Roving with a Digital Visual Library

Increased Learning Opportunities at Carlsbad Caverns National Park

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Abstract
At Carlsbad Caverns National Park, park rangers blended traditional personal interpretation with technology to showcase park-based research and to advance science literacy among visitors. *Interpreters and Scientists Working on Our Parks* (iSWOOP) provided interpreters with professional development and a selection of visualizations from scientists' research on Brazilian free-tailed bats and their habitat at Carlsbad Caverns. After using tablets containing these visualizations for informal interpretive interactions, the interpreters responded to an open-ended survey. The authors examined interpreters' responses, finding that interpreters regarded tablets as helpful in accomplishing several interpretive goals, especially in particular locations. Interpreters were strategic in initiating and sustaining interactions. Visitors' reactions were positive; nevertheless, there were challenges indicating that this new form of interpretation is worthy of further research.

Keywords
interpretation, informal education, park-based science, roving, tablet technology, revelation, science communication, National Park Service, iPad

Introduction

With its second century at hand, the National Park System has challenged its staff and partners to offer visitors interactive experiences, incorporating new technology, and highlighting current scholarship (National Park Service, 2012). Increasing visitors' science literacy; that is, the understanding of how we know what we know, has the potential to stimulate intellectual and emotional connections to national parks. With limited resources to accomplish these new and traditional interpretive goals, the demand for creative approaches is high.

Committed to increasing science learning opportunities and literacy, *Interpreters and Scientists Working on Our Parks* (iSWOOP) seeks to meet these challenges. iSWOOP delivers professional development that ensures interpreters have both a working knowledge of recent and current studies as well as questioning strategies to engage the public in two-way conversations about them. We are extending research in the areas of informal science learning with handheld devices in museums and school settings to parks while attending to the fit with the literature on personal interpretation.

In its pilot at Carlsbad Caverns (a pathways project funded by the National Science Foundation for professional development of interpreters), the project shared a library of scientists' visualizations on two tablets. During roves, which are informal conversations usually within an assigned area, interpreters used tablets to display a variety of visual media to visitors, revealing the research behind the scenes. Interpreters' assessment of the value of blending traditional personal, informal interpretation with 21st-century technology and the challenges they encountered established a starting point for further research on the value of tablets in park interpreters' hands.

Literature Review

Learning for park visitors can start on websites long before the visitors' arrival and can continue on after the visit. On-site, visitors can take advantage of ranger talks, service learning, citizen science projects, and special events. This is typical of informal learning, which is idiosyncratically pieced together across different venues and times, from a wealth of opportunities and through varied media (Falk & Dierking, 2010; National Research Council, 2009). In addition to structured tours and talks at national parks, visitors often interact informally with park rangers whose focus is interpretation and education. Informal education researchers are beginning to investigate the dynamics at work in these interactions. Reflecting on interviews with Cape Hatteras National Seashore visitors who interacted with rangers, Knackmuhs (2015) noted that all respondents remembered the general topic of conversation, while the ability to recall more detailed content varied widely. Respondents spoke at length about how they appreciated the ranger's time, genuine interest, and one-on-one attention. Pattison and Dierking (2013) argue for analyzing visitor-interpreter interactions using a mediated discourse perspective to gain insight into how adults negotiate roles, identities, power, and authority within these informal learning opportunities. Their research on interactions between museum educators and family groups makes it clear that adult family members play a critical role in shaping the nature of the interactions. In a

mixed methods study at a zoo, Mony and Heimlich (2008) found where and how the interactions were initiated influenced the length of the interactions and the number of key educational messages the interpreter delivered. Taken together, the literature suggests that in addition to analyzing discourse content, the field would do well to have a more nuanced understanding of the techniques for initiating and sustaining substantive engagement, as well as the value visitors ascribe to these interactions.

In the eyes of the National Park Service, an interpreter's job is to create opportunities for the audience to form their own intellectual and emotional connections with the meanings and significance inherent in the resource (Knackmuhs, 2015). In order to foster visitors' instincts to care for and protect natural resources, interpreters draw on techniques such as storytelling, questioning, and demonstrations with props. Interpreters are accustomed to finding a style and approach that works for them (K. Haynie, personal communication, January 2016). In a study of more than 300 interpretive programs, 66% of interpreters had the freedom to write a script, develop a delivery style, and select information to present even when the program topic was provided (Stern & Powell, 2013). Today's visitors are accustomed to richly interactive environments, where their stories, comments, and creativity contribute to a greater whole (Rudy, 2014). Furthermore, evidence from visitor interviews conducted months after an interpretive experience suggests that two-way communication can increase the strength of the impression interpreters make on visitors (Forist & Knapp, 2013, 2014). The Park Service is noticeably taking steps to endorse particular approaches. For example, the new competencies from the National Park Service's Interpretive Development Program emphasize audience involvement in programs that evolve with significant audience contributions (National Park System Advisory Board Education Committee, 2014; National Park Service's Interpretive Development Program, 2016).

