Printing the Past

Building Accessibility and Engagement Through 3-D Technologies

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ABSTRACT: This article describes and evaluates a 3-D scanned and printed exhibit created by students and faculty in collaboration with a local museum to increase accessibility to archaeological and historical collections for audiences with visual disabilities, neurodivergence, and sensory processing differences. 3-D technologies allowed for the creation of a hands-on exhibit, accompanied by a variety of accessible solutions, such as audio, video, and braille, allowing audiences to explore reproductions of artifacts through touch. Surveys of museum attendees and students who participated in the project revealed that the tactile exhibit and design experience were extremely positive. As museums and public historians strive for universal design and access in programs, this technology provides another opportunity for engagement. The authors explain methods and applications for public historians, museums, and outreach.

KEY WORDS: accessibility, exhibits, museum, teaching public history, 3-D technology

On a beautiful spring day in Conway, South Carolina, a diverse crowd of people descended on the Horry County Museum to touch a piece of history. The grand opening of the exhibition, *Printing the Past: SC in 3D*, offered visitors the opportunity to learn the history of the region by handling eighteen carefully curated and interpreted artifacts from the area's prehistoric and historic eras. These artifacts were in no danger from carefree visitors, children, or the environment; the carefully reproduced artifacts were 3-D printed from plastic, and even if they were damaged, printing a new one would be relatively easy, quick, and cost-effective. Over one hundred and seventy members of the public, including special guests from the South Carolina Commission for the Blind and SOS Healthcare (serving adults with developmental and intellectual disabilities), attended the event. Thirty-six students spoke to visitors and administered surveys, while proudly showing family, friends, and the public around the exhibit, explaining their role and providing further interpretation on the artifacts they chose.

This was the culmination of a semester-long collaboration among the students and instructors of two courses at Costal Carolina University, HIST 392: Museums

Opening Day at the Horry County Museum. (Photo by Scott Dean)

and Communities and ANTH 432: Cultural Resource Management; the Horry County Museum; and a variety of community stakeholders including descendant communities (the Waccamaw Indian People and families of those who donated artifacts), and local organizations that serve those with cognitive differences (SOS Healthcare) and visual disabilities (South Carolina Commission for the Blind). Throughout the Spring 2019 semester, students and faculty created a 3-D scanned and printed exhibit to increase accessibility to archaeological and historical collections. The main focus for the project was increasing opportunities for audiences with visual disabilities, neurodivergence, and sensory processing differences. Using 3-D technologies, students and professors created a hands-on exhibit, accompanied by a variety of accessible solutions, that allowed audiences to explore reproductions of these artifacts through touch.

As museums and public historians strive for universal design and access in programs, this technology provides another opportunity for engagement. Although the Americans with Disabilities Act (ADA) required museums to become accessible to all populations, given the fragile nature of archaeological and historical artifacts, it is often not possible to truly engage with an audience with visual or sensory differences who may benefit from a tactile experience.[1] The National Council on

1 Nicole Belolan, "An 'Effort to Bring This Little Handicapped Army in Personal Touch with Beauty': Democratizing Art for Crippled Children at the Metropolitan Museum of Art, 1919–1934,"

Public History has been proactive in addressing these issues, and the topic continues to grow as an important field of study for all public historians and museum professionals.[2] However, until recently, 3-D technologies were cost-prohibitive for many small museums. Museums, program developers, and public historians should all take an interest in learning about ways to build more accessible opportunities to truly reach all audiences. This article explains methods and applications for public historians, museums, and outreach to a variety of communities, using technologies that are now affordable to most institutions.

Background

The authors both worked in museums throughout their graduate careers, Katie Stringer Clary as a museum studies and public history student, and Carolyn Dillian as an archaeologist. This shared background created the perfect opportunity for inter-departmental collaboration on a semester-long project in their respective departments of History and Anthropology and Geography. Clary's public history background has focused on accessibility and programming for people with special needs at historic sites and in history museums, and she learned 3-D printing technologies for the purposes of this project. Dillian is an archaeologist, with expertise in laboratory methods, including 3-D scanning, and who has ongoing excavations throughout South Carolina and has worked with collections in museums throughout the United States and in Kenya.

