    - Fort Ashby
    - Greenbrier Historical Society & North House Museum
    - Pricketts Fort State Park
    - Trans-Allegheny Lunatic Asylum
- Texas
    - Heritage Farmstead Museum

    - Man House
    - Port Isabel Lighthouse State Historic Site
    - Fulton Mansion State Historic Site
    - Presidio la Bahía State Historic Site
    - Landmark Inn State Historic Site
    - Eisenhower Birthplace State Historic Site
    - Sam Rayburn House State Historic Site
    - Sam Bell Maxey House State Historic Site
    - Starr Family Home State Historic Site
    - Fort Griffin State Historic Site
    - Caddo Mounds State Historic Site
    - Mission Dolores State Historic Site
    - Magoffin Home State Historic Site
    - Fort Lancaster State Historic Site
    - Fort McKavett State Historic Site
    - Washington-on-the-Brazos State Historic Site
    - French Legation State Historic Site
    - Kreische Brewery State Historic Site
    - San Felipe de Austin State Historic Site
    - Casa Navarro State Historic Site
    - Varner-Hogg Plantation State Historic Site
    - Charles and Mary Ann Goodnight Ranch State Historic Site
    - Log Cabin Village
    - The Heritage Society
    - The Alamo
    - Neill-Cochran House Museum
    - Historic Waco
    - George Ranch Historical Park
    - Pioneer Museum
    - Villa Finale Museum And Gardens
    - Klein Historical Foundation
    - San Antonio Missions National Historical Park
- Georgia
    - World War II Home Front Museum
    - Atlanta History Center
    - Martin Luther King, Jr. National Historical Park
    - Owens-Thomas House & Slave Quarters
    - Old Fort Jackson
- Tennessee
    - Cannonsburgh Village
    - Historic Rugby
    - James K. Polk Home and Museum
    - Andrew Jackson’s Hermitage
    - Lotz house

- Vermont
    - Brandon Museum and Visitors Center
    - Ethan Allen Homestead Museum
    - Marsh - Billings - Rockefeller National Historical Park
    - Noyes House
    - Park-McCullough House
    - Old Stone House Museum & Historic Village
    - Billings Farm & Museum
    - Vermont State Historic Sites
    - Hildene, The Lincoln Family Home
- New Hampshire
    - Canterbury Shaker Village
    - Strawbery Banke Museum
    - Castle in the Clouds
    - Rundlet-May House
    - Langdon House
    - Jackson House
    - Gilman Garrison House
    - Barrett House
- Rhode Island
    - Borders Farm Museum
    - Gilbert Stuart Museum
    - Hale House
    - Hearthside House
    - The John Brown House Museum
    - Newport Restoration Foundation
    - Newport Historical Society
    - Lippitt House Museum
    - Preservation Society of Newport County
    - Blackstone River Valley National Historical Park
    - Clemence-Irons House
    - Arnold House
    - Casey Farm
    - Watson Farm
- Massachusetts
    - Old Sturbridge Village
    - House of the Seven Gables
    - Isabella Stewart Gardiner Museum
    - New Bedford Whaling National Historical Park
    - Lowell National Historical Park
    - Historic Deerfield
    - Hammond Castle Museum
    - Storrowton Village Museum
    - Rocky Hill Meeting House

    - Dole-Little House
    - Coffin House
    - Swett-Ilsley House
    - Spencer-Peirce-Little Farm
    - Beauport, the Sleeper-McCann House
    - Cogswell's Grant
    - Gedney House
    - Phillips House
    - Boardman House
    - Cooper-Frost-Austin House
    - Gropius House
    - Codman Estate
    - Lyman Estate
    - Lyman Estate Greenhouses
    - Browne House
    - Otis House
    - Pierce House
    - Eustis Estate Museum
    - Quincy House
    - Winslow Crocker House
    - Merwin House
- Maine
    - Wilson Museum
    - Washburn Norlands Living History Center
    - Woodlawn Museum
    - Jonathan Fisher House
    - Wadsworth-Longfellow House
    - Shaker Museum
    - Nickels-Sortwell House
    - Bowman House
    - Marrett House
    - Sarah Orne Jewett House
    - Hamilton House
    - Sayward-Wheeler House
    - Castle Tucker
- Connecticut
    - Roseland Cottage
    - Avery-Copp House Museum
    - Lebanon Historical Society
    - Bellamy-Ferriday House & Garden
    - Palmer-Warner House
    - Buttolph-Williams House
    - Stonington Historical Society
    - Clinton Historical Society

    - Eric Sloane Museum
    - Henry Whitfield State Museum
    - Prudence Crandall Museum
    - The Hotchkiss-Fyler House Museum
    - Hyland House
    - Ledyard Up-down sawmill
    - Lockwood-Mathews Mansion Museum
    - Mystic Seaport Museum
    - Nathan Hale Homestead
    - Butler-McCook House & Garden
    - Isham-Terry House
    - Phelps-Hatheway House & Garden
    - Nowashe Village
    - Old New-Gate Prison & Copper Mine
    - Osborne Homestead Museum
    - Oliver Ellsworth Homestead
    - The Glass House
    - The Mark Twain House & Museum
- Attempted contact; emails not deliverable
    - Joliet Area Historical Museum
    - Adena Mansion & Gardens
    - Newark Earthworks
    - The Coffey County Historical Museum
    - Bishops' House
    - Township of Ocean Historical Museum
    - Eleanor Roosevelt National Historic Site
    - Phelps Mansion Museum
    - Schenectady County Historical Society
    - Hernando Historical Museum Association, Inc
    - Immokalee Pioneer Museum at Roberts Ranch
    - Marco Island Historical Museum
    - The John and Mable Ringling Museum of Art
    - Laura Plantation
    - The Fauquier History Museum at the Old Jail
    - West Virginia State Farm Museum
    - Levi Jordan Plantation State Historic Site
    - Jourdan-Bachman Pioneer Farms Foundation
    - McFaddin-Ward House
    - Hempsted Houses

Appendix D

First Tier Survey Responses

Key:

- Alternating Green and White correspond to a change in the museum /organization responding
- Red represents a response that was removed from the analysis because it did not fit the criteria of being a 3D digital architectural product or did not correspond to a museum
- Yellow represents a product that was added based on a response from the second tier of the survey
- Blue represents the two responses where the respondent was not shown the whole survey due to a glitch

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of " Other" Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
[Redacted], Virginia	16-30	100,000-250,000	$5M-$14.9M	A 3D model		2020	We have a growing 3D model of the [redacted] Landscape that includes a 3D model of the main house along with about 20 other historic structures on property. This allows the public to experience and explore the landscape from anywhere. It is also used as an access point for our archival records related to each structure. When a structre is clicked on a pop up window appears with all the archive material tagged to it. This allows the public and staff to search for records using visual means instead of a search engine. This also gives the public access to buildings that are typically not physically accessible form the main visitor pathways or provides representations of structures that have been demolished. This landscape is constructed with the use of GIS mapping software combined with 3D models built in either Sketchup or 3DsMax.	Both	Very useful	Very useful	Definitely yes	Combination of in-house and outside company
				A point cloud		2019	We have point cloud models of artifacts for documentation purposes. We also have point clouds of archaeological excavation units. This is used to allow the public to view certain items in our collection anytime from anywhere. The point clouds of the excavation units allow for staff and the public to further study or investigate the units after the site have been refilled.	Both	Very useful	Very useful	Probably yes	In-house
				Drone footage or other immersive, digital experience		2016	We have drone footage to get arial views of the property. We also have LIDAR scans of the property to help identify road traces, fields, and buildings.	Both	Very useful	Very useful	Probably yes	Combination of in-house and outside company
[Redacted], Virginia	More than 200	Over 250,000	$1,000,000-$2.9M	A 3D model		2011	We use 3D models to show how a building used to look or how it will look. These spaces can be virtual reconstructions, areas that exist, but for safety reasons are not accessible to the public, etc.	Both	Extremely useful	Extremely useful	Definitely yes	In-house
				A 3d virtual tour		2023	We can document the build as it stands today, and then scan it again several months later to show progress.	Both	Extremely useful	Extremely useful	Definitely yes	In-house

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of " Other" Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
[Redacted], Indiana	6-15	25,000-99,999	$1,000,000-$2.9M	A 3D model		2015	We have extensive 3D modeling of collection and details of architectural features of the historic structure.	Both	Extremely useful	Very useful	Definitely yes	Combination of in-house and outside company
				A point cloud		2017	It is a 3D scan of the house structure made to assist with school programs with the [redacted] as well as other visitors.	Both	Extremely useful	Extremely useful	Definitely yes	Outside company
				A photogrammetric model		2017	See also the point cloud information - used photogrammetry to create the 3D model of the house.	Both	Extremely useful	Extremely useful	Definitely yes	Outside company
				A virtual and/or augmented reality experience		2016	To provide the widest public access to the museum without boundaries or limitations. It both augmented and virtually projects through [redacted]. There are over a dozen student partnership projects.	Both	Extremely useful	Extremely useful	Definitely yes	Outside company
				Drone footage or other immersive, digital experience		2017	Drone footage of the house to make a 3D model. See point cloud information again.	Both	Extremely useful	Extremely useful	Definitely yes	Outside company
[Redacted], Wyoming, USA	0-5	5,000-9,999	$350,000 and under	A 3D model		2016	3D model of an extinct bison in our virtual exhibit. visualization of similarities to modern bison	Interpretation (public or visitor facing)	Moderately useful		Probably yes	Outside company
[Redacted], AZ and [Redacted], WI	71-100	100,000-250,000	$5M-$14.9M	A 3D model		2018	Matterport model allowing people who can not access the site, an opportunity to explore it.	Both	Very useful	Very useful	Probably yes	Outside company
				Drone footage or other immersive, digital experience		continu-ously	Marketing	Interpretation (public or visitor facing)	Extremely useful		Definitely yes	Outside company
				A point cloud				Staff (museum personnel facing)				Outside company
				A Building Information Model (BIM)				Staff (museum personnel facing)				Outside company