At a glance, the interpretive assignment of roving sounds like a simple task: during roves interpreters simply greet and chat with groups of people (Ham, 1992). However, skilled interpreters listen for visitors' interests and look for opportunities to connect them with the natural resources (Miller, 2015; Bonnell, 2015; Sexton, 2015). The literature stresses that impressing visitors with facts about the park is not sufficient, whereas revelation—helping visitors explore and interpret what they see—is (Larsen, 2003; Tilden, 1957). In this article we also regard revelation as worthwhile and central to interpretation. We have seen how a striking or well-timed revelation focuses visitors' attention. Povis and Crowley (2015) found that parents and children who established joint attention using flashlights in an exhibit were more likely to engage in learning talk about an exhibited object than those who did not have a tool to focus their gaze. Thus revealing aspects of an artifact or resource can lead visitors to appreciate visible but easily overlooked details and such revelations can propel conversations. Flashlights, signs, and as we assert, tablets, also have the potential to increase joint looking.

Tablets have gained traction as the device of choice in a variety of settings. In the absence of multiple published studies of their uses and benefits to casual, recreational visitors in parks, we broadened our review of the literature to include articles on handheld devices and mobile computers in park and museum settings. In all settings a key affordance of handheld devices is the potential to increase visitors' appreciation for artifacts or places. MacArthur (2014), observing at Acadia National Park, found visitors offered more exclamations of interest when an interpreter used a tablet than when the he used books or brochures alone. In two articles about using hand-held devices in

museums, the visitors were in control of the devices. Mobile device users were able to tap into the collection, accessing information customized to their dominant senses (Linzer, 2013; Goodwin, 2013). Swift (2013) describes intersections in London coming alive with sounds and typical sights from past eras. Handheld devices were a vehicle to reveal aspects of what was on display that visitors might otherwise not have perceived or imagined.

In the case of 21-Tech, a collaboration of five science museums, tablets started off in the hands of floor educators rather than visitors. Then floor educators invited visitors to use apps on the tablets to explore the exhibit content. Evaluators found that visitors benefitted particularly when the apps had a tight relationship to the physical exhibit that was easy to understand and yet were not so compelling that they took visitor attention away from the exhibit (Garibay & Ostfeld, 2013). The literature suggests that keeping interpreters interacting with visitors yields benefits to learning such as stay time, knowledge gains, and enjoyment (Benne, Pattison, Rubin, & Dierking, 2016; Garibay & Ostfeld, 2013; Perdue, Stolinski, & Maple, 2012). However, having staff facilitate interactions with handheld devices is not a trivial undertaking. 21-Tech found that the staff needed time to practice using the devices in order to explore connections with exhibits, and handle the technology and transitions while effectively interacting with visitors (Garibay & Ostfeld, 2013).

Zimmerman and Land (2014) proposed design guidelines for mobile computers to advance place-based learning. The design guidelines underscore the potential for tablets to 1) amplify observations revealing aspects of a place or its artifacts; 2) explore non-visible aspects of a place through visualizations; and 3) be a catalyst for disciplinary conversations with personal relevance and explorations of new perspectives or representations of data. Even in relatively short, unplanned informal interactions, interpreters using the iSWOOP visual library reported conversations along these lines, which will be discussed later in this article. Although Stern and Powell (2013) didn't look for revelation as a program characteristic per se, when they observed interpretive programs, they did code for novelty and surprise. They drew a distinction between the two, defining novelty as the degree to which a program presented novel ideas, techniques, or viewpoints as an element of communication; i.e., using a device not usually associated with or related to the resource, whereas surprise was defined as an "aha" moment. Both characteristics were minimally represented in the 312 programs analyzed. Mean ratings hovered around 1.15 for groups of five or more, based on a three-point scale where novelty and surprise were 1, not used, 2, used as a minor element, and 3, used as a major element. The emphasis on revelation in the interpretive literature is well established, but the question of whether this is an interpretive practice that correlates with visitor satisfaction, visitor experience and appreciation, or behavior change is still to be determined. And the full extent of what this term of *revelation* encapsulates or how to operationalize it needs further articulation and agreement in the field.