At a reconstructive and experimental archaeology conference held at Colonial Williamsburg, Virginia, in 2017, the authors learned about 3-D printed archaeological artifacts, specifically basketry and textiles, that curators use in programming at the National Museum of Scotland.[3] Combining their specialties, the authors worked to pursue a similar project with their classes in Spring 2019. The Horry County Museum in Conway, South Carolina, was the ideal partner for this project, as the local repository for natural, prehistoric, and historic artifacts in the region. The main goal of this project was to create an exhibition that would welcome people of all abilities and hold to the principles of universal design and best practices in accessibility.

New York History 96, no. 1 (Winter 2015): 38–66; Johnnetta Betsch Cole, ed., *Diversity, Equity, Accessibility, and Inclusion in Museums* (Lanham, MD: Rowman and Littlefield, 2019); Juliee Decker, *Engagement and Access* (Lanham, MD: Rowman and Littlefield, 2015); Katie Stringer, *Programming for People with Special Needs* (Lanham, MD: Rowman and Littlefield, 2014).

2 Special Issue on Disability, *The Public Historian* 27, no. 2 (Spring 2005); "Making Public History Accessible: Exploring Best Practices for Disability Access, 2016 working group," National Council on Public History conference, Baltimore, MD, 2016; Stacia P. Hanscom, "Review: Access Salem: For Those with Disabilities, Old Salem Museum and Gardens, Winston-Salem, NC," *The Public Historian* 41 no. 3 (August 2019): 138–45; Katherine Ott, "Disability and the Practice of Public History: An Introduction," *The Public Historian* 27 no. 2 (Spring 2005): 9–24.

3 See work by Dr. Linda Hurcombe, University of Essex with the National Museum of Scotland, Edinburgh, UK.

The target audience for this project was people with visual impairment, neuro-divergence and autism, or other sensory processing differences. The final outcome of the project was an exhibition entitled *Printing the Past: SC in 3D* at the Horry County Museum, Conway, South Carolina, that fosters inclusivity for those with visual and sensory disabilities, and also works for all museum-goers, as visitors both with and without visual/sensory differences gain the opportunity to touch and learn about South Carolina's unique past.

Accessibility, Universal Design, and Tactile Programs

Access and accessibility have been buzzwords in the museum world for the last several decades, especially after the passage of the ADA in 1990.[4] Providing access to exhibits is a legal obligation for public spaces, historic places, museums, and other sites that interpret history to the public. In addition to meeting legal and moral obligations of equal opportunities, public historians should also view accessibility as a chance to reach a new or expanded audience, build community relationships, and engage stakeholders. These were integral parts of *Printing the Past: SC in 3D.*

Accessibility and Museums

The most recent Center for Disease Control report in 2018 states that 26 percent of people in the United States, including 61 million adults, live with a disability. Of those who reported a disability, 4.6 percent have a visual disability such as blindness or difficulty seeing when wearing corrective lenses, and 10.8 percent have a cognition disability with difficulty concentrating, remembering, or making decisions.[5] Additionally, according to the American Association for People with Disabilities, the number of Americans with a disability grows approximately 2 percent each year.[6] With this growing population, museums and public historians should find ways to work with these communities to find what works for them.

The ADA was the first major legislation in the United States that provided a promise of equality to all people with disabilities. The shift towards disability equality under the law began in 1973 when Congress passed Section 504 of the Rehabilitation Act, which banned discrimination based on disability for the receipt of federal funds. In 1988, soon after the disability civil rights movement gained momentum, the ADA was brought to Congress for consideration. In 1990, the act was passed which gave rights to people with disabilities that had previously not been guaranteed by federal law. Essentially, the law protected against disability

4 *Americans with Disabilities Act of 1990*, Public Law 101–336, 101st Cong., 2d sess. (26 July 1990), 104 Stat. 327.

5 Centers for Disease Control and Prevention, "Disability and Health Data System" (DHDS: updated 2018), http://dhds.cdc.gov.

6 A. Houtenville and S. Boege, *Annual Report on People with Disabilities in America: 2018* (Durham: University of New Hampshire, Institute on Disability, 2019).

discrimination in employment, public services, and public accommodation and services operated by private entities, transportation and telecommunications.

