



Students choosing their artifact from the Horry County Museum collections storage area. (Photo by author)

actually achieved, much to the chagrin of the instructor. However, students and instructors did work from the bullet points identified at the beginning of the project, which included goals of being accessible to all, working with communities, and telling the story of Horry County through material culture and natural artifacts.

To this end, students were paired up for a total of eighteen groups. Students visited the Horry County Museum to select an artifact that became their groups' responsibility throughout the project. The museum graciously opened their collections and exhibits to students and helped them select artifacts that piqued students' interests, told the larger story of the region, and met a list of requirements set by the limits of technology. This exhibit forms the first, and to date the only, 3-D printed exhibition at the museum. Exhibited artifacts were limited to objects less than ten centimeters in any direction and items that were not shiny or reflective. These parameters were put in place because of the limitations of the 3-D printer and scanner. Shiny or reflective surfaces do not produce good 3-D scans because the scanner uses laser technologies, and although objects could be coated with powder or spray-on matte pigment that may harm museum artifacts. The 3-D printer can print larger artifacts, but at a more significant cost of material and time.

The artifacts selected for 3-D scanning and printing captured a diverse subset of the collections. The authors worked closely with the museum's director, Walter Hill, in selection and interpretation. Native American artifacts spanning

Paleoindian through to modern-day Native American culture and people are featured. The 3-D exhibit includes an assortment of artifacts with tactile interest, including pottery, projectile points, a decorated pipe, and groundstone. The region's link to military history (the former Myrtle Beach Air Force Base played a major role in the growth of the region) is represented in the 3-D exhibit by aviator goggles, buttons, and military medals/medallions. Other historic artifacts include children's toys and personal items (including an ear trumpet, used by individuals who were hard of hearing, which opens conversations about how people in the past may have lived with sensory differences of their own). At the request of the museum's director, the exhibit also contains three Pleistocene fossils.

As students and faculty moved forward with creating the exhibit, they consulted with a number of stakeholders and community members, both in the disability community and the descendant communities. Students read a variety of articles on the topic of inclusion, both as an accessibility issue, and as an important principle in public history and museum practice.²⁸

At the beginning of the project, instructors met with a representative from SOS Healthcare, which serves members of the local community who have autism.²⁹ Through these stakeholder meetings, the authors received a lot of feedback and advice from the organization; perhaps the most important was an explanation of how many people with autism view images and artifacts quite literally. For instance, one of the artifacts included in the exhibit is a beaver skull. Sarah Pope, executive director at SOS Healthcare, explained that a child with autism may view the skull as separate from the beaver itself. She suggested that the exhibit include the 3-D replicated skull and a photo of a beaver skull, but also other images of live beavers in their natural habitats. This was an easy request to accommodate and met universal design best practices.

Before building the exhibit, the instructors also consulted stakeholders from the South Carolina Commission for the Blind and appreciated conversations with the interim CEO of the Pennsylvania Association for the Blind, John McInerney. Additionally, the professors received advice and guidance from Chief Harold "Buster" Hatcher of the Waccamaw Indian People, Aynor, South Carolina, who are the descendant Native American community in Horry County. Chief Hatcher spoke with students on ways to respectfully present Native American material culture and history. Finally, students interviewed family members, where appropriate, of those who used or donated historic artifacts that became part of the exhibit.

²⁸ Jenny Boulware and Elizabeth Satterfield, "Public History: Yours, Mine, and Ours," *History@Work*, <https://ncph.org/history-at-work/public-history-yours-mine-ours/>; Cherstin M. Lyon, Elizabeth M. Nix, and Rebecca K. Shrum, *Introduction to Public History: Interpreting the Past, Engaging Audiences* (Lanham, MD: Rowman and Littlefield, 2017); Katie Stringer, "The Legacy of Dime Museums and the Freakshow: How the Past Impacts the Present," *History News* 68, no. 4 (Autumn 2013): 13–18.

²⁹ SOS Healthcare, "About," SOS Healthcare website, <https://scautismhelp.com/about-us/>.