Research Questions

Interpreters recruited to participate in the project at Carlsbad Caverns National Park in New Mexico forged the iSWOOP approach of integrating handheld devices into the visitor experience. In this article on iSWOOP implementation, we look at: 1) how interpreters characterized the benefits of the iSWOOP visual library; i.e., what did it help them accomplish; 2) the strategies they used to initiate and sustain iSWOOP tablet-based

interpretive conversations on park-based research; i.e., how they began and sustained conversations; and 3) the challenges interpreters mentioned; i.e., challenges encountered when integrating tablets into their practice.

Methods and Data Sources

Methods
We selected a qualitative approach using interpretive methods to understand interpreters' perspectives and experience using tablets during their roves. Analyzing responses to an open-ended survey provided an opportunity to see the variation in interpreters' experiences, as well as to draw out thematic patterns. Observations and blog posts confirmed interpreters' assertions and informed categories and themes.

Setting
Carlsbad Caverns National Park attracted approximately 397,000 visitors in 2014. During summer months visitors gathered in the amphitheater at sunset to watch the emergence of hundreds of thousands of bats. Most park visitors followed the self-guided tour route through the cave. Low light, simple signage, and tours by candle-lit lanterns helped visitors imagine the experience of cave explorers a century ago. Curious visitors read signs, rented an audio guide, or asked rangers questions. Roving interpreters walked through the cave against visitor traffic or took up standing positions at specific locations for periods of about 90 minutes. Interpreters' roving styles varied from nods to actively inviting interaction with tour groups, families, singles, and couples. Interpreters used flashlights to point out features of the resource the visitors could easily overlook: an imprint of a prehistoric shellfish or a droplet of water forming a crust (Dillon, 2011). Not surprisingly, conversations about bats occurred most naturally at the sign that pointed out the passage to bat cave. At this spot, the sign abutted an area with a stone bench and standing space for about ten people.

Participants
Interpreters in both seasonal and permanent positions (8 seasonal; 9 permanent) took part in the iSWOOP project. Their experience at the Caverns ranged from several weeks to multiple seasons. All interpreters had worked at other parks and the majority had college degrees reflecting varied interests including environmental science, geology, anthropology, and history. The majority were in their 20s and 30s, with men being the slight majority of the participants. Comfort levels with the tablets varied; however, all expressed a strong interest in communicating science. During the project period, 17 staff were trained; however, due to turnover, 13 trained staff were on-site during the data collection timeframe. Of these, nine roved regularly with the tablets and completed the open-ended survey. (All interpreters named here have been assigned pseudonyms.) Supervisory interpreter Cox set up the system for collecting data on the number of interactions and synthesized the tallies. Project director Merson followed up to solicit the perspectives from three of the four interpreters who did not rove with the iPads. All of the authors had input in the design of the professional development and offered support for iSWOOP implementation.

Location	Roves & Contacts	Interpreters' Comments Noted alongside Contact Numbers
Main Corridor/Bat Cave Turn-off	26 Roves: 791 contacts	"Very interested, visitors engaged and excited" (*56 contacts)* "Good contacts, great questions" *47 contacts* "Kids loved the bat photos" *21 contacts* "Twenty-five minute iSWOOP interlude" *5 contacts*
Big Room	15 Roves: 369 contacts	"Pairs and singles; long, high quality conversations" *7 contacts* "Very busy rove, but traffic prevents more contacts" *112 contacts*
Visitor Center Rove	48 Roves: 489 Contacts	"One couple was really interested" *6 contacts* Visitor Comment: "Thanks for showing me this" *9 Contacts* "Critter program, used iPad to augment program" *42 contacts*