With the passage of the ADA in 1990, all public spaces were required to become accessible to all populations. ADA guidelines state: "The following private entities are considered public accommodations for purposes of this subchapter, if the operations of such entities affect commerce[:] . . . a *museum*, library, gallery, or other place of *public display or collection* [emphasis added]."[7] Additionally, Section 12182 explains that: "No individual shall be discriminated against on the basis of disability in the full and equal enjoyment of the goods, services, facilities, privileges, advantages, or accommodations of any place of public accommodation by any person who owns, leases (or leases to), or operates a place of public accommodation."[8] The Horry County Museum is definitionally a museum with public displays, and their mission makes clear their goal to reach all audiences and community members.[9]

Almost all museums and historic sites are included under ADA as public places. The Department of Justice ADA website contains a section on museum access that is informational and important for all museums. Approximately 17,500 museums across the United States operated at the time the department published the article, and all of those museums had legal obligations to provide accessibility. Private museums are covered under ADA Title III, and public institutions are covered under the ADA Title II; museums that receive federal funding are covered by Section 504 of the Rehabilitation Act. For compliance, the US Department of Justice provides many tips for museums on its website, including information about accessible entrances, routes throughout the museum, and accessibility in program offerings by the museum.[10]

Many of the accommodations under ADA apply to people who use mobility devices or are sight and/or hearing impaired. However, not all disabilities are physical, and those are not always recognized by people who do not know the affected individual. Defining access becomes an exercise in its own right; museums may be accessible for wheelchairs or people with mobility issues, but what about those with mental or intellectual barriers, sensory processing disorders, differences in learning styles, or even access to travel?

In *Running a Museum: A Practical Handbook*, published in 2010 by the International Council of Museums, Vicky Woollard asks, "what is access?" She defines museum access as: "giving the visitor the opportunity to use facilities and services, view displays, attend lectures, research and study the collections, and to meet staff. This does not only mean physical access, but also includes access at the appropriate intellectual level that is free from social and cultural

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7 Houtenville and Boege, *Annual Report.*

8 US Department of Justice, *Americans with Disabilities Act of 1990,* 1990.

9 "Horry County Museum—Southern Culture, Heritage & Natural Treasures," Horry County Museum website, http://www.horrycountymuseum.org/.

10 Department of Justice, Disability Rights Section, "Maintaining Accessibility in Museums," http://www.ada.gov/business/museum_access.htm.

prejudice."[11] She goes on to cite Article 27 of the United Nation's Universal Declaration of Human Rights 1948, which states, "Everyone has the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits."[12] Wollard asserts that museums and the programs and exhibits offered therein fall under the right to participate in cultural life, and there should be no discrimination against age, sex, religious or cultural beliefs, disabilities, or sexual orientation at these places.[13]

People who study and work in museums are often left wondering what they can do in the post-ADA world to go beyond the legal obligations to serve their larger communities. Promoters of universal design principles for public spaces typically champion a larger variety of types of accommodations for those with intellectual and physical disabilities.

Universal Design

To create truly inclusive experiences, many museums and exhibit designers turn to universal design (UD) practices. Universal design provides accessibility for all people, all the time, regardless of ability, age, impairment, or knowledge. The Center for Universal Design (CUD) at the North Carolina State University College of Design describes universal design as "the design of products and environments to be usable by all people."[14] In 1997 the center published "7 Principles of Universal Design": equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and size and space for approach and use.[15]

Universal design does not just benefit individuals with disabilities, but helps all individuals experience a more positive environment. A typical example of universal design in the real world is a sidewalk with a ramp from the street; the ramp benefits wheelchairs, but also individuals who have mobility problems, strollers, bicycles, and other wheeled vehicles. As the Universal Designs and Consultants Inc. group explains, "by designing for this human diversity, we can create things that will be easier for all people to use."[16]

Universal design seemingly seeks to do the impossible: make everyone happy. Although it may be unlikely that every visitor will be accommodated at every moment, designing with UD in mind can provide a more holistic and inclusive experience. As students and instructors set out to create an accessible exhibit,

11 Vicky Woollard, "Caring for the Visitor," in *Running a Museum: A Practical Handbook*, ed. Patrick Boylan (Paris: International Council of Museums, 2010), 105.

12 United Nations, "United Nations Universal Declaration of Human Rights 1948," http://www.un.org/en/documents/udhr/index.shtml.

13 Woollard, "Caring for the Visitor," 107.

14 The Center for Universal Design, "The Principles of Universal Design," version 2.0 (Raleigh: North Carolina State University, 1997), http://www.ncsu.edu/ncsu/design/cud/about_ud/udprinciplestext.htm.

