2020

Designing a Portable Museum Display of Native American Stone Projectile Points (Arrowheads) to Ensure Accessibility and Tactile Quality

Cheryl K. Fogle-Hatch

Joe Nicoli
Direct Dimensions, Inc.

Donald Winiecki
Boise State University

JBIR Journal of Blindness Innovation and Research

Home > Vol 10, No 2 (2020)

Designing a Portable Museum Display of Native American Stone Projectile Points (Arrowheads) to Ensure Accessibility and Tactile Quality

By Cheryl K. Fogle-Hatch, Joe Nicoli, and Donald Winiecki

Cheryl K. Fogle-Hatch is an archaeologist, and independent museum Professional in Baltimore, Maryland.

Joe Nicoli is an archaeologist and heritage scanning specialist at Direct Dimensions, Inc.

Donald Winiecki is a professor of ethics and morality in professional practice at the Boise State University, College of Engineering in the Department of Organizational Performance & Workplace Learning (OPWL).

Abstract

Two archaeologists and one engineering professor designed a prototype of a traveling museum exhibit that is inclusive to both blind and sighted visitors. While three dimensional (3D) replicas provide tactile information to people who are blind or have low vision, they can also be appreciated by sighted people. This paper describes the process of creating 3D replicas of stone projectile points (spear tips and arrowheads) that are found in the collections of the Maryland Archaeological and Conservation Laboratory. We define the design considerations related to (1) scanning artifacts to acquire accurate data with which to produce high-quality replicas, and (2) ensuring that visitors can retrieve information about these artifacts, including electronic braille and audio-text descriptions accessed through quick response (QR) codes on a common web-enabled smartphone.

Keywords

Museum, display, Native American artifacts, tactile exhibits

Introduction

This paper describes a prototype of a museum exhibit that is designed, from the beginning, to use technology that is accessible to museum visitors who are blind or have low vision. Our exhibit is also designed to be used by sighted visitors. The exhibit consists of three-dimensional (3D)-printed replicas of artifacts that can be physically manipulated so that they can be explored tactually. Use of 3D-printed replicas of artifacts facilitates accessibility because the replicas can be handled by the general public, both blind and sighted, while the original artifacts are kept in glass display cases where they can only be seen. Additionally, quick response (QR) codes are included that can be scanned with a smartphone (Lacoma & Weisbein, 2020) to direct the user to a webpage displaying information about the artifacts. The cost of materials used in 3D printing replicas, and fabricating and attaching QR codes was about $350. Thus, the exhibit is both affordable and inclusive as it can be experienced by mixed groups of visitors comprised of both blind and sighted people.

Our project is informed by ongoing conversations in the museum field regarding 3D printing, as well as the trend to "bring your own device" (BYOD). First, there are many applications of 3D-printing technology in the museum field (Neely & Langer, 2013), and in arts and education more generally (Krassenstein, 2015). In some cases, access to museum exhibits has been considered for blind visitors that includes creation of tactile materials (Goldberg, 2010).

Second, some museums have invested in programming to allow visitor use of their own devices (Hudelson & Austin-Gonzalez, 2019; Sayre, 2015; Walker, 2008). BYOD programming has the potential to provide access to blind people because personal devices like modern smartphones and tablets contain features that make media accessible (Goldberg, 2010). Assistive technologies such as refreshable braille displays, screen readers, and screen magnification can help this population to access content of museum exhibits providing that the exhibits are well-designed and use media that enables access of information through these technologies. If blind visitors are encouraged to use their own devices, they may use their preferred accessibility settings to retrieve information, thus providing a greater degree of independence for the visitor.

The prototype exhibit design described in this article provides an example of methods that museums can employ to take advantage of both 3D printing and the access technology common on smartphones to improve accessibility of information for visitors who are blind or have low vision. Our prototype was tested by a mixed group of blind and sighted attendees at a tactile graphics symposium (Fogle-Hatch et al. 2018), organized by the National Federation of the Blind Jernigan Institute in Baltimore, Maryland. Since we have not displayed this exhibit at another venue, we cannot comment on any resource constraints that could be faced by a potential museum partner to complete a similar project. Our aim in writing this paper is to describe our innovation and to further the exploration of ways in which exhibit content can be made accessible to visitors who are blind or have low vision while also being inclusive to a general sighted audience.

The Content

The artifacts that were scanned to produce 3D-printed replicas in this prototype exhibit came from the collections of the Maryland Archaeological Conservation Laboratory, at the Jefferson Patterson Park and Museum (https://jefpat.maryland.gov). The museum's collection of artifacts documents 12,000 years of prehistoric human occupation in what is now the state of Maryland in the United States. The artifacts are available for research and educational purposes. They have been cleaned, and they are accompanied by hand-written artifact tags that identify the archaeological site from which they were recovered.