Table 1: Fostering Science Literacy

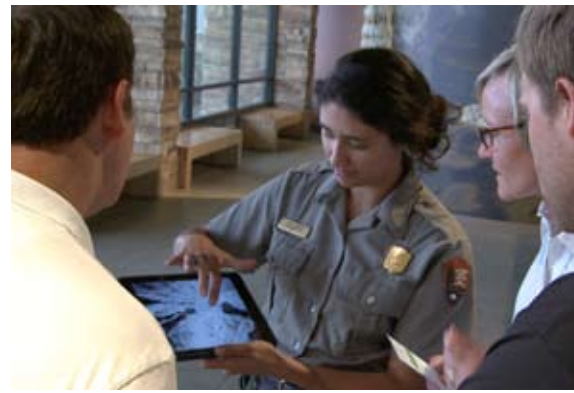
Professional development

Beginning in January 2014, iSWOOP conducted 24 hours of seminar-style and field-based professional development for interpreters, and made available a visual library and display devices to Carlsbad Caverns. To ensure compatibility with researchers' file formats, the project used Apple products, which is the reason interpreters refer to iPads rather than tablets in their survey responses. During professional development sessions, participants in seminars and field-based experiences became familiar with cutting-edge methods for studying wildlife. They operated laser scanners and thermal cameras. Project leaders encouraged interpreters to design programs with opportunities for visitors to observe, speculate, and make predictions based on elements from the visual library. Professional development and interpretive programming were designed to build on the curiosity that drives individuals to ask questions and figure out ways to answer them (Firestein, 2012). In June 2014, biologists Allen and Hristov configured two tablets with a visual library of colorful images, video, animations, and graphs based on a decade of their research on the Brazilian free-tailed bat, its habitat, and colony dynamics. As a result of the iSWOOP project, interpreters had access to arresting visual examples of research on public lands, strategies for discussing scientists' findings, and a greater knowledge base of the research on Brazilian free-tailed bats (Char, 2015).

Once interpreters had tablets at their disposal, they had the means to convey information based on current scholarship, along with the mobility and flexibility to customize the content as they engaged visitors. An interpreter described her approach as follows:

> "As I rove the cave and I approach groups I will say hello and ask them how they are doing and if they are enjoying the cave. This usually helps them warm up and invites them to talk to me. I will then ask them if they have any questions. Depending on what they say I will then use the iPad or not. If they have questions regarding studies in the cave, or the bats I will use the iPad." —Mina, 8/22/14

As shown in Table 1, when met with a question, interpreters could promote science literacy and provoke thinking about what and how scientists know what they know. With iSWOOP they had questioning strategies and the visual library with graphs, videos, animations, and still images they could draw on to invite visitors to take an active part in answering their own questions.



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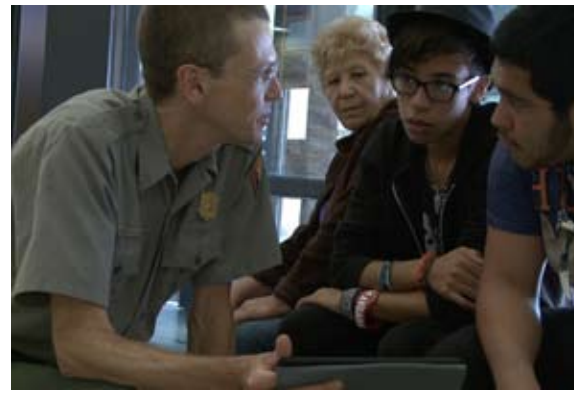

JONATHAN PFUNDSTEIN

Figure 1: Roving with a Tablet-based Visual Library Using iPads during roves in the visitor center and in the cave became an accepted practice. Interpreters roved in the visitor center, sharing scientists' visualizations with interested visitors.

Data sources

For this study, we used a qualitative approach, drawing from techniques in constructivist grounded theory (Charmaz, 2006) to understand interpreters' perspectives and experiences using tablets during their roves. Emerging themes from several data sources were used to inform the open-ended survey on roving and subsequently to organize and analyze open-ended responses.

During the project, the research team collected a variety of data. Interpreters were shadowed during formal programs and roves; this generated field notes on roves led by iSWOOP interpreters. Email exchanges, approximately 75 blog posts, notes from three conference calls, interpreters' feedback on the professional development sessions, and pre- and post-surveys administered before and approximately 12 weeks after professional development were collected. According to park-collected statistics, the number of visitor interactions ranged from three to 300 per rove. "Interactions" were cases where interpreters showed one or more visitors visualizations on the project tablet and conversed for some time, usually between two and 20 minutes. Each visitor present for the interaction counted as a contact. Table 2 summarizes the park-collected statistics. The table shows the number of roves, number of contacts, and includes examples of comments from three locations. (One location, the visitor center, is shown in Figure 1.)

Theme	Prompts
Initiating and sustaining conversations	Did you usually start conversations with visitors, or did they usually approach you first? What questions did you ask to initiate a conversation with a visitor? Give examples of questions that generated dialogue. List which images and animations you used.
Visitor response	What kind of responses did you hear to information you gave to visitors?
Challenges	Using iPads on roves is new. What challenges do you see?
Opportunities	What value do you see in this approach?

Table 2: Summary of the Park's Statistics: 89 Roves with Tablets, 1,649 Contacts

The main data source analyzed for this article is the set of responses to the open-ended survey that interpreters submitted via a completed Google form and/or blog post. The intent of the form was to elicit information that would document 1) effective practices for initiating and sustaining conversations, 2) the visitor response, 3) new challenges, and 4) opportunities. Examples of themes and prompts appear in Table 3. Nine interpreters responded, summarizing multiple uses of the iPads, which occurred during periods of two to four weeks. Each interpreter completed the survey one time during his or her first eight weeks of iPad use. The lead author followed up with three interpreters who did not complete the survey. They were asked to confirm whether they had or had not used the iPads and if they had not, to answer the question, "What were the barriers for you?" We have email responses from two of them; one responded verbally.