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of "Other" Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
[Redacted], Virginia	31-50	10,000-24,999	$1,000,000-$2.9M	A 3d virtual tour (e.g. Matterport)		2020	3-D virtual tours of exhibition spaces at [redacted] and the [redacted]. The tours were originally created as an alternative means of interpretation during closures caused by the COVID-19 pandemic.	Interpretation (public or visitor facing)	Very useful		Definitely yes	Outside company
				Other (please specify)	Archived recordings of public programs.	2020	Also in response to the pandemic, [redacted] utilized online programs exclusively for approximately one year before reopening sites to the public. Virtual content remains an important part of the museums' public programs.	Interpretation (public or visitor facing)	Extremely useful		Definitely yes	In-house
[Redacted], MA	101-150	100,000-250,000	$1,000,000-$2.9M	A 3d virtual tour (e.g. Matterport)		2020	The virtual tour was created during Covid when students could not visit the village and visitors to the museum could not enter the buildings.	Interpretation (public or visitor facing)	Very useful		Definitely yes	Combination of in-house and outside company
NY	0-5	5,000-9,999	$350,000 and under	A 3d virtual tour (e.g. Matterport)		2023	It creates an accessible experience for the duration of the closure of the museum. The museum will be closing in 2024 for a capital project that will make the site ADA compliant	Interpretation (public or visitor facing)	Moderately useful		Probably not	Outside company
[Redacted] NY	0-5	2,000-4,999	$350,000 and under	A 3d virtual tour (e.g. Matterport)		2023	Allows people to see our second and third floors that are not accessible to them.	Both	Extremely useful	Very useful	Definitely yes	In-house
[Redacted], FL	16-30	100,000-250,000	$1,000,000-$2.9M	A 3d virtual tour (e.g. Matterport)		2020	We use the virtual tours for a wide range of purposes: documentation, ADA access, when buildings are closed for repairs/renovation, and for people not able to visit the site.	Both	Very useful	Very useful	Definitely yes	In-house
[Redacted], RI	6-15	25,000-99,999	$1,000,000-$2.9M	A 3d virtual tour (e.g. Matterport)		2019	A Matterport 3D model of the [redacted]. Provides a walk-through of the museum space, as well as some of the interpretive text on display.	Interpretation (public or visitor facing)	Moderately useful		Probably not	Outside company
[Redacted], Virginia	6-15	100,000-250,000	$350,000 and under	A 3d virtual tour (e.g. Matterport)		2022	To make our sites more accessible.	Both	Very useful	Extremely useful	Definitely yes	In-house
[Redacted], TX	0-5	5,000-9,999	$350,000-$499,999	A 3d virtual tour (e.g. Matterport)		2020	The 360 tour was created during COVID when we were closed, in order to continue to connect with the public. We then adapted it to a stable, permanent tour after COVID, in particular for visitors who are unable to navigate stairs to our second floor.	Interpretation (public or visitor facing)	Very useful		Probably yes	Outside company
				A virtual and/or augmented reality experience		2023	VR school curriculum to connect students to our site and to the history of [redacted]	Interpretation (public or visitor facing)	Very useful		Probably yes	Outside company

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of "Other" Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
[Redacted], Indiana	0-5	5,000-9,999	$350,000 and under	A 3d virtual tour (e.g. Matterport)		2022	It's a virtual tour so that people can visit the site without being in [redacted]. It is a one-of-a-kind site and we wanted to share it with the world!	Both	Extremely useful	Very useful	Definitely yes	Combination of in-house and outside company
[Redacted], NY	0-5	10,000-24,999	$350,000-$499,999	A 3d virtual tour (e.g. Matterport)		2023	Map view of property in 1838, featuring both extant and razed buildings	Interpretation (public or visitor facing)	Moderately useful		Might or might not	Outside company
				A point cloud		2019	documentation of extant building interior	Staff (museum personnel facing)		Not at all useful	Might or might not	Outside company
				A 3D model								Outside company
All over New England, from Maine to Rhode Island	71-100	100,000-250,000	$5M-$14.9M	A 3d virtual tour (e.g. Matterport)		2020	Originally it was to provide access to our sites during COVID and now provides access for people who live too far away to visit or cannot navigate the many physical impediments at our sites like stairs, thresholds, and narrow doorways.	Interpretation (public or visitor facing)	Extremely useful		Definitely yes	In-house
				Drone footage or other immersive, digital experience		2020	New perspectives on our sites	Interpretation (public or visitor facing)	Extremely useful		Definitely yes	Outside company
				Other (please specify)	Web apps that include audio, video, flythroughs, 360 tours, etc.	2017	To provide a self-guided, deep dive into a historic site	Interpretation (public or visitor facing)	Extremely useful		Definitely yes	Combination of in-house and outside company
[Redacted], Connecticut	16-30	25,000-99,999	$1,000,000-$2.9M	A 3d virtual tour (e.g. Matterport)								
[Redacted], VA	6-15	5,000-9,999	$1,000,000-$2.9M	A 3d virtual tour (e.g. Matterport)		2021	To offer visitors with mobility issues a chance to see the outbuildings at the site and the second story of the main house.	Interpretation (public or visitor facing)	Very useful		Definitely yes	Outside company
				A virtual and/or augmented reality experience		2020	To bring history to life in our historic slave quarter and to bridge the gap between our past (history) and today with the use of technology.	Interpretation (public or visitor facing)	Moderately useful		Probably yes	Outside company

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of " Other" Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
[Redacted], Connecticut	0-5	500-1,999	$500,000-$999,999	A 3d virtual tour (e.g. Matterport)		2019	The [redacted] closed in late 2019 for a significant restoration process that lasted 2 years. The 3D tour served to capture the museum pre-restoration, provide accessibility to second-floor exhibits, and offer interpretation opportunites while the building was undergoing restoration.	Both	Extremely useful	Extremely useful	Definitely yes	Outside company
				Drone footage or other immersive, digital experience		2019	same as above	Both	Extremely useful	Extremely useful	Definitely yes	Outside company
[Redacted], New York	0-5	25,000-99,999	$350,000 and under	A 3d virtual tour (e.g. Matterport)		2023	The intent of the project was for it to be used in developing design options for a solution to our museum building's accessibility issues. This will likely include an annex to the current building.	Staff (museum personnel facing)		Very useful	Probably yes	Outside company
[Redacted], Iowa	6-15	5,000-9,999	$1,000,000-$2.9M	A 3d virtual tour (e.g. Matterport)		2019	Online access to gallery installations and historic building tours. This is an ongoing program, with new 3D Matterport tours created as exhibitions change. virtual tours remain accessible on the website.	Interpretation (public or visitor facing)	Moderately useful		Probably yes	Outside company
				Drone footage or other immersive, digital experience		2022	Landscape views of our 35-acre campus	Interpretation (public or visitor facing)	Moderately useful		Probably yes	In-house
[Redacted], CT	0-5	5,000-9,999	$500,000-$999,999	A 3d virtual tour (e.g. Matterport)		2019	It serves to promote a capital campaign with a three dimensional tour of the site.	Interpretation (public or visitor facing)	Slightly useful		Probably yes	Outside company
[Redacted], Illinois	0-5	2,000-4,999	$500,000-$999,999	A 3d virtual tour (e.g. Matterport)		2019	To offer people the opportunity to see the interior of the building on their own instead of a docent led tour.	Interpretation (public or visitor facing)	Very useful		Might or might not	Outside company
[Redacted], Maine	16-30	10,000-24,999	$1,000,000-$2.9M	A 3d virtual tour (e.g. Matterport)		2022	Walk through of our physical exhibitions. We have three of these. Started in 2020 for those that couldn't visit the museum.	Interpretation (public or visitor facing)	Moderately useful		Definitely yes	Outside company
[Redacted], MA	6-15	10,000-24,999	$1,000,000-$2.9M	A 3d virtual tour (e.g. Matterport)		2023	Interpretation of a park foundational resource	Both	Moderately useful	Moderately useful	Definitely yes	Combination of in-house and outside company
				A virtual and/or augmented reality experience				Interpretation (public or visitor facing)				

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of "Other" Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
[Redacted], IL	0-5	Less than 500	$350,000 and under	A 3d virtual tour (e.g. Matterport)		2023	Offers a tour of the museums online for people who can't make it in.	Interpretation (public or visitor facing)	Moderately useful		Might or might not	Combination of in-house and outside company
[Redacted], VA	151-200	Over 250,000	$15m and over	A Building Information Model (BIM)		2014	It is used to manage care of our 18th-century dwelling	Both	Slightly useful	Very useful	Definitely yes	Combination of in-house and outside company
				A photogrammetric model		2021	To record archaeological features.	Both	Very useful	Very useful	Definitely yes	In-house
				Other (please specify)	360-degree virtual tour	2017	Website experience	Both	Extremely useful	Very useful	Definitely yes	In-house
				A point cloud				Staff (museum personnel facing)				
[Redacted], NY	6-15	500-1,999	$1,000,000-$2.9M	A photogram-metric model		2023	To assist in the interpretation of historic house sites and exhibitions	Both	Very useful	Slightly useful	Definitely yes	In-house
[Redacted], Virginia	0-5	2,000-4,999	$350,000 and under	A photogram-metric model		2020	It provides a view of the regular exhibit spaces as well as documents the state of the museum at that particular point in time.	Both	Very useful	Extremely useful	Definitely yes	In-house
[Redacted], Florida	31-50	100,000-250,000	$1,000,000-$2.9M	A photogram-metric model		2020	It is a photomodel of a shipwreck that was used for further analysis and to see changes to the wreck as it remained open to the elements.	Both	Extremely useful	Moderately useful	Definitely yes	In-house
				A photogram-metric model		2016	Photomodel of an artifact that is still in conservation. Allows for people to see what the artifact looks like while the physical artifact is unable to be on display.	Interpretation (public or visitor facing)	Extremely useful		Definitely yes	In-house