Stone projectile points (spear tips or arrowheads) were chosen for this case study because they are relatively inexpensive to replicate as 3D-printed models given their small size (about 5-10 cm, or 2-4 inches, in length). Furthermore, these stone tools can be distinguished tactually based on differences in their size, shape, material characteristics, and surface features. The projectile points have a triangular tip, a somewhat wider midsection, and a base specifically shaped to attach to the spear or arrow shaft. Although the tool is generally uniform in thickness, it is not entirely flat. Irregularities on the surface of the projectile point are called flake scars, impressions that were left as material was removed during manufacture.

Projectile points are common in the archaeological record, and archaeologists working in Maryland have documented changes in their shape through time (Dent, 1995). The projectile points replicated for this project were made by hunter-gatherers during what archaeologists classify as the Paleoindian and Archaic periods of Maryland prehistory. The Paleoindian period occurred at the end of the last ice age (approximately 11,000 B.C. – 9500 B.C.) prior to the onset of modern climatic conditions during the Archaic period (approximately 9500 B.C. – 1250 B.C.). Photographs and descriptions of the various projectile point styles can be found on the website of the Maryland Archaeological Conservation Laboratory (https://jefpat.maryland.gov).

Design Begins with the Principal Goal in Mind

Museum professionals generally agree that technology can support and guide sighted museum visitors as they learn about the content of a particular exhibit (Walker, 2008). Additionally, the sighted visitor's museum experience can be enhanced with use of well-designed digital tools (Falk & Dierking, 2008). In the same manner, design considerations also affect accessibility for blind museum visitors (Goldberg, 2010). The use of audio recordings and hand-held playback devices allows visitors to listen to descriptions of artifacts as they guide themselves through a museum. However, while these technologies permit access to narrated information for blind visitors, they cannot be substituted for the direct experience of seeing artifacts as they are described. To ensure accessibility for all visitors we set out several design goals for this project.

Direct Experience: The exhibit should contain a set of objects that are inexpensive reproductions of actual artifacts (this allows us to design the exhibit for direct, personal experience with the artifacts, and not be afraid of damaging original materials).

Authentic Feel: The exhibit should provide material characteristics that are accurate for the intended purposes and visitors attending the exhibit.

Interpretive Information: In addition to direct access to replicas of the artifacts, the exhibit should provide a parallel set of information that describes and interprets physical features of the artifacts and provides a look into the culture and technologies of the people who created them.

Easy to Use: The exhibit should facilitate convenient access to physical details and additional information without introducing unfamiliar technologies.

Provide a Full Museum Experience: The exhibit should permit a direct, personal experience with the artifacts and associated information that is not inhibited by common problems in museums that sacrifice accessibility in favor of protecting the artifacts.

Portability and Ease of Setup/Takedown, and Maintenance: The exhibit should be lightweight, compact, and easily transportable, and made of materials that are not expensive.

We imagined that the experience of this exhibit includes at least three components: (a) museum professionals and visitors; (b) artifacts; and (c) additional information. Following is a description of how we envisioned that the exhibit would be experienced.

When visitors approach the exhibit, a representative of the museum will orient them to the display and demonstrate scanning a QR code with a smartphone. The exhibit will be small enough to fit on a table and can be arranged in the desired chronological order. The small size of each replica allows visitors to pick it up with one hand and investigate the tactile characteristics of the artifact including its shape and surface features. Connected to each replica artifact will be a means through which the visitor could use a modern smartphone to access more information about the object. Visitors would be encouraged to bring earbuds for use with their smartphones to reduce clutter in the sonic environment. Alternatively, if the cell-phone user had connected a refreshable-braille device to his or her phone, he or she could read the text of the webpage in braille.

Material Considerations

Preparing an object for 3D printing involves scanning it with a laser system to create a mathematical model of the physical surface and form to be reproduced. These data are then stored in a digital file. This file is known as a model of the original object. "Then, 3D printing is a process of taking a digital 3D model and turning that digital file into a physical object" (Krassenstein, 2015, para. 2).

Scanning for 3D Printing of Replica Artifacts

In archaeology, the texture of an artifact is a critical quality. The second author has shown that replicas made from objects that have a "soft," more or less porous, or finely-textured surface do not scan as well as artifacts made of materials with hard and polished, or smooth, surfaces. Grainy materials like quartzite do not scan well. By contrast, a dull gray, volcanic material called rhyolite is a good candidate for scanning. As such, we chose projectile points for scanning based on the material from which they were made. We expect that improvements in 3D-scanning technology will eventually allow high-quality scanning of materials found here to be unacceptable candidates.