A number of other data sources were pertinent to substantiating interpreters' expectations and experience. The iPad sign-out form and park-collected statistics on contacts during roves confirmed that 9 of 13 iSWOOP interpreters were regularly roving with iPads from July 2014 through March 2015. For every rove, interpreters signed iPads in and out, recorded tallies of contacts made, and made notes on unusual responses or interactions. During conference calls held every four to six weeks, the conundrum of where and when to interact with visitors about park-based research dominated conversations. Observers' field notes also served as confirmation of interpreters' survey responses. Following a set of written guidelines, two observers shadowed eight interpreters during eight hours of roves. Observers were as unobtrusive as possible, taking care to stand out of the way while visitors and interpreters were interacting.

Data Analysis

Text from blog posts was segmented into units by topic, axially coded, and analyzed by constant comparison. On the blog, comments fell into eight categories including:

Category/ Theme	Definition	Sample Responses
Opportunities afforded for accomplishing interpretation; Interpreters' hopes and expectations	Interpreters' intent to make connections for visitors. The ways that tablets increased the likelihood that interpreters could advance their mission to make personal connections between the visitors and the resource (cave or bats)	Great potential for rewarding encounters. The flythrough of the Natural Entrance and to Bat Cave seem to enrich the experience of visitors who wish to go but cannot set foot in these areas. Evan, 1/10/15
Location & the interpreters' bids to initiate and sustain conversations	Strategic placement of self to invite interaction; Opening questions, bids for attention or interaction and the techniques used to sustain conversations, such as questions, eliciting interest, attending to cues from body language that indicated the visitor might want to see or hear more	[Interpreter tended to] rove in the area near the bat cave sign and, when visitors stopped there, he asked if the individual or any members of the group were particularly interested in our bats here at CAVE. Marvin ,7/14/14 I find that asking why they think things are happening tends to generate questions. Shawn, 10/4/14
The visitor response	Verbal or physical reactions to visuals or interpreters' questions or comments	Smiles, wow's, "Thank you for showing us that"; "That is amazing!" "Do we have to pay extra for this? This is awesome!" Evan, 1/10/
Challenges	Factors that interfered with maximizing the interpretive opportunity or that interfered with the interaction	The biggest challenge I have come across is that if I don't check, sometimes the battery is low. I have also found that showing the slides can be hard to be fluid. Shawn, 10/4/14

Table 3: Themes and Prompts

Sample Visitor Questions	iSWOOP Approach—Visitors are prompted to observe, speculate, predict	Visual Library Support
How many bats are there?	About 300,000. This took researchers years to answer. Why do you think it is difficult to count bats? What tools can you imagine would help researchers overcome the obstacles of studying a small, fast, nocturnal, animal?	Videos of bat flight emergence in real time, in slow motion, being counted with a computer algorithm
When is the best time of year to see the bats?	It varies a lot. We tell visitors to come in July or August, but take a look at these graphs, which show the number that emerged in April, July, and September. What do you notice?	Graphs of numbers of bats emerging over the course of three evenings
Where do the bats live?	About 1/3 mile down this passage from the sign I can show you what it looks like when bats fly in from the cave entrance. This video is based on laser scans [describe how laser scanning works]. Ever wondered what the bats are doing back in the cave all day?	Fly-through animation of the passage to bat cave; thermal video from the roost taken during the day

Table 4: Categories, Themes, Definitions, and Sample Responses

hopes and expectations of visitor response; technology—its attractiveness and potential; program descriptions, including crafting programs; and logistics. These categories were in alignment with project priorities and were thus useful as the basis for categories for coding interpreters' responses about their experience using tablets six months later.

In conference calls between researchers and park staff, interpreters debated the advantages of various locations for their formal programs. These back-and-forth exchanges were significant as they spoke to competing priorities such as visibility vs. safety; visitors' passive vs. active posture; and audience stability vs. fluidity. Being at the right place and time to respond to visitors was an important part of making connections

between visitors and the resource. Therefore, we looked at the theme of location along with the strategies interpreters mentioned for initiating and sustaining conversations.

Eliciting and analyzing challenges was important during this proof-of-concept project. We analyzed survey responses for challenges, noting frustrations and possible solutions. Each element of iSWOOP—the devices, the professional development, and the content of the visual library were all scrutinized and targets for revision, further investment, or elimination.