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of " Other" Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
[Redacted], Massachusetts	6-15	25,000-99,999	$500,000-$999,999	A photogram-metric model		2021	We have several 3D models (and plans for more) created for different purposes, including recreation of lost features, visualization of inaccessible areas, digital preservation of artifacts, multimedia use, and merchandise to raise funds for the museum.	Both	Extremely useful	Very useful	Definitely yes	In-house
				A point cloud		2021	The point clouds are used for the purposes of creating full 3D meshes for the same functions as previously listed.	Staff (museum personnel facing)		Extremely useful	Definitely yes	In-house
				A 3D model		2021	Beyond 3D scans and photogrammetric models, we also use custom-made 3D models to help visualize complex topics such as examples of historical technologies, educational videos, merchandise, and for exhibit models.	Both	Extremely useful	Extremely useful	Definitely yes	In-house
				Drone footage or other immersive, digital experience		2023	Primarily for the capture of the building for the purposes of digital recreation for videos and 3D printing for models.	Both	Moderately useful	Moderately useful	Definitely yes	Combination of in-house and outside company
Louisiana	6-15	Less than 500	$1,000,000-$2.9M	A point cloud		2019	To document the condition and design of the building to educate the public and create drawings if the building is lost.	Both	Extremely useful	Extremely useful	Definitely yes	In-house
				Other (please specify)	3D Models, 3D Virtual Tours, Augmented reality tours, fly through videos of 3D products.	2020	To document the condition and design of the building to educate the public and create drawings if the building is lost.	Both	Extremely useful	Extremely useful	Definitely yes	In-house

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of "Other" Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
[Redacted], Virginia	151-200	Over 250,000	$5M-$14.9M	A point cloud		2020	We have multiple point clouds of artifacts, used to replicate them for display in outdoor settings. We also have a comprehensive point cloud of the entire site (interior and exterior), which we hope to use for the creation of up to date 2D drawings as well as an HBIM, but those have not been created yet.	Both	Very useful	Moderately useful	Probably yes	Combination of in-house and outside company
				Drone footage or other immersive, digital experience		2020	Panoramic drone footage for marketing	Interpretation (public or visitor facing)	Very useful		Probably yes	In-house
				A Building Information Model (BIM)		2024	To be able to visually interpret (for staff and visitors) what architectural features date to what period. Potentially also to house documentation for specific architectural features, but we aren't sure yet whether we will do that!	Both	Moderately useful	Moderately useful	Might or might not	Outside company
[Redacted], Mi	More than 200	Over 250,000	$15m and over	A point cloud		2023	Record keeping of large scale artifact	Both	Moderately useful	Moderately useful	Probably yes	Combination of in-house and outside company
				A virtual and/or augmented reality experience		2019	offers more interpretation of an object	Interpretation (public or visitor facing)	Moderately useful		Probably yes	Outside company
[Redacted], ND	0-5	500-1,999	$350,000 and under	A virtual and/or augmented reality experience		2021	It allows for school groups to tour our building. Secondary is access for physically challenged.	Interpretation (public or visitor facing)	Moderately useful		Probably yes	In-house
				Other (please specify)	digital photos	2023	construction of an elevator	Both	Moderately useful	Moderately useful	Probably yes	In-house
[Redacted], VA	0-5	25,000-99,999	$350,000-$499,999	A virtual and/or augmented reality experience		2021	ADA tablet to provides visitors to see areas of the site that are not as accessible (ie. 2nd floor exhibits and buildings that visitors may have to talk far to visit)/	Interpretation (public or visitor facing)	Very useful		Probably yes	Combination of in-house and outside company
				Other (please specify)	YouTube Videos	2020	To provide virtual tours and virtual content.	Interpretation (public or visitor facing)	Moderately useful		Might or might not	In-house
[Redacted], Virginia	0-5	5,000-9,999	$350,000 and under	A virtual and/or augmented reality experience								

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of “ Other” Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
[Redacted], NY	6-15	25,000-99,999	$350,000-$499,999	A virtual and/or augmented reality experience		2021	Recreate a battle	Interpretation (public or visitor facing)	Moderately useful		Probably not	Outside company
[Redacted], Nebraska	16-30	25,000-99,999	$1,000,000-$2.9M	A virtual and/or augmented reality experience		2023	An interactive map was first created on the program Thing Link for our education department in order to provide information about the historic structures on our campus to classroom teachers during self-guided field trips. Recently we decided to modify that map to use as past of the Living history portion of the museum during the off season, when it is not staffed. This allows visitors to still get a glimpse into the history of the sites when we are unable to provide a historical interpreter (tour guide). We made this available to the public through a QR code that is located to the entrances of the historic area. When scanned, it opens an interactive map where visitors can click on images of all our sites, pulling up additional information specific to that site. Currently this QR code is available in English, but can be translated to other languages within the map. We are currently in the process of testing and editing a Spanish version of the QR code, which would be available in the same way the English version is now and allow our grounds to become more accessible to the visitors coming through.	Both	Very useful	Moderately useful	Definitely yes	Combination of in-house and outside company
[Redacted], IL	0-5	10,000-24,999	$500,000-$999,999	Drone footage or other immersive, digital experience		2022	Drone footage/photography provides us with a more comprehensive way to document the built environment of the city of [redacted].	Both	Extremely useful	Extremely useful	Definitely yes	In-house
[Redacted], Wisconsin	6-15	25,000-99,999	$350,000-$499,999	Drone footage or other immersive, digital experience		2019	It is an interactive drone-based map of the area with points that can be tapped to access more information about that area or structure	Interpretation (public or visitor facing)	Very useful		Definitely yes	Outside company
				A virtual and/or augmented reality experience		2023	It is a boating safety simulator in order to teach about different skills used while safely operating a motorized vessel	Interpretation (public or visitor facing)	Extremely useful		Definitely yes	Outside company
				A 3D model		2023	A 3D model of each gallery used in exhibition design	Staff (museum personnel facing)		Extremely useful	Definitely yes	In-house
				Other (please specify)	Interactive quizzes and screens	2019	They are used to enhance visitor perceptions of the information put forward in an exhibition. these are usually used to access different information, quiz the visitor, or keep them engaged	Interpretation (public or visitor facing)	Very useful		Probably yes	Outside company

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of "Other" Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
[Redacted], SC; [Redacted], SC; [Redacted], NC; [Redacted], NY; [Redacted], NY	6-15	500-1,999	$5M-$14.9M	Drone footage or other immersive, digital experience		2023	The panoramic photo model helps put the built environment in context to the topographic features of the site and also identifies locations of previously existing support structures, including winter kitchens and potential domiciles for sharecroppers and enslaved individuals.	Both	Very useful	Extremely useful	Definitely yes	Combination of in-house and outside company
[Redacted], NY	0-5	500-1,999	$350,000 and under	Drone footage or other immersive, digital experience		2023	eyecatcher on website homepage	Interpretation (public or visitor facing)	Moderately useful		Probably yes	In-house
[Redacted], KY	0-5	10,000-24,999	$500,000-$999,999	Drone footage or other immersive, digital experience		2021	We have several drone shots/fottage of the estate that we use as B roll/filler/background or other footage in various projects.	Both	Moderately useful	Very useful	Might or might not	Outside company
[Redacted], Connecticut	0-5	10,000-24,999	$350,000 and under	Drone footage or other immersive, digital experience		2018	access the site remotely. Provide access to the copper mine for people who can't physically visit.	Interpretation (public or visitor facing)	Very useful		Definitely yes	Outside company
[Redacted], CT	0-5	10,000-24,999	$350,000-$499,999	Drone footage or other immersive, digital experience		2020	Provides web access to the regular house tour, and drone footage of the property and surrounding area	Both	Moderately useful	Very useful	Probably yes	Combination of in-house and outside company
				Other (please specify)	we have 38 sites, most of which have the same digital resources that [redacted] has	2020-23	regular tours	Both	Moderately useful	Extremely useful	Probably yes	In-house
[Redacted], IL	0-5	500-1,999	$350,000 and under	Drone footage or other immersive, digital experience		2022	Visualization of [redacted]'s Oldest House	Both	Moderately useful	Moderately useful	Definitely yes	Combination of in-house and outside company
				Other (please specify)	Videos	2023	Videos of featured speakers	Both	Very useful	Moderately useful	Definitely yes	Combination of in-house and outside company

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of "Other" Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
New Jersey	0-5	2,000-4,999	$500,000-$999,999	Drone footage or other immersive, digital experience		2022	Digital access; Visualization of space not normally accessible;	Interpretation (public or visitor facing)	Very useful		Definitely yes	Combination of in-house and outside company
[Redacted], North Carolina	0-5	2,000-4,999	$350,000 and under	Drone footage or other immersive, digital experience		2021	We have drone footage showing aerial views of the house and grounds for interpretive and educational purposes.	Both	Moderately useful	Moderately useful	Might or might not	Outside company
[Redacted], [Redacted], [Redacted], New York	16-30	25,000-99,999	$3M-$4.9M	None of the above								
[Redacted], NY	16-30	25,000-99,999	$1,000,000-$2.9M	None of the above								
[Redacted], FL	0-5	2,000-4,999	$350,000 and under	None of the above								
[Redacted], AL	0-5	500-1,999	$350,000 and under	None of the above								
[Redacted], New Jersey	0-5	2,000-4,999	$350,000 and under	None of the above								
New York	31-50	25,000-99,999	$3M-$4.9M	None of the above								
[Redacted], WV	0-5	2,000-4,999	$350,000 and under	None of the above								
[Redacted], NC	0-5	10,000-24,999		None of the above								
[Redacted], TX	0-5	10,000-24,999	$500,000-$999,999	None of the above								
[Redacted], Maine	0-5	5,000-9,999	$500,000-$999,999	None of the above								
[Redacted], Texas	0-5	2,000-4,999	$350,000 and under	None of the above								
[Redacted], Virginia (within [redacted])	0-5	500-1,999	$350,000 and under	None of the above								