15 "The Principles of Universal Design."

16 Universal Design Consultants, Inc., "What Is Universal Design?," http://www.universaldesign.com/what-is-ud/.

A sidewalk and ramp at an intersection, illustrating universal design principles. (Photo by author)

universal design and barrier-free education were at the forefront of planning and execution of the project.

Tactile Learning

An example of accessibility and universal design in museums is the development of tactile exhibits that visitors can engage with through touch. Elaine Davis explains in *How Students Understand the Past* that one must know how the past is constructed in the minds of individuals who are shaped in turn by their age, culture, ethnicity, and other factors in order to teach history (or pre-history) effectively. Davis argues that historical knowledge is constructed through narrative understanding and logical-scientific understanding.[17] The first is important for the processing of new information in the learners' minds, while the latter is generally the

17 Elaine Davis, *How Students Understand the Past: From Theory to Practice* (Walnut Creek, CA: AltaMira Press, 2005), 117.

kind of learning that takes place in the traditional academic space or classroom. To stimulate informal learning, such as that which takes place at museums, archaeological sites, or historic places, Davis argues for active engagement, including the use of objects such as artifacts or replicas to help a learner connect to the past on a personal level. By using interactive and object-based learning, learners can be better engaged and connected in studies of the past.[18]

Davis's argument aligns with the observations of museum professionals that visitors, from small children to retired adults, all want to touch the artifacts on display. Most people learn through engagement of a variety of senses, with touch being one of the strongest. Touch is a powerful tool for learning for all people, but especially for those who are unable to see artifacts visually, or those with other sensory processing disorders or neurodivergence.[19] Restrictions on touching objects can be especially difficult for these visitors. As one visually impaired visitor claimed, "My experience [in museums] has been very poor. Usually I have to have a sighted guide with me to explain...and I've been very frustrated for you can't touch things in museums, yes very frustrated!"[20]

Because curators and archivists may balk at the suggestion that artifacts should be put on display in a tactile exhibit where any visitor can handle them, museums have come up with alternative ways of allowing visitors to have tactile experiences. Some museums use costly reproductions, such as iron tools or replicated textiles. Others have educational collections of extraneous or unprovenanced artifacts that they use for hands-on experiences.[21] One other way museums, sites, and public historians can mitigate the division between preservation and conservation and tactile exhibition is through 3-D technologies.[22] Art museums are the pioneers in 3-D printing for people with visual disabilities, though the possibilities for these technologies are seemingly endless.[23] Additionally, the costs associated with 3-D technologies are now surprisingly low.

18 Davis, *How Students Understand the Past*, 115.

19 Caroline Braden, "Welcoming All Visitors: Museums, Accessibility, and Visitors with Disabilities," *University of Michigan Working Papers in Museum Studies* 12 (2016): 1–15.

20 Saki Asakawa, João Guerreiro, Dragan Ahmetovic, Kris M. Kitani, and Chieko Asakawa, "The Present and Future of Museum Accessibility for People with Visual Impairments," in *ASSETS '18: Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility* (Galway, Ireland: ACM Press, 2018), 382–84.

21 Rebecca Gavin, "A Study of Interactives in Virginia Museums," *The Journal of Museum Education* 36, no. 2 (2011): 155–164; Tim Grove, "I Never Knew History Could Be So Fun! Visitor Experiences in the Hands-on- History Room," *History News* 54, no. 4 (1999): 18–20.

22 Yvonne French, "3D replicas create museums where touching is encouraged," *The National Library Service for the Blind and Physically Handicapped Quarterly Newsletter* (April to June 2017).

23 Caterina Balletti, Martina Ballarin, Francesco Guerra, "3D Printing: State of the Art and Future Perspectives," *Journal of Cultural Heritage* 26 (July-August 2017): 172–82; Bernard K. Means, "Printing the Past: 3D Printed Artifact Replicas Aid in Research," *Research & Development Magazine* 59, no. 3 (October 2017): 20–23.