The salient categories defined with examples appear in Table 4.

One of the known problems of relying on self-report is that participants may answer in a way that will please researchers (Hoskin, 2012). To establish the trustworthiness of the data, we reviewed observers' field notes. In this way authors were able to confirm the accuracy of interpreters' statements about visitors' enthusiasm and engagement, opportunities, and logistical constraints and disconfirm exaggerations or embellished responses that would have distorted results. Furthermore, the fact that one-third of interpreters who could have used the iPads did not and that two were forthcoming in voicing their concerns confirms that some interpreters were not under undue pressure to comply with researchers' expectations.

Findings

The findings are reported by theme: accomplishing interpretive goals with the iSWOOP visual library, optimal locations for using the iSWOOP visual library, initiating and sustaining interactions, and the challenges posed by integrating tablets into roving assignments.

Interpretation

Typically during roves, interpreters satisfied curiosity, answering visitors' questions if they were able to do so. In this section we look at the ways the tablet-based iSWOOP visual library helped accomplish interpretive goals. Interpreters reported increasing understanding of the resource, both the bats and a spatial understanding of the cave system. At the same time they felt they increased visitors' science literacy by building awareness of the research program and technological applications to the study of wildlife and its habitat, they strengthened emotional and intellectual connections to the wildlife and caverns which can inspire concern and stewardship activities.

Of the nine interpreters, eight explained the value they saw in roving with iPads. Interpreters gave 13 examples of what they could accomplish. Their examples fell into two categories, one related to informing visitors about bats (seven examples) and the other related to informing them about relevant research and technology (six examples). Within each category we coded a spectrum of responses. Within the category of informing visitors about bats, three of the seven responses included straightforward supplying information and satisfying curiosity. An interpreter observed, "When visitors are receptive and genuinely interested in the bats, the iPad is a great tool for…enhancing their understanding of the bats" (Winston, 8/19/14). Two comments referenced the more complex task of eliciting and changing attitudes. An interpreter wrote, "These tools and our training have also helped a great deal to change or clarify the perceptions and superstitions many of our visitors hold on bats" (Evan, 1/10/14). Interpreters expressed confidence that the tablet-based interactions were having an impact on visitors' perceptions of bats. An interpreter reported that, a visitor exclaimed, "Oh! They're

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Figure 2: Infant Bat Pups Gathered in the Roost and Nursing
Sample image visitors found enchanting. Visitors rarely get a chance to see baby bats in the roost despite their keen interest in mother-pup interactions.

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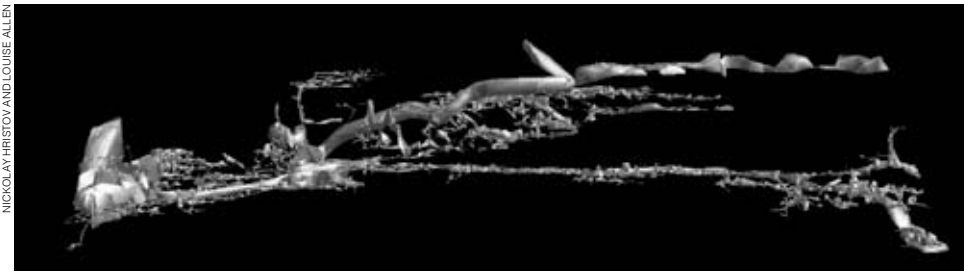

Figure 3: Schema of caverns
The red dot indicates the bat roost.

cuter than I thought they would be," upon seeing the close up image of the free-tailed bat (Rico, 12/7/14; Figure 2). The realization that bats —which are often feared—can be perceived as cute was noteworthy. A revelation precipitated a shift in attitude, which had the potential to lead to increased concern for bats and their survival.

Within the category of research and technology four of six responses were about showing and telling, implying a one-way dissemination of information, while two responses indicated interactive two-way discussions. Winston's response exemplifies the show and tell approach: "The iPad…allows rangers to get out the message regarding the interesting research being done here" (8/19/2014). In his comment, the agency rests with interpreters who get the message out. In contrast, Mina commented, "The videos of the scans of the cave are also really neat because we can see what other areas of the cave look like virtually *and discuss* [authors' emphasis] how technology has changed the way we look at things and study them" (8/19/14). Notice that Mina uses the first-person plural *we,* making it clear that she and the visitor play an active role.