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of " Other" Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
[Redacted], NY	0-5	5,000-9,999	$350,000-$499,999	None of the above								
[Redacted], NY	0-5	2,000-4,999	$350,000 and under	None of the above								
[Redacted], Missouri (redacted)	0-5	5,000-9,999	$350,000 and under	None of the above								
[Redacted], Arkansas	6-15	25,000-99,999	$1,000,000-$2.9M	None of the above								
[Redacted], LA	16-30	25,000-99,999	$1,000,000-$2.9M	None of the above								
[Redacted], Virginia	0-5	2,000-4,999	$500,000-$999,999	None of the above								
[Redacted], co	6-15	Unsure	$1,000,000-$2.9M	None of the above								
[Redacted] CT	0-5	5,000-9,999	$350,000 and under	None of the above								
[Redacted], West Virginia	0-5	500-1,999	$350,000 and under	None of the above								
[Redacted], FL	6-15	25,000-99,999	$1,000,000-$2.9M	None of the above								
[Redacted], Alabama	6-15	25,000-99,999	$350,000-$499,999	None of the above								
[Redacted], [Redacted], NJ [Redacted]	0-5	Less than 500	$350,000 and under	None of the above								
[Redacted] Illinois	0-5	5,000-9,999	$350,000 and under	None of the above								
[Redacted], Kentucky	0-5	500-1,999	$350,000 and under	None of the above								
[Redacted], Louisiana	0-5	5,000-9,999	$350,000 and under	None of the above								
[Redacted], Ohio	0-5	500-1,999	$350,000 and under	None of the above								

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of " Other" Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
[Redacted], Nebraska	0-5	500-1,999	$350,000 and under	None of the above								
[Redacted], ME	0-5	Less than 500	$350,000 and under	None of the above								
[Redacted], Mississippi	0-5	Unsure		None of the above								
[Redacted], FL	0-5	2,000-4,999	$350,000 and under	None of the above								
[Redacted], NJ	0-5	Less than 500	$350,000 and under	None of the above								
[Redacted] NY	0-5	500-1,999	$350,000 and under	None of the above								
[Redacted], Missouri	Unsure	Unsure		None of the above								
[Redacted], NM	Unsure	Unsure		None of the above								
[Redacted], South Dakota	Unsure	Unsure		None of the above								
[Redacted], OK	Unsure	Unsure		None of the above								
[Redacted], CO	Unsure	Unsure		None of the above								
[Redacted], NJ	Unsure	Unsure		None of the above								
[Redacted], NJ	Unsure	Unsure		None of the above								
[Redacted], NY	Unsure	Unsure		None of the above								
[Redacted], NY	Unsure	Unsure		None of the above								
[Redacted], NY	Unsure	Unsure		None of the above								
[Redacted], FL	Unsure	Unsure		None of the above								
[Redacted], FL	0-5	Unsure		None of the above								

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of " Other" Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
[Redacted], Kentucky	Unsure	Unsure		None of the above								
[Redacted], Kentucky	Unsure	Unsure		None of the above								
[Redacted], Kentucky	0-5	Less than 500		None of the above								
[Redacted], LA	Unsure	Unsure		None of the above								
[Redacted], NC	Unsure	Unsure		None of the above								
[Redacted], NC	Unsure	Unsure		None of the above								
[Redacted], VA	Unsure	Unsure		None of the above								
[Redacted], VA	Unsure	Unsure		None of the above								
[Redacted], TX	Unsure	Unsure		None of the above								
[Redacted], VT	Unsure	Unsure		None of the above								
[Redacted], CT	Unsure	Unsure		None of the above								
[Redacted], Illinois	0-5	10,000-24,999	$500,000-$999,999	Other (please specify)	touch table with maps of city	2000	Drone- to help capture footage of city in order help understand the changing landscape over the years. BIM-Sketch Up- help with exhibition layout and design. Touch table takes mosaics of historic maps and shows their evolution over time from 1880 to 2021.	Both	Very useful	Very useful	Probably yes	Outside company
				Other (please specify)	Touch screens	2010	It has a touch screen for our guests to interactive in videos, activities, quizes within the exhibition space.	Interpretation (public or visitor facing)	Extremely useful		Definitely yes	Outside company
[Redacted], Colorado	0-5	25,000-99,999	$350,000 and under	Other (please specify)	Clio tour, Storymaps	2023	Visualization of a space that is only accessible during operating hours	Interpretation (public or visitor facing)	Very useful		Definitely yes	In-house
				A 3D model		2022	Assists with design of exhibits inside historic cabins, houses, and structures	Staff (museum personnel facing)		Very useful	Definitely yes	In-house

State	No. of Full-Time Staff	Annual Visitation	Annual Budget	3D Digital Product	Description of "Other" Product	Date of Creation	Description of Product	Interpretation, Staff, or Both Purposes?	Usefulness of Interpretive Products	Usefulness of Staff-facing Products	Likelihood of Reinvesting in Product	In-House, Outside Company, or Combination
[Redacted], NJ, USA	0-5	Less than 500	$350,000 and under	Other (please specify)	We created a digitally enhanced walking tour in 2023. Not 3D, but uses QR codes to link to archive photos/info on our website	2023	Our archives are not easily accessible by the public, so this simple signage program using 20 signposts with QR codes in the historic district allows visitors to see streetscapes and buildings/house imagery from our archives while standing in the exact modern-day location—a striking then-and-now experience.	Interpretation (public or visitor facing)	Very useful		Definitely yes	In-house
[Redacted], VT	0-5	5,000-9,999	$350,000 and under	Other (please specify)	2D virtual tours	2019	Offer access to people unable to physically visit the site	Interpretation (public or visitor facing)	Slightly useful		Probably not	In-house
[Redacted], TX	0-5	2,000-4,999	$350,000-$499,999	Other (please specify)	Online Exhibit	2019	It is a short online exhibit discussing kitchens in historic homes.	Interpretation (public or visitor facing)	Slightly useful		Probably not	In-house
[Redacted], PA	151-200	Over 250,000	$3M-$4.9M	Other (please specify)	A digital interactive of Benjamin Franklin's home.	2012	It recreates a lost building.	Interpretation (public or visitor facing)	Very useful		Might or might not	Outside company
				Other (please specify)	Touchscreen interactives	2012	One is Oregon Trail like game, one is a virtual glass armonica that visitors can play, one is a virtual printing press, and the other four are exploratory interactives. We also have touchscreens used for accessibility purposes.	Interpretation (public or visitor facing)	Very useful		Might or might not	Outside company
				Other (please specify)	Interactive touchscreens	2022 and 2023	Allows visitors to pick different video interviews to watch and to further dive deeply into various topics.	Interpretation (public or visitor facing)	Very useful		Might or might not	In-house
[Redacted], CA	0-5	10,000-24,999	$350,000 and under	A 3d virtual tour (e.g. Matterport)	We have a virtual tour with Matterport, but have not been able to use it.	2021	It was created so people could tour the museum when they could not attend in person. This was created when [redacted] was a various stages of lock-down during the pandemic.	Interpretation (public or visitor facing)	Moderately useful		Probably yes	Outside company
New Jersey	0-5	2,000-4,999	$350,000 and under	Drone footage or other immersive, digital experience		2022	The only digital product we have is a video "walk through" of the upper floors, which is available for viewing on a ground-floor monitor. The purpose of this footage is to show the upper floors of a historic building to people who cannot climb stairs. It is not immersive. It was made for us by a local real estate agent, who donated the service (it was done by a company that does these sorts of "walk-through" videos for homes shown on real estate websites.)	Interpretation (public or visitor facing)	Moderately useful		Definitely yes	Outside company

Appendix E

Second Tier Survey Responses

Key:

- Alternating Green and White correspond to a change in the respondent
- Red represents a response that was removed from the analysis because it did not fit the criteria of being a 3D digital architectural product or did not correspond to a museum
- Yellow represents a product that was added to the first tier from the second tier data
- Blue represents a product that does not correspond to a digital product counted in the analysis of data collected in the first tier of the survey; these responses were removed from the analysis of the second tier data, but were used to add additional contextual information in the analysis

Highest Level of Education Completed	Program of Study	Description of “Other” Program of Study	3D Digital Product	Description of “Other” Product	Description of Product	Interpretation, Staff, or Both Purposes?	Was the Product Used as Intended?	If Not, Why Not?	Software Used to Create Product	Where the Software Was Learned	Description of “Other” Location the Software was Learned
Graduate degree	Historic preservation, Other (please specify)	Architectural Design & Build	A 3D model		I digitally recreated buildings to how they would have looked in 1776. Some of the buildings are still standing, but were modified in later years. Some of the buildings were lost over time, and with the help of architectural research and archaeology, I could recreate them digitally.	Both	Yes		AutoCAD, 3ds Max (with v-ray for rendering), Unity	Undergraduate core class, Other (please specify)	On the job training
Graduate degree	Historic preservation, Other (please specify)	Building Science	A 3D model		We make 3D models for use to site visitors as a handicap accessible alternative or when the site is closed.	Both	Yes		Fara Scene, Revit, Bently Tools.	Other (please specify)	Manufactor training and YouTube
			A 3d virtual tour		For virtual visitors to the site.	Interpretation (public or visitor facing)	Yes		Matterport	Other (please specify)	YouTube
			A point cloud		To create a virtual model and CAD drawings of a site that was demolished.	Staff (museum personnel facing)	Yes		AutoCAD, Revit, Leica Capture	Undergraduate core class, Other (please specify)	Manuf workshop