Staff at Direct Dimensions—a company specializing in 3D scanning, imaging, and reproduction technologies—scanned 18 projectile points using a Faro Edge Arm. The Faro Edge Arm is a laser scanning system able to produce extremely reliable 3D scans of complex and intricate objects. Data scanned from each artifact was saved to a laptop along with a picture of the hand-written artifact tag from the Jefferson Patterson Museum that accompanied it. The data from each scan was processed into a 3D model at the Direct Dimensions facility in Owings Mills, Maryland. Three-dimensional prints using these scanned models were produced using an acrylic resin because that material has surface and hardness characteristics that were assessed to be an approximation of the stone material from which the artifacts were made (figure 1).

Making Additional Information Accessible

The 3D replicas included had to be readily identifiable and relevant archaeological information needed to be accessible to visitors. We experimented with several strategies to accomplish these goals. A QR code is a type of barcode that is square in shape and contains a matrix of dots (Christensson, 2015) that encodes additional information, such as a webpage URL. We created QR codes that linked to specific pages on the website of the Maryland Archaeological Conservation Laboratory that described each of the 18 types of projectile point that we included in our prototype exhibit. The QR codes were created using a free web-based tool (https://www.qr-code-generator.com/how-to-create-a-qr-code/). One need only enter the URL to which the QR code should be linked, and the tool generates the QR code in common graphic formats.

We discovered a drawback to this early in our prototyping. The QR codes generated are specific to one particular URL. If the URL changes, the associated QR code must be updated to direct a smartphone to the new website address. We discovered this when the museum changed the design of their webpages and thus the URLs. We had to quickly re-create the QR codes to match the new URLs. This suggests that designers of such exhibits should be in constant and direct communication with individuals who maintain the webpages so that similar issues do not interrupt access to information.

At first, we tried including the QR code in the 3D model so that it was printed directly on the surface of each replica. This proved unworkable. While QR codes are supposed to be very tolerant of surface variation and resolution of the embedded dots, when the QR codes were printed directly onto the side of our replica artifacts, they were unreadable by our smartphones.

Still seeking a very compact solution, we decided to attach the QR code to the 3D-printed replica. We determined that adding material to one side of the base was the most effective way of creating an attachment point for the 3D prints. Although this method has the disadvantage of altering features on one face of the projectile point replica, it preserves the accurate flaking pattern on the other face. Each print was then attached by a sturdy lanyard connected to a wooden "coin" containing the corresponding QR code (figure 2a, 2b). Even with the addition of the lanyards and QR code coins, the exhibit of 18 3D replicas remains compact and durable (figure 3).

Testing the Design

Our test run occurred during our presentation at the National Federation of the Blind Jernigan Institute Tactile Graphics Symposium on October 12, 2018. As suggested above, we decided that it would be helpful to give brief instructions to our audience in order to ensure that both blind and sighted people could access information provided by the QR code. Attendees were instructed to hold their smartphones over the QR coin and open the camera app. We explained that the camera would recognize the QR code and prompt the user to open a website. Once on the website, we directed attendees to find the text describing the projectile point type. For most attendees, once they opened the website, their cursor was placed on the descriptive text, but for others, we advised them to skip the masthead of the museum's website. This problem could be avoided by producing dedicated webpages that only contain descriptions of each replica artifact. This would ensure the desired information was immediately found by all smartphones.

We found that our design of 3D prints including a standardized, compact, and easy-to-locate placement of QR codes along with brief instructions resulted in successful use by both blind and sighted users. We concluded that visitors may access information via QR code with minimal instruction, and therefore, the QR code represents proof of one approach to ensure accessibility of BYOD programming for visitors who are blind or have low vision. Our presentation at the symposium provided a test of the technology and use of QR codes to access additional information about the 3D-printed replicas. While added teaching about archaeology was beyond the scope of that presentation, the fact that visitors were readily able to access relevant information makes that a next step that most museum professionals and docents would welcome!

Conclusion

We employed widely available technology to create a prototype of a museum exhibit that is accessible to museum visitors who are blind or have low vision. The design includes elements that are also accessible to sighted visitors. The 3D-printed replicas of stone projectile points can be experienced tactually, and visitors can obtain additional information about these replicas by scanning QR codes with their own devices. This extends the trend for BYOD programming in the museum field to include visitors who are blind or have low vision.