The visual library enabled interpreters to reveal parts of the cave that visitors could not or did not see on their own, like the bat cave, which especially interested children,

according to Kate (7/22/14). Of the 10 survey responses, nine explicitly or implicitly spoke to interactions that fostered understanding of the spatial layout, capacity, or distances in the cave system. Interpreters could use elements of the visual library to relate where visitors were standing to other parts of the cavern (Figure 3). One interpreter witnessed the visualizations compensate for a limited first-hand experience. He noted:

> "The fly-through of the Natural Entrance and to Bat Cave seems to enrich the experience of visitors who wish to go but cannot set foot in these areas. Particularly for visitors with physical or psychological limitations that keep them from walking the Natural Entrance…. Instead of feeling left out [after seeing the fly-through], visitors feel fortunate." —Evan, 1/10/15

When interpreters foregrounded technology like laser scanners and thermal cameras, visitors were impressed. One interpreter enjoyed letting visitors know that the park had access to such technology. Two interpreters reported visitors' comments of this type: "Wow! Technology is amazing!" in response to laser scans of the cave (Rico, 12/7/14). Lena noted visitors' body language: gasps, wide-eyed faces, and large grins (7/14/14). Another interpreter captured this visitor's response: "That is amazing! I didn't know you could film the bats like that" (Mina, 7/22/14). The quotes speak to appreciation expressed for technological innovation, with the second quote explicitly addressing applications to the study of wildlife. These comments further support the observation cited above that the iPad allowed rangers to get out the message regarding the interesting research being done in the park.

Overall interpreters' responses confirmed the value of the tablet-based visual library in supporting their efforts to increase awareness of the resource and research activities at Carlsbad Caverns. The tablets were a tool for colorfully displaying behind the scenes work researchers have undertaken to better understand Brazilian free-tailed bats and their habitat. Interpreters with the visual library were able to highlight new perspectives on park-based research. They revealed areas of the cave, offered up-close images of the bats in the roost, nursing, and in flight, and provided examples of the visualizations possible with thermal cameras and laser scanners. Visitors expressed pleasure, astonishment, gratitude, and curiosity in response to interpreters' efforts to illustrate and inform them about how we know what we know about the bats and their Carlsbad Caverns habitat.

Location

All interpreters using tablets were successful in initiating contact with visitors and engaging them in STEM learning in a variety of locations. According to interpreters' survey responses, only one of the 1,649 visitors who were approached by an interpreter offering to show images on the iPad chose not to engage. In five of the interpreters' survey responses, they named locations where they were successful in engaging visitors. One approach was to leverage the opportunities the resource presented; for example, elaborating on the sign pointing out the passage to the bat cave. The other was to seek out locations where visitors might have time and mental space to absorb something new. Kate and Lena talked about such opportunities: engaging visitors who were resting on stone benches and those waiting for a guided tour. In both instances interpreters were being strategic, talking to visitors in places where they avoided causing traffic jams.