Highest Level of Education Completed	Program of Study	Description of " Other" Program of Study	3D Digital Product	Description of " Other" Product	Description of Product	Interpretation, Staff, or Both Purposes?	Was the Product Used as Intended?	If Not, Why Not?	Software Used to Create Product	Where the Software Was Learned	Description of " Other" Location the Software was Learned
Some undergraduate coursework	Art history, Other (please specify)	Philosophy	Other (please specify)	Interactive touch table map	Visitors approach this touch table, titled "Explore [redacted] through Time and Space," and tap to invoke their own 9" (roughly) round viewport. Using the viewport, which they can move anywhere on the table, they may explore an underlying map of this [redacted] city in space, discovering pins as they go which can be tapped to pull up historic photos and captions at the exact place where the images were captured. At the same time, visitors may also explore through time, using a dial to choose any decade back to the 1850s. As they change decades, both the city's border annexations and the selection of deeper-dive content pins update to reflect that choice, allowing exploration through time. As it happens, we are currently working (for delivery THIS Monday–how's that for a coincidence!) with [redacted] to update this 2014 project with newer data, content and current technology. We are completely revising the experience, reframing the entire piece as a single-user, docent led experience. We are a little wistful about abandoning the multi-user, open-ended exploration model originally built for a general museum visitor, but this revised, docent-led approach matches the museum's current attendance patterns. We are doing the new app in Unity, as opposed to the original AIR app, and also developing a custom Content Management System so that museum staff can make content updates through time without needing to approach us.	Interpretation (public or visitor facing)	Yes		As noted on the prior page, the original program was developed in AIR, and the new version is Unity. The new CMS is custom-programmed and hosted on our web servers.	Undergraduate core class, Post-graduation professional development (self-sponsored), Other (please specify)	Apart from a couple of basic undergrad courses, all of our developers are primarily self-taught, since very little of this existed when we were in school.
			A virtual and/or augmented reality experience		This touch table allows visitors to choose from a number of T.Rex and Triceratops attributes, such as size, color, etc., then watch a battle. Positioned adjacent to a fossil display of the two animals, it was designed to help visitors envision what the landscape of Cretaceous [redacted] looked like.	Interpretation (public or visitor facing)	Yes		Unity, 3DS	Undergraduate core class, Post-graduation professional development (self-sponsored), Other (please specify)	Same answer as before

Highest Level of Education Completed	Program of Study	Description of " Other" Program of Study	3D Digital Product	Description of " Other" Product	Description of Product	Interpretation, Staff, or Both Purposes?	Was the Product Used as Intended?	If Not, Why Not?	Software Used to Create Product	Where the Software Was Learned	Description of " Other" Location the Software was Learned
			Other (please specify)	Many, many others over 15 to 20 years	Hopefully this general answer doesn't break your survey, but I have a general point about tech and museums. Looking back over 25 years, as museums have brought more and more digital technology into exhibition spaces, the most successful projects are ones that don't rush headlong into a new technology just because it's exciting to its producers and practitioners. There's nothing at all wrong with fun new techniques–and they can work great–but it's very important to carefully consider how a digital project aligns with the exhibit's content, visitor demographics, intended dwell time, the surrounding content and experiences and of course, resources the institution has to work with, including staffing. For example, this is anecdotal, but we've had three separate projects over the past 18 months in which we helped institutions remove VR headsets as they refreshed certain visitor experiences. In every case, there was excitement around VR initially, but the spaces were choke points, or led to increased staffing to help visitors with the tech, or suffered a lot of equipment failures. In two cases, we re-used the 3D source footage to create multi-visitor, in-the-round projected theaters that don't suffer from the need to provide staff facilitation and are far more accessible. Our point of view is biased by the majority of our work being visitor-facing exhibits, and of course, there are always great uses of cutting-edge techniques in facilitated or educational spaces within museums. Out on the floor, however, especially in high volume museums, it's critical to keep a comprehensive list of criteria in mind when choosing how to use tech in museum storytelling.	Interpretation (public or visitor facing)	Yes		(sorry for breaking your format!)	Other (please specify)	(sorry for breaking your format!)

Highest Level of Education Completed	Program of Study	Description of "Other" Program of Study	3D Digital Product	Description of "Other" Product	Description of Product	Interpretation, Staff, or Both Purposes?	Was the Product Used as Intended?	If Not, Why Not?	Software Used to Create Product	Where the Software Was Learned	Description of "Other" Location the Software was Learned
Some graduate school coursework	Other (please specify)	Architect	A point cloud		Lidar point cloud and Revit model of historic building for historic documentation and preservation.	Staff (museum personnel facing)	Yes		Recap and Revit	Post-graduation professional development (employer funded), Post-graduation professional development (self-sponsored)	
			A Building Information Model (BIM)		We have recreated lost features on other projects. On the project noted, [redacted], [redacted] used Lidar to capture the existing conditions of the building. Than, Revit was used to present the information to the engineer and architect for use in preservation work.	Staff (museum personnel facing)	Yes		Recap and Revit	Post-graduation professional development (employer funded), Post-graduation professional development (self-sponsored)	
Undergraduate degree	History, Historic preservation, Architectural history		A virtual and/or augmented reality experience		Matterport video of a fishing vessel. Incorporates historic photos and interviews as part of the video.	Interpretation (public or visitor facing)	No	Hasn't been released yet.	Not sure	Other (please specify)	I was not the video developer
Some undergraduate coursework	Other (please specify)	Education	A 3d virtual tour		3D virtual tour of a few different installations at [redacted]	Interpretation (public or visitor facing)	Yes		Matterport	Post-graduation professional development (self-sponsored)	
Undergraduate degree	Other (please specify)	BFA - Studio Art	A photogram-metric model		The feature is a duplication of lost architectural details, using photogrammetry and 3D printing. We assisted a local contractor with replicating lost sheet metal ornamentation on a National Register of Historic Places building. After a partial collapse and rebuilding of the structure, I made a model of the sole remaining example of the ornamentation. Then, 3D printed four examples that were installed on the building. This project was referenced in the National Park Service's Preservation Brief 16, The Use of Substitute Materials on Historic Building Exteriors, page 23.	Interpretation (public or visitor facing)	Yes		Autodesk Fusion 360, Blender	Post-graduation professional development (self-sponsored)	

Highest Level of Education Completed	Program of Study	Description of " Other" Program of Study	3D Digital Product	Description of " Other" Product	Description of Product	Interpretation, Staff, or Both Purposes?	Was the Product Used as Intended?	If Not, Why Not?	Software Used to Create Product	Where the Software Was Learned	Description of " Other" Location the Software was Learned
			A 3d virtual tour		I have created a series of virtual tours for our museums during Covid closures. Then, continued to develop virtual tours as an alternative offering for non-ADA accessible historic buildings and museum exhibition documentation.	Interpretation (public or visitor facing)	Yes		Matterport	Post-graduation professional development (self-sponsored)	
			A photogram-metric model		We have created many photogrammetry based models in order to 3D print replicas of museum objects for interpretation. We've used this method for installations in off-site displays and specifically for interactive elements.	Interpretation (public or visitor facing)	Yes		Blender, Artec Studio	Post-graduation professional development (self-sponsored)	
Some graduate school coursework	History, Other (please specify)	Education	A 3D model		Most of the 3D models I've created serve multiple purposes. In the case of models that I've designed, it's generally to help serve as a visual aid for educational videos and/or printed material, or to serve as the basis for a physical or digital exhibit model.	Both	Yes		ZBrush, Tinkercad, DAZ Studio, Meshmixer, Blender, Nomad Sculpt	Post-graduation professional development (self-sponsored)	
			A point cloud		In the case of point clouds, these are used as the basis for the generation of more complex photogrammetric 3D models, generally of artifacts and/or architectural features in the museum.	Both	Yes		3DF Zephyr	Post-graduation professional development (self-sponsored)	
			A photogram-metric model		Our photogrammetric models serve multiple functions: 1) to create a digital archive of artifacts and architectural elements, 2) to serve as the basis for creating replicas of the same, either through 3D printing or other manufacturing methods, for use in education, to recreate damaged pieces, or for use in creating merchandise to help fund museum programs, and 3) for use in multimedia educational and reference material.	Both	Yes		3DF Zephyr, Luma AI, Polycam	Post-graduation professional development (self-sponsored)	

Highest Level of Education Completed	Program of Study	Description of " Other" Program of Study	3D Digital Product	Description of " Other" Product	Description of Product	Interpretation, Staff, or Both Purposes?	Was the Product Used as Intended?	If Not, Why Not?	Software Used to Create Product	Where the Software Was Learned	Description of " Other" Location the Software was Learned
			Drone footage or other immersive, digital experience		In the case of drone footage, this is used for the creation of 3D models based on the historic building as well as possible applications in creating B roll for video content as well as digital sets for compositing with video footage.	Both	Yes		MicMac	Other (please specify)	Used by a third party
Undergraduate degree	History		A virtual and/or augmented reality experience		It is viewing some parts of the building which will not be accessible to the public or covered over. These were digital pictures of wall papers from the 19th century.	Both	Yes		just digital cameras or ipad.	Other (please specify)	My son-in-law who has an IT degree
			A 3D model		a 3d gam.e to replace our escape room	Interpretation (public or visitor facing)	No	The projected was cancelled by the university of the student in charge of creating the game.	I did not use ant program	Other (please specify)	Not part of my education
Undergraduate degree	Other (please specify)	Graphic Design	Other (please specify)	Simple QR Coded signage to create a digitally enhanced self-guided walking tour	Not a 3D digital product. We used QR codes on 20 signposts throughout our historic district to create a self-guided walking tour. This enables a viewer to connect with site-specific historic images and text, which showed historic photographs of the same viewpoints/streetscapes/buildings corresponding to their current location. This also "unlocked" access to images in our archives, which are not generally easily accessed by the public.	Interpretation (public or visitor facing)	Yes		Adobe Creative Cloud (InDesign/ Illustrator) to create sign graphics; Website pages	Post-graduation professional development (employer funded), Post-graduation professional development (self-sponsored)	

Highest Level of Education Completed	Program of Study	Description of " Other" Program of Study	3D Digital Product	Description of " Other" Product	Description of Product	Interpretation, Staff, or Both Purposes?	Was the Product Used as Intended?	If Not, Why Not?	Software Used to Create Product	Where the Software Was Learned	Description of " Other" Location the Software was Learned
Graduate degree	Other (please specify)	Fine Art - Photography	A 3d virtual tour		As a part of my position, I create Matterport tours of Historic Homes owned by [redacted] (3d virtual tours). This allows visitors who are not able to attend our sites in person (due to physical limitations or other) to experience our properties. It also serves as a form of preservation as it documents the homes and the objects within them.	Both	Yes		Matterport	Other (please specify)	I learned to operate the Matterport Camera and to work with the program to create and edit models while working in my current position. I did matterport training with the person previously in this position and also learned through the [redacted] Digital Photographer Training Manual.
			Other (please specify)	My position also involves photographic digitization of all objects and archives in [redacted]'s collection. I also frequently create stitched reproductions of 2d archival materials for patron or internal use.	Photography of the collection. This allows people to access the collection online for research or other purposes. It also documents the collection for preservation purposes. Reproductions allow for the use of our images in exhibitions, banners, or as framed prints (while keeping the originals safely stored).	Both	Yes		Capture One, Photoshop	Undergraduate elective class, Graduate core class	