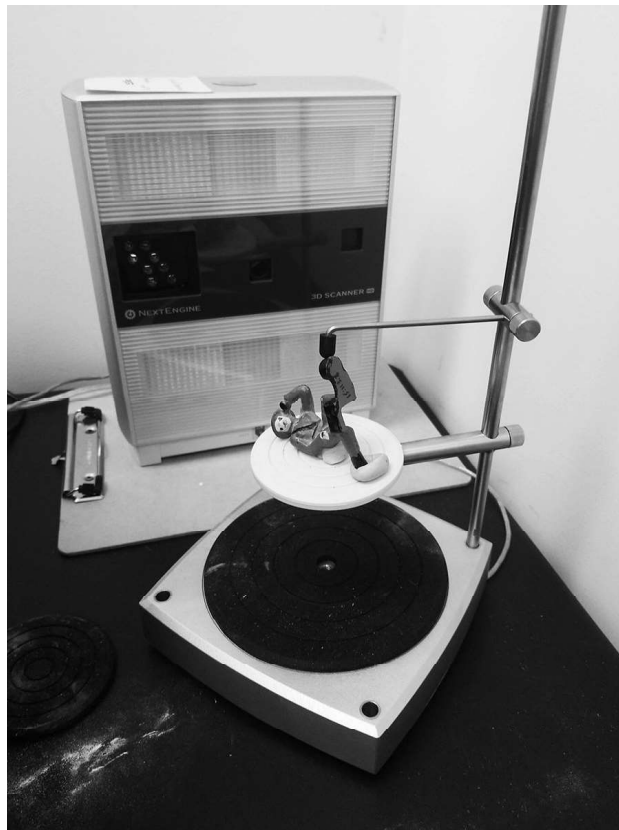


Image of students working with the 3D scanner. (Photo by author)

Building an Accessible Exhibit Using 3-D Technologies in the Classroom and Community

Once artifacts were selected, students made an appointment with Dillian to make a 3-D scan of their exhibit piece. Artifacts were scanned using a NextEngine 3-D scanner and edited using Scanstudio software in order to create an accurate digital 3-D model of each object. Students were responsible for helping to set up the scan, move the artifact around on the scanning stand to get a complete picture, and use the software to clean up and stitch the files to prepare them for printing.

The NextEngine 3-D scanner takes photographs of the object as it rotates on a stage for a complete 360-degree scan, taking up to sixteen photographs that are automatically stitched together. It also employs laser triangulation to scan depths on the surface of the object to achieve up to 0.1 mm resolution scans with full color. Users also can take additional bracketed or single scans (typically of the base and/or top of the object) and stitch them together in order to achieve a true 360-degree model. Total time per scan varied between two hours and ten hours, depending on the number of bracketed scans needed and the amount of stitching and repair required. The large file can be exported into a variety of file types for printing, study, or manipulation. In this project, files were exported as .stl files for printing using the 3-D printer under Clary's supervision.



Students working with the 3D printer. (Photo by author)

Then, students met with Clary to set up the file in another software program to prepare them for printing. The replica artifacts were 3-D printed using a Creality 3-D printer with Cura software for manipulation of 3-D files. Printing was done using 1.75 mm 3-D printer filament in a variety of colors, capable of achieving ± 0.03 mm accuracy. Colors were selected to closely match individual artifacts, including metallic copper, brass, and silver. Printing time took between two hours and sixteen hours depending on the size and complexity of the artifact. Once the artifacts were printed, students processed their objects by sanding, clipping excess filament, and preparing them for exhibition. Multicolored artifacts were painted with acrylic paints to better represent the artifact as it appeared in accompanying images.

With the printed objects in hand, students researched them with the assistance of university librarians. They then wrote interpretive panels for their group's object to give context and meaning to these seeming disparate pieces. After all the artifacts were processed and the interpretive text written, students worked with museum