Here we have described the range of considerations necessary in the design of a tactile museum exhibit of Native American stone projectile points. At each point in the design (and redesign) and development of this exhibit we returned to the original design goals for the project. To summarize, the project goal is to provide visitors with a direct experience in which they examine objects that are inexpensive reproductions of actual artifacts. These reproductions were created from 3D digital models and printed with high-quality materials to create an accurate representation of the tactile characteristics of the artifacts. The exhibit is lightweight, compact, and easily transportable. The exhibit is easy to use; it facilitates convenient access to physical details and additional information without introducing unfamiliar technologies. The entire cost of materials involved in creating and printing 3D replicas, along with the QR coins was about $350. We should note that for this project, the actual cost of materials and labor was donated. Readers interested in experimenting with our design process should verify that materials can be produced within their budget before proceeding.

Implications for Practitioners

The materials and methods prototyped in this project can be applied to the design of accessible displays in museums generally. For example, in two museums in Idaho and one in Texas, the third author of this article is helping to design tactile display items to include QR codes similar to those described here. While the previous materials were tactile and thus somewhat accessible, information about the objects was previously only available in print. The QR codes improve accessibility to the text of museum labels, thus allowing the blind visitor to have an experience that more closely matches that of a typical sighted museum visitor. Use of BYOD devices allows visitors more independence in exploring material and supporting information, which in turn improves the visitor’s experience and increases overall enjoyment and learning in museums for all visitors.

In a next-generation application of QR codes arising from this project, the third author of this article is redesigning touchscreen displays in kiosk locations to include QR codes that allow a patron using a smartphone to access a separate and fully accessible version of the touchscreen display on that device. The QR code is always located a fixed distance from the bottom-left corner of the touchscreen and is marked by a tactile feature on the bezel of the touchscreen to permit a patron to locate it easily. The user need only know that the QR code is available, and that a standardized tactile feature can be used to help locate it. This simple treatment converts what was previously an inaccessible touchscreen to a display device that is accessible and independently controllable by a patron using a smartphone with voiceover or a connected refreshable-braille device.

In both cases, the coin-sized QR code becomes, quite literally, an opening to new possibilities for visitors to interact with exhibits and learn in museums. As new information becomes available for existing display materials or touchscreens, only the webpages linked to the QR codes need be updated—no changes need be made to the actual exhibits and displays. This reduces costs for updates and redesigns, which increases the possibility that museums will take advantage of this technology. The nearly ubiquitous and easy-to-use QR code thus becomes a means to improve accessibility to materials and information in museums.

QR codes and an attachment system like the one that we have described could be added to other 3D models from online libraries such as Sketchfab, Thingiverse, Shapeify, BTactile, etc. The attachment system could also be added to pre-existing 3D-scanned models using free software such as K-3D, or paid software such as SketchUp. For example, a teacher could create a tactile replica for a student, and include a QR code that, when scanned, would provide access to additional information about the object. The same concepts described here could be applied in other venues limited only to the imagination of designers.

Acknowledgements

We heartily thank the research staff at the Maryland Archaeological Conservation Laboratory, particularly Ed Chaney for granting us access to the artifact collections, and Rebecca Morehouse for helping us select projectile points for scanning. We also thank Michael Raphael, the CEO of Direct Dimensions who provided significant in-kind support for this project that included donating the time and labor of employees to scan and produce the 3D models. He also covered the materials cost for the 3D replicas and QR code attachment system.

References

Christensson, P. (2015, March 5). *QR Code Definition*. Retrieved August 30, 2018, from https://techterms.com/definition/qr_code

Dent, R. J. (1995). *Chesapeake prehistory: Old traditions, new directions*. Plenum Press.

Falk, J. H., & Dierking, L. D. (2008). Enhancing visitor interaction and learning with mobile technologies. In L. Tallon & K. Walker (Eds.), *Digital technologies and the museum experience: Handheld guides and other media* (pp. 19–34). AltaMira Press.

Fogle-Hatch, C., J. Nicoli, & D. Winiecki (2018, October 12) Prototyping a tactile archaeological museum exhibit for blind and visually-impaired visitors: A design study [Conference Session]. Tactile Graphics in Education and Careers, National Federation of the Blind, Jernigan Institute, Baltimore MD United States.

Goldberg, L. (2010). Exhibit design relating to low vision and blindness: Current media technology, appropriate application of technology, future research needs. (White paper). Indiana University, Bloomington, IN, United States.