Highest Level of Education Completed	Program of Study	Description of " Other" Program of Study	3D Digital Product	Description of " Other" Product	Description of Product	Interpretation, Staff, or Both Purposes?	Was the Product Used as Intended?	If Not, Why Not?	Software Used to Create Product	Where the Software Was Learned	Description of " Other" Location the Software was Learned
Undergraduate degree	History		Other (please specify)	Touchscreen interactive	What I created was very simple, using Microsoft PowerPoint, I created a touchscreen interactive that allows people to touch different areas and objects on an image of a reconstructed historic room. That object or area is linked to another slide that interprets the object for the visitor. There is a "Back" button that takes them back to the image of the room where they can pick another object or area of the room.	Interpretation (public or visitor facing)	Yes		Microsoft PowerPoint, and Keynote for an accessible version for people who are blind or have low vision.	Other (please specify)	Self-taught.
Graduate degree	History, Public History		A 3d virtual tour		The virtual tour of the [redacted] factory allows visitors to tour the site without being physically present. It highlights many of the same things a visitor would see on a tour in person but has better accessibility and more information. It also saved the views in case we had another flood.	Both	Yes		Matterport	Other (please specify)	Research Online & Help with Local Consultant
Graduate degree	Architectural history, Other (please specify)	Architecture	A point cloud		3D scans of multiple artifacts and architectural sites - some features are no longer extant, so still remain - in the cases of architecture the data is used for historical structure reports, BIM models or other architectural documentation - in the cases of artifacts, the data was used for archival documentation, 3D printing, 3d modeling, etc...	Both	Yes		scan data processed with FARO Scene (architectural data) or 3D Systems Geomagic (artifact data) - derivatives of data may be primarily authored with 3D Studio Max, Autodesk ReCap, Rhino 3D	Non-university sponsored workshop, Post-graduation professional development (employer funded)	

Highest Level of Education Completed	Program of Study	Description of " Other" Program of Study	3D Digital Product	Description of " Other" Product	Description of Product	Interpretation, Staff, or Both Purposes?	Was the Product Used as Intended?	If Not, Why Not?	Software Used to Create Product	Where the Software Was Learned	Description of " Other" Location the Software was Learned
			A 3D model		3D model of the historic composition of [redacted], as it was the former capital of [redacted]; this model represents over 3000 buildings that have been destroyed or dilapidated; the model exists as a 3D GIS body of information that was translated into an interactive virtual environment	Both	Yes		3D Studio Max, ArcGIS, City Engine, Unity 3D	Post-graduation professional development (employer funded), Other (please specify)	self taught
			A photogram-metric model		photogrammetry of [redacted] monuments and material culture; this process was used to document physical structures in the [redacted] landscape around [redacted] that were present in 2016; it is not certain if these features still exist;	Both	Yes		Agisoft Metashape, 3D Studio Max, Steam VR, ArcGIS, City Engine	Post-graduation professional development (employer funded), Other (please specify)	self taught
Graduate degree	Historic preservation, Archaeology, Anthropology		A photogram-metric model		It was a photogrammetric model of a shipwreck site to have it available for future reference and to provide a visual for visitors to know.	Both	Yes		Metashape	Graduate elective class, University-sponsored workshop, Post-graduation professional development (self-sponsored)	
Graduate degree	History, Museum studies		Drone footage or other immersive, digital experience		There's nothing too fancy about what we do with the drone footage I've produced. We use it to document the built environment of [redacted] for the historical record, as the city is rapidly changing due to redevelopment and construction in our business districts, as well as for marketing/social media purposes as well. The interpretive value of some of this footage/photography may not reach its full potential for generations.	Both	Yes		Photoshop	Undergraduate core class	

Highest Level of Education Completed	Program of Study	Description of " Other" Program of Study	3D Digital Product	Description of " Other" Product	Description of Product	Interpretation, Staff, or Both Purposes?	Was the Product Used as Intended?	If Not, Why Not?	Software Used to Create Product	Where the Software Was Learned	Description of " Other" Location the Software was Learned
Graduate degree	History, Art history, Architectural history, Archaeology, Anthropology		A photogram-metric model		Used a Ricoh 360 camera with the Matterport app to create 3D scans of our historic house museums as they currently appear to the public. The scans are also tagged with information about the history, architecture, and artifacts.	Both	Yes		Matterport	Other (please specify)	A colleague at a different organization introduced me to the software, and I used Youtube tutorials and Matterport's own support documentation to learn more.
Undergraduate degree	Historic preservation, Museum studies		A 3D model		I have worked to create models of the early 20th century buildings here on property in an effort to create a virtual landscape that is accessible to anyone anywhere. Most of this buildings are deteriorated and are unaccessible to the public. I have also worked to make this model a access point to archival information for research purposes.	Both	Yes		SketchUp, ArcGIS Pro, ArcGIS Online, AutoCAD	Undergraduate elective class, Post-graduation professional development (employer funded)	
			Drone footage or other immersive, digital experience		I have worked to capture drone footage of [redacted]'s Historic structures to aid in documentation purposes.	Both	Yes		Drone Phantom	Other (please specify)	Job Training
Graduate degree	History, Museum studies, Public History		Other (please specify)	Clio, Storymaps	We used Clio to semi-replicate information inside the historic structures during the 'at-home' portion of the COVID-19 pandemic in 2020. Using images, video, audio, and text, we created a narrative accessible outside the ten historic structures with a QR code. We also use StoryMap to provide accessible versions of exhibitions inside historic structures with little or no ADA-quality accessibility.	Interpretation (public or visitor facing)	Yes		ArcGIS Storymap, Clio	Graduate core class, Graduate elective class, Internship	

Highest Level of Education Completed	Program of Study	Description of " Other" Program of Study	3D Digital Product	Description of " Other" Product	Description of Product	Interpretation, Staff, or Both Purposes?	Was the Product Used as Intended?	If Not, Why Not?	Software Used to Create Product	Where the Software Was Learned	Description of " Other" Location the Software was Learned
			A 3D model		We used SketchUp to create 3D models of historic structures as part of our exhibit design process. Historic structures are unique with odd corners, roof angles, and non-traditional windows. Having an accurate 3d rendering assists with visualizing options.	Staff (museum personnel facing)	Yes		SketchUp	Graduate core class	
Graduate degree	History, Other (please specify)	Education	Drone footage or other immersive, digital experience		Fly through of the Nature Trail and Property and building for our website	Both	Yes		not sure	Other (please specify)	Drone pilot provided and edited
Graduate degree	History, Museum studies		Drone footage or other immersive, digital experience		As part of a small documentary about a local shipwreck that took place in 1853, we were able to use a drone to capture footage that replicated the approximate first-person point of view that survivors would have experienced. The ship was wrecked only a few hundred yards offshore during a storm; hundreds died and many survivors were stranded on remains of the ship for more than 24 hours before being rescued.	Interpretation (public or visitor facing)	Yes		DJI Fly for DJI Mini 2 drone; iMovie	Other (please specify)	mainly self-teaching through online tutorials
Some undergraduate coursework	Other (please specify)	Criminal justice	Drone footage or other immersive, digital experience		I have created several videos of the museum grounds and buildings with a drone.	Both	Yes		Just the DJI drone software	Other (please specify)	Self taught
Graduate degree	Other (please specify)	Computer Graphics	A 3d virtual tour		Recreates a chapel that holds significant cultural and historical value for African American history in [redacted].	Both	Yes		Zbrush, Maya, Substance, Unity, Unreal, and many others	Undergraduate core class, Undergraduate elective class	
			A 3D model		Church and everything inside it.	Both	Yes		see last	Undergraduate core class, Undergraduate elective class	

Highest Level of Education Completed	Program of Study	Description of " Other" Program of Study	3D Digital Product	Description of " Other" Product	Description of Product	Interpretation, Staff, or Both Purposes?	Was the Product Used as Intended?	If Not, Why Not?	Software Used to Create Product	Where the Software Was Learned	Description of " Other" Location the Software was Learned
Graduate degree	Other (please specify)	POLI and Public Policy	A 3d virtual tour		Digital 3D walkthrough space, with added text and photos	Interpretation (public or visitor facing)	Yes		Matterport	Other (please specify)	Self taught
Graduate degree	Other (please specify)	English	A 3d virtual tour		We developed a 3D tour during the pandemic to allow people to see inside buildings in the museum that were closed to the public. In 2020 all interpretation was done through open windows and there were no field trips to the site. This enabled us to bring visitors in and create virtual field trips for students.	Interpretation (public or visitor facing)	Yes		Matterport	Other (please specify)	this was a grant funded project and the software was handled by an outside contractor
Graduate degree	Archaeology, Anthropology ,Other (please specify)	Chemistry	A 3d virtual tour		The end product was a virtual interpretive tour of a tall ship (schooner) that has both historic significance and is still in use. The interpretive tour is a digital twin of the ship as it is today, and incorporates interviews with current crew members, oral histories with community members, historic photographs, video footage, etc. The product is intended for the public to be able to visit the ship when it isn't in port, or if they are not in town; it also is in a format (Matterport) where materials can be added as the ship continues to evolve.	Interpretation (public or visitor facing)	Yes		Matterport (Matterport Pro3 and Theta cameras)	Other (please specify)	on the job
Graduate degree	Other (please specify)	Master in Information Systems	A 3d virtual tour		Online guided tour through a virtual reconstruction of vanished heritage	Both	Yes		Revit	Other (please specify)	Architecture school program
			Other (please specify)	Web Portal	Web Portal with information about the occupation of a vanished heritage site	Both	Yes		Web Development tools	Other (please specify)	Online courses