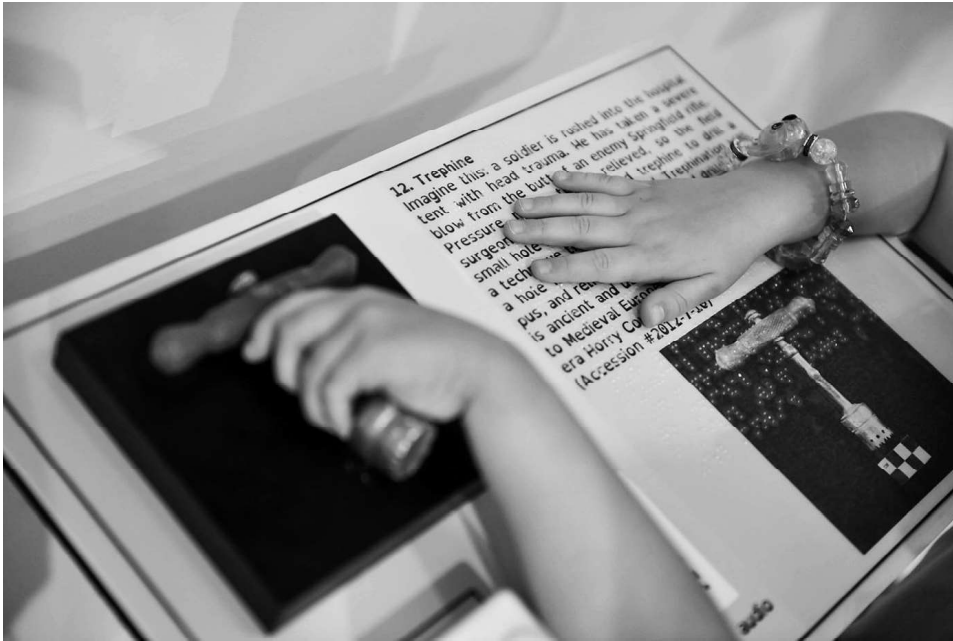


Image of a completed accessible station with 3D replica. (Photo by Scott Dean)

staff to build an individual plinth for each artifact. This meant that each group had a station for their object. Each station was designed to be as accessible to as many audiences as possible, including those who use wheelchairs or other assistive devices.

Text panels were printed on foamboard using a dyslexie font, designed to be easily read by individuals with dyslexia. All text was also provided in large-print booklets for audience use in the exhibition. Additionally, all exhibition text was printed on transparent braille panels that were affixed over the dyslexie-font printed text for braille readers. Each interpretive station also includes audio buttons using EZSoundbox audio players for non-readers. All text and images are also accessible using QR codes printed on the exhibit panels that are linked to soundcloud files³⁰ and the exhibit website, for those who prefer to use headphones in the exhibit, or for those who are hard of hearing.

For people who are unable to visit the exhibit in person, students created a website that incorporates the audio interpretation of the artifacts, as well as a layout of the floor plan, and information about the technology used to build this exhibit. Student perspectives on using the technology and creating the exhibit are also included.³¹ One of the most important parts of the website is the “What to Expect” section, which gives visitors an idea of what they will see, smell, and hear in the exhibit, which is particularly important for people with sensory differences.

³⁰ “Printing the Past: SC in 3D,” Soundcloud, <https://soundcloud.com/user-475547154/printing-the-past-sc-in-3d>.

³¹ “About,” Printing the Past: SC in 3D website, www.printingthepastscin3d.com



The exhibit space before and after installation. (Photo by author)

The university produced a video about the creation of the exhibit, which includes text captioning for those who may not be able to hear the audio. This video is on display in the exhibit, as well as available in the online exhibit. The video, produced by Coastal Carolina University, Edwards College media services, shows the processes of selecting artifacts, 3-D scanning, 3-D printing, and building the exhibit using new technologies.³²

Additionally, ANTH 432 student Sydney James used Geographic Information Systems (GIS) mapping technologies to create an interactive map of the artifacts and their original locations. Here, visitors can use the web map to identify where different artifacts on display were found. Visitors to the website can click on different locations, which are color-coded by the types of artifacts found there. The interactive map provides the visitor with general information about some of the objects on display, while also putting them into geographical and historical contexts.³³

At the museum, students decided on a chronological display of the artifacts, with the oldest pieces, Pleistocene fossils, at the beginning and the most recent,

³² "Printing the Past: SC in 3D," YouTube, <https://www.youtube.com/watch?v=QoFlfWao9U8>.

³³ "Welcome to the 'Printing the Past: SC in 3D' interactive web map!," ArcGIS, <https://www.arcgis.com/apps/webappviewer/index.html?id=0278e06efd4d4207857b6c355a06d8be>.

World War I and World War II Medals, at the end. The artifacts were arranged in a U-shape around the room, with the original artifacts in traditional display cases in the middle of the room which directed the audience to each individual display plinth for more information.