Hudelson, N., & Austin-Gonzalez, C. (2019, January 15). *Innovation on a shoestring: Testing BYOD concepts without building anything* [Conference Session]. Museums and the Web, Boston, MA, United States. https://mw19.mwconf.org/paper/innovation-on-a-shoestring-testing-byod-concepts-without-building-anything/

Krassenstein, B. (2015, July 18). *What is 3D printing & how do 3D printers work? -- A guide*. 3DR Holdings, LLC. https://3dprint.com/82272/what-3d-printing-works/

Lacoma, T., & Weisbein, J. (2020, April 6). How to scan a QR code on Android and iOS, Designtechnica Corporation. Retrieved May 16, 2020, from Digital Trends website: https://www.digitaltrends.com/mobile/how-to-scan-a-qr-code/

Neely, L., & Langer, M. (2013, January 31). *Please feel the museum: The emergence of 3D printing and scanning* [Conference Session]. Museums and the Web, Portland, OR, United States. https://mw2013.museumsandtheweb.com/paper/please-feel-the-museum-the-emergence-of-3d-printing-and-scanning/

Sayre, S. (2015, January 31). *Bring it on: Ensuring the success of BYOD programming in the museum environment* [Conference Session]. Museums and the Web, Boston, MA, United States. https://mw2015.museumsandtheweb.com/paper/bring-it-on-ensuring-the-success-of-byod-programming-in-the-museum-environment/

Walker, K. (2008). Structuring visitor participation. In L. Tallon & K. Walker (Eds.), *Digital technologies and the museum experience: Handheld guides and other media* (pp. 109–124). AltaMira Press.

List of Figures

Figure 1. 2D image of stone projectile points modeled and arrayed on a computer screen prior to 3D printing.

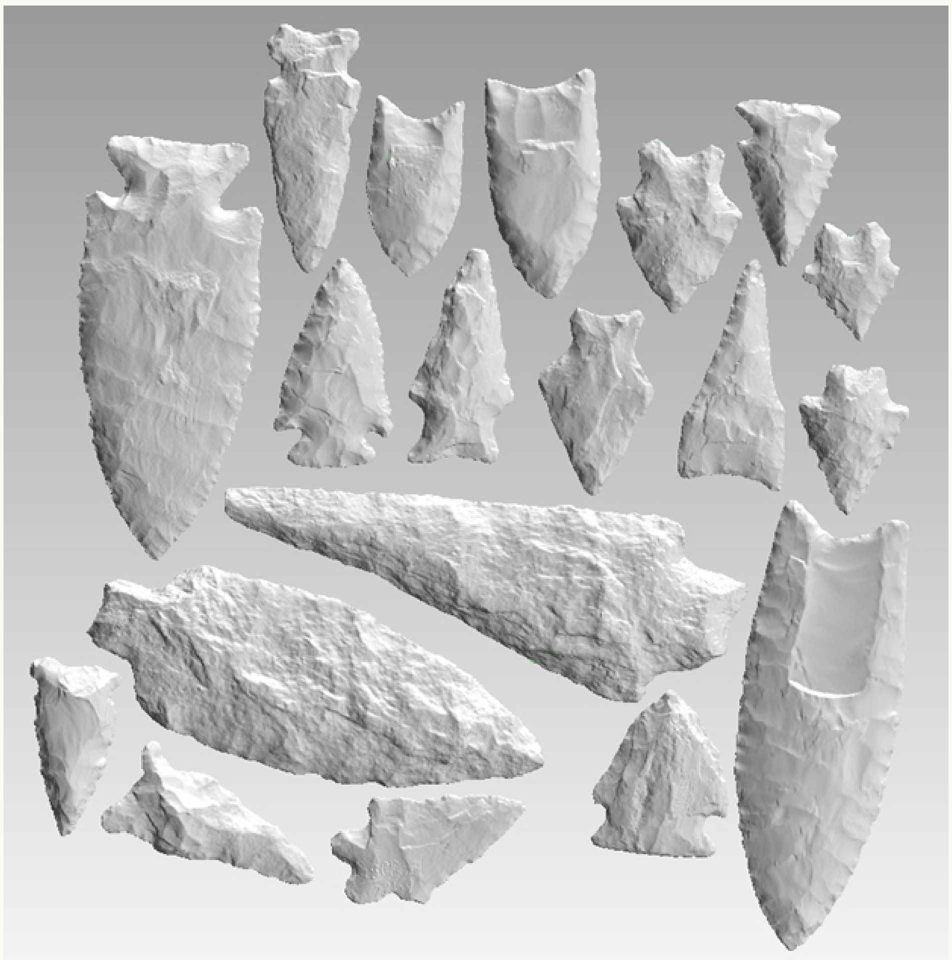

Figure 2a. Wooden ‘coin’ with QR code and lanyard.

Figure 2b. 3D printed stone point with lanyard attachment.

Figure 3. All 18 replica stone points, with affixed QR code ‘coins’.