Highest Level of Education Completed	Program of Study	Description of “ Other” Program of Study	3D Digital Product	Description of “ Other” Product	Description of Product	Interpretation, Staff, or Both Purposes?	Was the Product Used as Intended?	If Not, Why Not?	Software Used to Create Product	Where the Software Was Learned	Description of “ Other” Location the Software was Learned
Undergraduate degree	Other (please specify)	Architecture	A Building Information Model (BIM)		Historic Building Information Management (HBIM)- a digital twin platform designed specifically for historic property stewardship. Building structures are modeled in great detail and incorporated into a user interface that can connect information from external databases to individual building elements. Modeled elements include plaster finishes, plaster patches, wood studs, wood joists, wood ceiling hangers, door surrounds, and more. A value was assigned to each model element indicating the accuracy of the shape, location and material as modeled. Additional information associated with elements included date of construction, date of restoration, original craftsman, restoration craftsman, and resources used to inform the modeling. Individual buildings are brought into GIS, positioned in context to one another and the surrounding neighborhood. The result is a fully navigable 3D model that can retrieve relevant data about model elements. The capabilities of what HBIM can do go beyond what was developed for [redacted]. What was developed at [redacted] was a proof of concept and did not go so far as to fully develop the user interface allowing for data input in addition to data retrieval.	Both	No	The level of effort to complete the platform exceeded the museum’s budget. In addition, the technology available at the time required far more effort to develop the platform that what is available today (and continues to develop).	Revit, ArcGIS, CityEngine, FME, Excel	Other (please specify)	Project budget/ employer
Graduate degree	Historic preservation, Architectural history, Archaeology, Other (please specify)	Classics	A 3D model		We created a Historic Building Information Management System (HBIM) to manage all information (historical, maintenance, restoration) about our 28th century dwelling house	Both	No	We are challenged to train staff to be fluent in Revit (which created the model)	Revit	Other (please specify)	We hired a contractor to make it
			A point cloud		We used the point cloud as the basis for our Revit model	Staff (museum personnel facing)	Yes		Various scanners	Other (please specify)	contractor

Appendix F

Where Respondents Learned the Software vs. Area of Study Table

Where Respondents Learned the Software vs. Area of Study																																								
	Anthropology		Archaeology		Architectural history		Architecture		Art history		Classics		Criminal justice		Education		English		Fine Art - Photography		Historic preservation		History		Master in Information Systems		Museum studies		Philosophy		POLI and Public Policy		Public History		Total Count
Where Respondents Learned the Software	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	
Graduate core class		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	1	33.3%		0.0%	1	33.3%		0.0%		0.0%	1	33.3%	3
Graduate elective class	1	16.7%	1	16.7%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	1	16.7%	1	16.7%		0.0%	1	16.7%		0.0%		0.0%	1	16.7%	6
Internship		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	1	33.3%		0.0%	1	33.3%		0.0%		0.0%	1	33.3%	3
Non-university sponsored workshop		0.0%		0.0%	1	50.0%	1	50.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	2
Other (on the job)		0.0%		0.0%		0.0%	2	33.3%		0.0%		0.0%		0.0%		0.0%		0.0%	1	16.7%	2	33.3%		0.0%		0.0%	1	16.7%		0.0%		0.0%		0.0%	6
Other (self-taught)	1	7.1%	1	7.1%	1	7.1%		0.0%	2	14.3%		0.0%	1	7.1%		0.0%		0.0%		0.0%		0.0%	4	28.6%		0.0%	1	7.1%	1	7.1%	1	7.1%	1	7.1%	14
Other (worked with a third party)		0.0%	1	7.1%	2	14.3%		0.0%		0.0%	1	7.1%		0.0%	2	14.3%	1	7.1%		0.0%	2	14.3%	4	28.6%	1	7.1%		0.0%		0.0%		0.0%		0.0%	14
Post-graduation professional development (employer funded)		0.0%		0.0%	1	20.0%	2	40.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	1	20.0%		0.0%		0.0%	1	20.0%		0.0%		0.0%		0.0%	5
Post-graduation professional development (self-sponsored)	1	11.1%	1	11.1%		0.0%	1	11.1%	1	11.1%		0.0%		0.0%	2	22.2%		0.0%		0.0%	1	11.1%	1	11.1%		0.0%		0.0%	1	11.1%		0.0%		0.0%	9
Undergraduate core class		0.0%		0.0%		0.0%	1	16.7%	1	16.7%		0.0%		0.0%		0.0%		0.0%		0.0%	1	16.7%	1	16.7%		0.0%	1	16.7%	1	16.7%		0.0%		0.0%	6
Undergraduate elective class		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	1	50.0%		0.0%		0.0%	1	50.0%		0.0%		0.0%		0.0%	2
University-sponsored workshop	1	33.3%	1	33.3%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	1	33.3%		0.0%		0.0%		0.0%		0.0%		0.0%		0.0%	3
Grand Total	**4**	**5.5%**	**5**	**6.8%**	**5**	**6.8%**	**7**	**9.6%**	**4**	**5.5%**	**1**	**1.4%**	**1**	**1.4%**	**4**	**5.5%**	**1**	**1.4%**	**1**	**1.4%**	**10**	**13.7%**	**13**	**17.8%**	**1**	**1.4%**	**8**	**11.0%**	**3**	**4.1%**	**1**	**1.4%**	**4**	**5.5%**	**73**

BIBLIOGRAPHY

"About Esri: Overview." Esri.com. Esri. Accessed March 8, 2024. https://www.esri.com/en-us/about/about-esri/overview.

"About Us." Matterport.com. Matterport, 2024. https://matterport.com/about-us.

Ackroyd, Robert Charles. "Smart Arts: Applying Digital Technology to Increase Engagement and Value in Museums and Historic Sites." Order No. MR33105. University of Alberta (Canada), 2007. https://doi.org/10.7939/r3-884h-bj40.

Akboy-İlk, Serra. "The Mediated Environment of Heritage Recording and Documentation." *Preservation Education and Research,* Vol. 6, 2013. https://www.ncpe.us/wp-content/uploads/2014/11/PER2013-offprint-AKBOY-ILK.pdf.

American Alliance of Museums and Wilkening Consulting. *National Snapshot of COVID-19 Impact on United States Museums.* American Alliance of Museums, February 8, 2022. https://www.aam-us.org/wp-content/uploads/2022/02/COVID-19-Snapshot-of-the-Museum-Field-Dec-Jan.pdf.

"Autodesk 3ds Max: Create Massive Worlds and High-Quality Designs." Autodesk.com. Autodesk, 2024. https://www.autodesk.com/products/3ds-max/overview?term=1-YEAR&tab=subscription.

"Autodesk Products." Autodesk.com. Autodesk, 2024. https://www.autodesk.com/products?page=2.

Awayda, Conner. "Cravens Virtual Museum Project: A Case Study of Digital Heritage and Museum Education." Order No. 10822826. State University of New York at Buffalo, 2018. http://libproxy.clemson.edu/login?url=https://www.proquest.com/dissertations-theses/cravens-virtual-museum-project-case-study-digital/docview/2057242985/se-2?accountid=6167.

Bici, M., F. Campana, O. Colacicchi, and G. D'Ercoli. "CAD-CAE Methods to Support Restoration and Museum Exhibition of Bronze Statues: The 'Principe Ellenistico'." *IOP Conference Series: Materials Science and Engineering* 364, no. 1 (June, 2018). doi:10.1088/1757-899X/364/1/012014.

Biedermann, Bernadette. “Virtual Museums As an Extended Museum Experience: Challenges and Impacts for Museology, Digital Humanities, Museums and Visitors - In Times of (Coronavirus) Crisis.” *Digital Humanities Quarterly* 15, no. 3 (2021). http://libproxy.clemson.edu/login?url=https://www.proquest.com/scholarly-journals/virtual-museums-as-extended-museum-experience/docview/2603407527/se-2?accountid=6167.

Bird, Lawrence and Guillaume LaBelle. “Re-Animating Greg Lynn’s Embryological House: A Case Study in Digital Design Preservation.” *Leonardo* 43, no. 3 (2010): 242-249. https://www.jstor.org/stable/26859538.

Brown, Amanda. "City-Scaled Digital Documentation: A Comparative Analysis of Digital Documentation Technologies for Recording Architectural Heritage." Clemson University, 2016. https://tigerprints.clemson.edu/all_theses/2405.

“Building Information Modeling.” Autodesk.com. Autodesk, 2024. https://www.autodesk.com/solutions/aec/bim.

Burns, John A. “Chapter 1: Overview.” In *Recording Historic Structures*, 2nd ed., edited by John A. Burns. Hoboken, NJ: John Wiley & Sons, Inc., 2004.

“CDC Museum COVID-19 Timeline.” CDC.gov. David J. Sencer CDC Museum: In Association with the Smithsonian Institution, Centers for Disease Control and Prevention, March 15, 2023. https://www.cdc.gov/museum/timeline/covid19.html.

Denscombe, Martyn. *The Good Research Guide: For Small-Scale Social Research Projects.* 6th edition. London: McGraw-Hill Education, 2017. https://www.google.com/books/edition/EBOOK_The_Good_Research_Guide_For_Small/SMovEAAAQBAJ?hl=en&gbpv=1&dq=The%20Good%20Research%20Guide%3A%20For%20Small-Scale%20Social%20Research%20Projects&pg=PA19&printsec=frontcover.

“Digital Awakening: Essential Technologies for Pandemic Survival and Future Success.” From “TrendsWatch: Navigating a Disrupted Future.” Center for the Future of Museums, American Alliance of Museums, 2021. https://www.aam-us.org/wp-content/uploads/2021/02/2021_TrendsWatch_V1_full_draft_Hyperlinked_v3.pdf.