All of this work was done while also teaching museum best practices, museum history, cultural resource management law and practice, and best practices in public history to students in a variety of majors including history, anthropology, geography, education, and others.³⁴ The classes met separately about half of the time, to achieve student learning outcomes for each course, but the remaining class sessions combined both courses and both instructors. The benefit of this is that students received instruction from two experts in their fields, and also learned more about fields they may be less familiar with. Students were also exposed to the inherent interdisciplinarity of public history, as well as museum, archaeology, and cultural resource management careers.

Evaluation of Effectiveness

The objective of *Printing the Past: SC in 3D* was to remove barriers to access for those with disabilities by bringing a hands-on museum experience to a population that is unable to benefit from traditional museum exhibit design. However, benefits were not limited to the target audience. It also provides an experience for all visitors that allows tactile learning through touching a (re-created) piece of the past. The experience of touching and feeling an artifact, even if it is a 3-D rendering, helps people connect to the past and understand the experiences of people who lived hundreds or thousands of years ago. Additionally, the use of digital spaces, websites, and videos allows people who are unable to visit the museum physically to interact with artifacts and interpretation. Further, one of the major goals of this project was to educate Coastal Carolina University students in 3-D scanning/printing and museum design and to educate museum professionals about the technology and ways it can be used to make museum exhibits more accessible. The project benefited students and museum professionals, and as a result, evaluation included these audiences as well.

Evaluation of the effectiveness of the exhibit for the target audience with visual and sensory differences was done through the use of a questionnaire (IRB 2019.217) consisting of ten brief questions administered on the opening day of the exhibit.

³⁴ A selection of formative readings and resources used in the courses included: Larry Borowsky, "Telling a Story in 100 Words: Effective Label Copy," *AASLH Technical Leaflet Series* (Nashville: AASLH, 2007); Eugene Dillenburg, "What, If Anything, Is a Museum?" *Exhibitionist* (Spring 2011), 8–13; International Council of Museums, *Running a Museum: A Practical Handbook* (Paris: International Council Of Museums, 2010); Bernard K. Means, "Promoting a More Interactive Public Archaeology: Archaeological Visualization and Reflexivity through Virtual Artifact Curation," *Advances in Archaeological Practice* 3, no. 3 (2015): 235–48; "Resources for #D Documentation and Printing," The Virginia Commonwealth University Virtual Creation Lab website, <https://vcuarchaeology3d.wordpress.com/resources-for-3d-documentation-and-printing/>.



Students administering surveys at the exhibit opening. (Photo by Scott Dean)

Subjects could take the questionnaire as a paper survey or orally. A total of 171 people visited the exhibit on its opening day, and 95 people also attended an opening reception. Those in attendance at the grand opening of the exhibition and who completed evaluations included Coastal Carolina University students and faculty, clients of SOS Healthcare, members and clients of the SC Commission for the Blind, teachers and students from special needs classrooms in Horry County schools, the mayor of Conway, Coastal Carolina University administrators, and members of the general public. The grand opening included attendees of all ages, abilities, and backgrounds.

A total of 51 people completed a survey upon exiting the exhibit on its opening day, of which 39 (41 percent) completed the optional demographic portion and of those, 13 (33 percent) self-identified as having a disability. Respondents with disabilities offered suggestions in their evaluations to include bigger pictures and artifacts, and several requested headphones for the audio (which were provided, but only two pairs were available, and that was not enough for the opening day crowd). All of the respondents to the survey—including those who self-identified as not having a disability—stated that the ability to touch the 3-D printed artifacts greatly improved their museum experience. Evaluation of the effectiveness of the exhibit on Coastal Carolina University students who participated in the design was conducted through online course evaluations that assessed experiential learning objectives. A total of 14 students completed online evaluations. Students stated that



Students painting and preparing 3D prints for exhibition. (Photo by author)

they enjoyed the project and learning the 3-D scanning/printing technology. The ability to see the project to completion and interact with its target audience was one of the biggest benefits.

Measured outcomes revealed that the exhibit greatly increased the museum’s ability to serve individuals with visual or sensory differences, and raised awareness of the needs of this demographic among Coastal Carolina University students and museum professionals. Through this exhibit, instructors and students were able to demonstrate the effectiveness of 3-D scanning and printing technology in creating exhibits with universal design that can benefit the entire museum-going population. Surveys revealed that even those who did not identify as having a disability or sensory difference enjoyed the ability to touch and explore 3-D printed objects and to listen to a narration of the text through audio buttons. As a result, this exhibit improved the museum’s capacity to serve the entire community.