Some museums are increasing their use of 3-D scanning and printing to document artifacts and specimens, to create or restore accurate replicas for study or display, and to make digital models available for remote access and printing. In an early example, the American Museum of Natural History made 3-D scans available as part of an educational program that resulted in 3-D prints of dinosaur fossils. The Smithsonian Institution has a large-scale 3-D digitization project with collections that can be accessed online.[24] Additionally, the National Museums of Kenya (NMK) recently completed an extensive scanning project of artifacts and fossils in their collections, resulting in a massive database of 3-D models with associated research data that can be accessed from anywhere in the world.[25] The use of 3-D scanning and printing can benefit researchers all over the world by providing remote access to specimens that can be replicated simply, accurately, and inexpensively, and provides new levels of access for those with visual and cognitive differences. 3-D printed tactiles may provide opportunities to bridge the gap for students with a range of disabilities.[26] This is what the exhibit created in the spring of 2019 tried to do.

Teaching Museum Studies, Building Community Exhibits

Preparation and Planning

In preparation for undertaking the creation of an exhibition through the academic classroom for a local museum partner, the instructors did a lot of groundwork. The authors decided that the best fit would be through courses HIST 392: Museum and Communities and ANTH 432: Cultural Resource Management (CRM). The history course generally covers the history and role of museums, and includes an experiential learning component for students. The anthropology course in CRM teaches students the best practices of cultural resource management, associated laws, and generally includes a public outreach experiential opportunity as well. Together, these courses, and the expertise of the instructors, worked well to bring together students, community members, historical and prehistorical artifacts, and a variety of stakeholders to build an exhibit using 3-D technologies. As the professors introduced the topic to students, use of tactile objects and universal design techniques for accessibility rose to the forefront as essential factors.

Coastal Carolina University is fortunate to have a wonderful partner in the Horry County Museum, and the two institutions have partnered on efforts in history and anthropology for more than a decade. Students work with the museum in internships each semester in roles such as education, curation, and

24 3D offerings, Smithsonian Institute website, https://3d.si.edu/.

25 Virtual Museum," National Museums of Kenya website, https://www.museums.or.ke/virtual-museum/.

26 Aaron D. Knochel, Wen-Hsia Hsiao, and Alyssa Pittenger, "Touching to See: Tactile Learning, Assistive Technologies, and 3-D Printing," *Art Education* 71, no. 3 (May 2018): 7–13.

communications. The partnership with this local repository for historical, prehistorical, and natural specimens benefitted all involved. The mission of the Horry County Museum is "to collect and preserve material related to the prehistory, natural history, history and culture of Horry County; to interpret and to create exhibits of such materials and to prepare educational programs related to them for presentation to the public."[27] The Horry County Museum typically welcomes approximately 25,000 visitors each year, mostly drawn from the local community, school groups, and organized tours. The mission and audience served as a starting point for students to choose and interpret important artifacts.

The instructors applied for two external grants to implement the project and purchase materials. Both grant proposals were funded through a Public Outreach Grant from the Southeastern Archaeological Conference and a South Carolina Humanities Mini-Grant. The funds were used to cover expenses associated with 3-D printing, exhibit construction, audio, and text and image panels used in the exhibit. The Horry County Museum donated the use of the exhibit space for the project and assisted in the construction of exhibit furniture. The project also received logistical, administrative, equipment, and media support from Coastal Carolina University.

The project was very cost-effective; total costs amounted to approximately $4,000, with in-kind donations including the museum space valued at approximately $2,000. The equipment to create 3-D scans and 3-D prints of the artifacts was already owned by Coastal Carolina University, which saved a substantial amount of money. The NextEngine 3-D scanner and ScanStudio software can be purchased today for approximately $3,000 and the Creality10s 3-D printer and Cura Ultimaker software are valued at approximately $450. As a result, most of the expenses were for 3D printing filament (approximately $10 per kilogram of filament printed all twenty artifacts for the exhibit) and supplies, exhibit supplies, and text and image panels, as well as the opening reception at the Horry County Museum for the target audience and general public.

Co-Creation of an Exhibition

Once funds were secured, the partnership established, and the semester began, the classes jumped straight into the work of completing the exhibition within the limited time-frame available. Students and instructors set an opening date of April 30, 2019, and everyone worked hard all semester to meet that deadline. The project had a venue, an opening date, and a vague idea of using the 3-D technologies available to us to build an exhibition that focused on accessibility for local audiences.

The first step with students was to try to write a mission statement for the exhibit. Students participated in brainstorming, but a mission statement was never

27 "Horry County Museum: Southern Culture, Heritage & Natural Treasure," Horry County Museum website, http://www.horrycountymuseum.org/.