Ding, Mandy. “Augmented Reality in Museums.” *Arts Management & Technology Laboratory.* Carnegie Mellon University, May 2017. https://static1.squarespace.com/static/51d98be2e4b05a25fc200cbc/t/5908d019f5e2314ab790c269/1493749785593/Augmented+Reality+in+Museums.pdf.

"Disconnecting to Reconnect." From "Trendswatch 2013: Back to the Future." Center for the Future of Museums, American Alliance of Museums, January/February 2013. https://www.aam-us.org/wp-content/uploads/2017/12/2013_TrendsWatch.pdf.

Disney, M., A. Burt, K. Calders, C. Schaaf, and A. Stovall. "Innovations in Ground and Airborne Technologies as Reference and for Training and Validation: Terrestrial Laser Scanning (TLS)." *Surveys in Geophysics* 40, no. 4 (July 2019): 937-958. https://doi.org/10.1007/s10712-019-09527-x.

"Features." Cryengine.com. CryEngine, 2024. https://www.cryengine.com/features.

Federal Aviation Administration. "Certified Remote Pilots Including Commercial Operators." FAA.gov. Department of Transportation, August 8, 2023. https://www.faa.gov/uas/commercial_operators.

Fortenberry, Brent R. "Research Notes: Digital Documentation in Vernacular Architecture Studies." *Buildings & Landscapes: Journal of the Vernacular Architecture Forum* 26, no. 2 (2019): 98–114. https://doi.org/10.5749/buildland.26.2.0098.

Fortenberry, Brent R. and Amalia Leifeste. "Querying the Products of Two Recording Techniques: Analog and Digital." *APT Bulletin: The Journal of Preservation Technology* 51, no. 2/3 (2020): 47–56. https://www.jstor.org/stable/26943427.

Fusion Research + Analytics. *Mobile Survey*. Museums Association, 2012. https://archive-media.museumsassociation.org/15052012-ma-mobile-survey.pdf.

Gheorghiu, Dragoş and Livia Ştefan. "Virtual Museums: Dealing with Cultural Identity in the Digital Age." In *The International Scientific Conference eLearning and Software for Education, Bucharest* (2018): 463-470. https://doi.org/10.12753/2066-026X-18-280.

"Help Center." Matterport.com. Matterport, 2024. https://support.matterport.com/s/?language=en_US.

Heritage Documentation Programs. "Historic American Buildings Survey." NPS.gov. National Park Service, September 20, 2023. https://www.nps.gov/subjects/heritagedocumentation/habs.htm.

Heritage Documentation Programs. "Historic American Engineering Record." NPS.gov. National Park Service, September 20, 2023. https://www.nps.gov/subjects/heritagedocumentation/haer.htm.

Hudgins, Carter L. and Amalia Leifeste. “The Documentation Course: Beyond Drawing.” *Preservation Education and Research* 9 (2017): 47-61. https://www.ncpe.us/wp-content/uploads/2017/09/PER2016-v9-offprint-03-Hudgins-Leifeste.pdf.

“Institutional Review Board.” Clemson.edu. Office of Research Compliance, Clemson University, 2023. https://www.clemson.edu/research/division-of-research/offices/orc/irb/index.html.

Kapp, Paul Hardin. ‘“So, Can You Revit?’ Historic Preservation Design Education and Digital Media.” *Preservation Education and Research* 2, (2009): 15-26. https://www.ncpe.us/wp-content/uploads/2012/06/KAPP.pdf.

Kapp, Paul Hardin, Lauren Weiss Bricker, and Luis Hoyos. “Documentation and Design in Association: Historic Preservation Design Using Social History, Advocacy, and Drawing in the Architecture Design Studio.” In *Preservation Education: Sharing Best Practices and Finding Common Ground*, edited by Barry L. Stiefel and Jeremy C. Wells, 175-191. University Press of New England, 2014.

Kent State University. “Statistical & Qualitative Data Analysis Software: About Qualtrics.” Libguides.library.kent.edu. Kent State University Libraries, November 29, 2023. https://libguides.library.kent.edu/statconsulting/qualtrics.

Lebovich, William L. “Chapter 3: Photography.” In *Recording Historic Structures*, 2nd ed., edited by John A. Burns. Hoboken, NJ: John Wiley & Sons, Inc., 2004.

Lindgren, James M. “Chapter 4: ‘A Spirit that Fires the Imagination’ Historic Preservation and Cultural Regeneration in Virginia and New England, 1850-1950.” In *Giving Preservation a History: Histories of Historic Preservation in the United States*, edited by Max Page and Randall Mason. New York: Routledge, 2004.

Medway, Rebecca, Melissa Scardaville, Chris Paek, Paula Dias, Ashley Kaiser, Mahi Megra, and Scott Pulizzi. *National Household Education Surveys Program of 2019: Qualitative Study of Nonresponding Addresses.* Washington, D.C.: U.S. Department of Education National Center for Education Statistics, 2022. https://nces.ed.gov/pubs2022/2022043.pdf.

“Me/We/Here/There: Museums and the Matrix of Place-Based Augmented Devices.” From “Trendswatch 2016.” Center for the Future of Museums, American Alliance of Museums, 2016. https://www.aam-us.org/2016/05/01/meweherethere-museums-and-the-matrix-of-place-based-augmented-devices/.

Milonas, Abby. "Physical Accessibility and Historic Preservation in Historic House Museums of the Southeast." Clemson University, 2023. https://tigerprints.clemson.edu/all_theses/4098.

"More Than Real." From "Trendswatch 2012: Museums and the Pulse of the Future." Center for the Future of Museums, American Alliance of Museums, 2012. https://www.aam-us.org/wp-content/uploads/2017/12/2012_TrendsWatch.pdf.

Mount Vernon Ladies' Association. "About Mount Vernon." Mountvernon.org. George Washington's Mount Vernon, 2024. https://www.mountvernon.org/about/.

"Our Company: Who We Are." Unity.com. Unity, 2024. https://unity.com/our-company.

Paladini, A., A. Dhanda, M. Reina Ortiz, A. Weigert, E. Nofal, A. Min, M. Gyi, S. Su, K. Van Balen, and M. Santana Quintero. "Impact of Virtual Reality Experience on Accessibility of Cultural Heritage." *The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences* 42 (May 5, 2019): 929-936. https://doi.org/10.5194/isprs-archives-XLII-2-W11-929-2019.

"Preserving George Washington's Home." Quinn Evans. Accessed February 26, 2024. https://www.quinnevans.com/projects/mount-vernon.

Puig, Anna, Inmaculada Rodríguez, Josep Ll. Arcos, Juan A. Rodríguez-Aguilar, Sergi Cebrià̀n, Anton Bogdanovych, Núria Morera, Antoni Palomo, and Raquel Piqué. "Lessons Learned from Supplementing Archaeological Museum Exhibitions with Virtual Reality." Virtual Reality 24, no. 2 (June, 2020): 343-358. https://doi.org/10.1007/s10055-019-00391-z.

Rosenstein, Carole, PhD and Nevill Vakharia. "2022 National Census of History Organizations: A Report on the History Community in the United States." Nashville, TN: American Association for State and Local History, 2022. http://download.aaslh.org/Research/2022+National+Census+of+History+Organizations.pdf.

Smith, Andréa Livi. "The Young Preservationist: Findings from the First Undergraduate Historic Preservation Education Symposium." *Preservation Education and Research*, 5 (2012): 87-96. https://www.ncpe.us/wp-content/uploads/2014/03/PER2012-offprint-SMITH.pdf.

Spallone, R., F. Lamberti, L. M. Olivieri, F. Ronco, and L. Castagna. "AR and VR for Enhancing Museum's Heritage Through 3D Reconstruction of Fragmented Statue and Architectural Context." *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLVI-2/W1 (2022): 473-480. https://doi.org/10.5194/isprs-archives-XLVI-2-W1-2022-473-2022.

"Synthesia: Multisensory Experiences for a Multisensory World." From "Trendswatch 2014." Center for the Future of Museums, American Alliance of Museums, 2014. https://www.aam-us.org/wp-content/uploads/2017/12/2014_TrendsWatch.pdf.

Tilden, Freeman. *Interpreting Our Heritage*. 4th edition. Chapel Hill: The University of North Carolina Press, 2007. https://ebookcentral.proquest.com/lib/clemson/reader.action?docID=4322102&ppg=5.

Tsilimantou, Elisavet, Ekaterini T. Delegou, Ioannis A. Nikitakos, Charalabos Ioannidis, and Antonia Moropoulou. "GIS and BIM as Integrated Digital Environments for Modeling and Monitoring of Historic Buildings." *Applied Sciences* 10, no. 3 (2020): 1078. https://doi.org/10.3390/app10031078.

Tyler, Norman, Ted J. Ligibel, and Ilene R. Tyler. *Historic Preservation: An Introduction to Its History, Principles, and Practice*. 2nd ed. New York: W. W. Norton & Company, 2009.

United States Department of the Interior. "HABS Guidelines: Recording Historic Structures and Sites with HABS Measured Drawings." Heritage Documentation Programs, National Park Service, 2008. https://www.nps.gov/subjects/heritagedocumentation/upload/HABS-Guidelines-Measured-Drawings_508.pdf.

"Univariate Data Analysis." Home.csulb.edu. California State University, Long Beach. Accessed March 7, 2024. https://home.csulb.edu/~msaintg/ppa696/696uni.htm.

"What is Open Source Software?" IBM.com. IBM. Accessed February 3, 2023, https://www.ibm.com/topics/open-source.

"What is Parametric Modeling & How Does it Work?" Adobe.com. Adobe, 2024. https://www.adobe.com/products/substance3d/discover/parametric-modeling.html.

Wilson. Rachel W. "This Is Not a Drill: A Survey of Natural Disaster Preparedness in House Museums and Historic Sites." Clemson University, 2020. https://tigerprints.clemson.edu/all_theses/3295.

Worrell, Laura Lee. "Building Information Modeling (BIM): The Untapped Potential for Preservation Documentation and Management." Order No. 1591152. Clemson University, 2015. https://tigerprints.clemson.edu/all_theses/2146.