Conclusions

Although the authors are thrilled with the results of evaluation by visitors and of students, perhaps the farthest-reaching impact is that this project serves as a model

for other museums. The partnership between multiple university departments and the museum allowed the use of sophisticated technology, which distributed costs that might otherwise have been prohibitive. The transparency in the development of this project, and the exhibition of process within the exhibit and online, should serve to inspire other museums to create similar exhibits and partnerships. Oftentimes, limited museum budgets prohibit this type of project. Partnering with a local university's public history, museum studies, and archaeological programs can alleviate some of these costs while also providing hands-on experience in the field for students.

Printing the Past: SC in 3D will remain on display at the Horry County Museum for one year, at which point, exhibit stands will be moved and placed throughout the museum hallways for visitors to explore while walking between other exhibits. Because printing the artifacts as 3-D replicas was relatively simple and inexpensive once the basic setup and digital files had been achieved, students also cost-effectively printed duplicates of some of the artifacts for the Horry County Museum to have on-hand in case portions of the display are damaged or broken. The Horry County Museum is enthusiastic about keeping the exhibit up for a full year and then using components of the exhibit throughout its hallways as stand-alone displays. The authors will continue to work with the museum on future needs in maintaining these materials.

Additional 3-D printed copies of artifacts and the accompanying text will be placed into education kits that are used in school outreach programs and teaching materials. The website for the exhibit will remain online with photographs, text, audio links, and GIS data. 3-D models are not currently available online to the public but can be requested on a case-by-case basis from the museum. The authors' hope is that other museums or historical and archaeological organizations will partner with universities and community stakeholders to replicate this project.

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Katie Stringer Clary is a public historian and assistant professor of history at Coastal Carolina University. She received her PhD in public history from Middle Tennessee State University. Her work in accessibility in museums resulted in publication of *Programming for People with Special Needs at Museums and Historic Places* in 2014, and her current work is on the role of bodies, living and dead, in the museum.

Carolyn Dillian is an archaeologist who has conducted excavations throughout the US and Kenya to examine patterns of trade and exchange of stone and ceramic artifacts. Her work helps us understand how people moved throughout the landscape and interacted in the past, sometimes over very long distances. She holds a PhD in anthropology from the University of California, Berkeley, and serves as professor and department chair of the Department of Anthropology and Geography at Coastal Carolina University.

The exhibit, *Printing the Past: SC in 3D* was produced by Coastal Carolina University students in History 392: Museums and Communities and Anthropology 432: Cultural Resource Management, under the direction of Assistant Professor Katie Stringer Clary and Professor Carolyn Dillian. Our project greatly benefitted through conversations with a variety of stakeholders including SOS Healthcare, Myrtle Beach, South Carolina, and the South Carolina Commission for the Blind. We also appreciated conversations with the Interim CEO of the Pennsylvania Association for the Blind, John McInerney. We received advice and guidance from Chief Harold “Buster” Hatcher of the Waccamaw Indian People, Aynor, South Carolina, whose ancestors made the Native American belongings within the collections. Finally, we would like to thank the family members of those who used or donated historic artifacts that became part of the exhibit who kindly spoke to our students about the objects’ histories. Funding for this project was provided by South Carolina Humanities, a not-for-profit organization inspiring, engaging, and enriching South Carolinians with programs on literature, history, culture, and heritage; and by a Public Outreach grant from the Southeastern Archaeological Conference. Bernard Means provided helpful feedback, and we thank him for his time and review. Thank you to those at Coastal Carolina University including Michael DiGiorgio for the exhibit video production, and Abby Sink, Alli Crandell, Judy Johns, and Scott Dean, for website, printing, and photography. Thank you to staff and volunteers of the Horry County Museum, including Director Walter Hill, and Curator Hillary Winburn, and members of the campus and community for their assistance and support for this project.

Appendix – Survey Questions from Opening Day

Printing the Past: SC in 3D

Thank you for taking the time to help us develop this exhibit further by answering these 10 short questions. Optional demographic information is on the back (please only answer if you are comfortable with sharing this information)

1. Is this your first visit to the Horry County Museum?
Yes
No
2. Have you ever experienced a 3D Printed exhibit before?
3. How would you improve this exhibit?

Optional Demographic Information:

1. Age Range:
0–12
13–17