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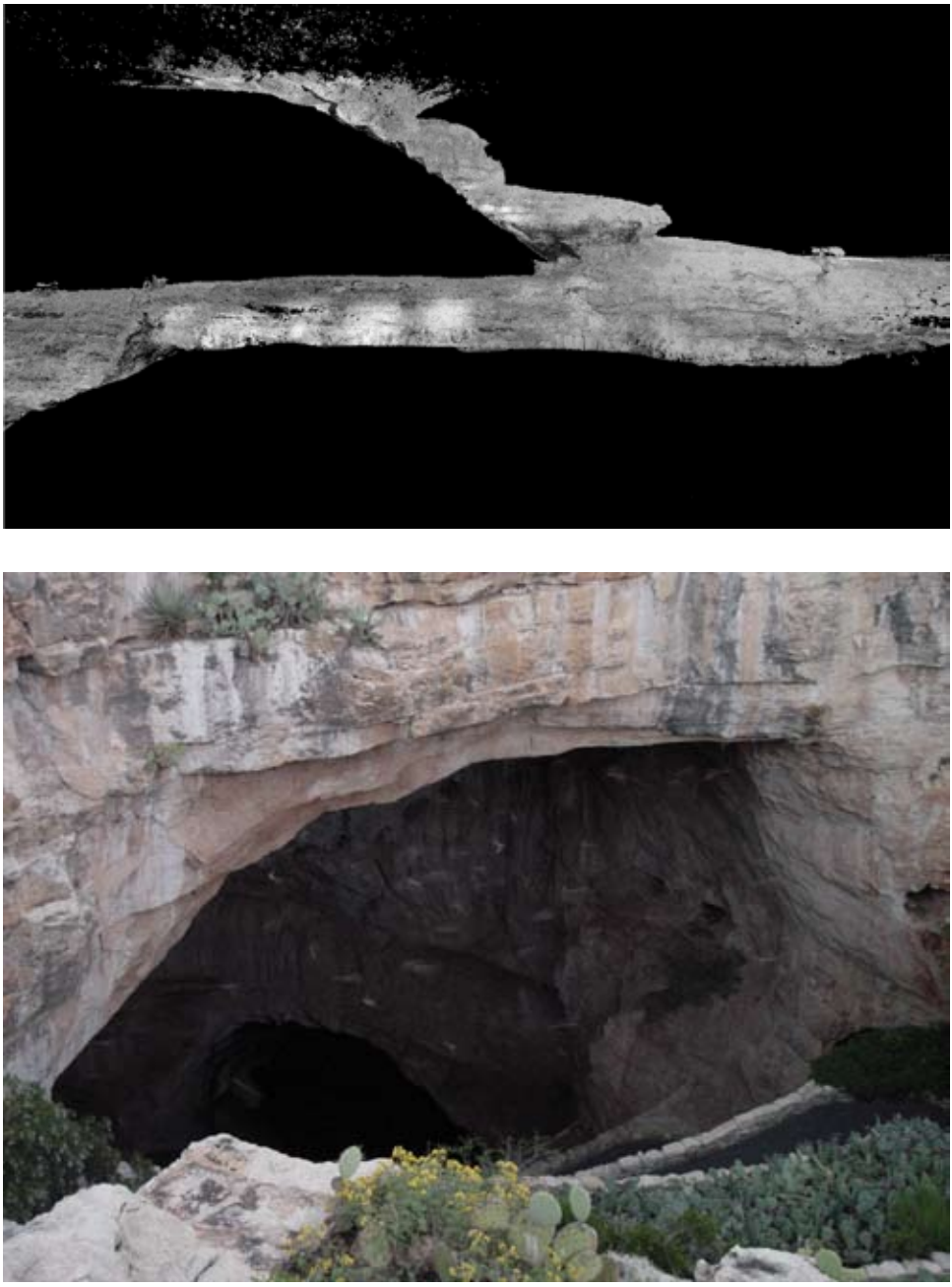

Figure 4: Still Image of Fly-through
Still image taken from the fly-through sequence (on the right) reveals the cavern beyond the natural entrance (pictured on the left), including the switchbacks along the path that leads to the Underground Lunchroom. Using long-range laser scanning technology, the cave is captured as a three-dimensional point-cloud generated from billions of points.

Initiating and sustaining tablet-based interactions

During roves, interpreters greeted visitors. One interpreter noted that because she is an introvert, in the past she has had a hard time starting conversations. Having images to display on a tablet made her feel more at ease when striking up conversations with visitors. Although she stated that she didn't want to become too dependent on the tablet, she acknowledged that it made her more comfortable initiating contacts during roves (Observer's field notes, July 2014).

In one-third of survey responses, iSWOOP interpreters explicitly mentioned that iSWOOP conversations over the iPads were longer and more substantive than typical interactions. More time in conversation meant more opportunities to forge intellectual and emotional connections, more time to learn about the visitors' interests and to offer information tailored to these interests. Of the five interpreters who quantified how often they initiated contact with visitors, four estimated that they initiated 75% to 85% of contacts, while one reported that visitors approached him 75% of the time. An interpreter offered this description: "While stationed at Bat Cave, I initiate conversations with visitors if they pause to look at the wayside exhibit. If they just walk by, I usually just offer a greeting, but don't stop them" (Rico, 12/7/14).

Most often the cave itself, or research on the cave, made sense as an overture. Two interpreters began conversations by asking visitors if they were interested in seeing the cave in a new light and continued the dialogue after showing the fly-through (animated laser scans from a bat's eye perspective) by asking if they saw something familiar in the video (Figure 4). Another said he simply asked if visitors were interested in bats or in research being done in the cave.

To sustain conversations, interpreters tailored their comments to visitors' interests and questions. Visitors frequently had questions about bats and their cave habitat. Interpreters took these questions as opportunities to invite discussions on bat reproduction, behavior in the roost, and the location of the bat cave relative to other areas of the cavern, as well as wildlife biologists' research agenda. Some interpreters found ways to incorporate iSWOOP images and video even when the topic of conversation was not related to bats. In one instance, a visitor asked if the cave was safe during earthquakes. During their exchange the interpreter learned that the visitor was studying engineering. This prompted the interpreter to offer to show the fly-through as an example of new technology researchers and interpreters are using to survey caves (Lena, 7/14/14).

In sum, nine of the 13 interpreters in the project found using the iSWOOP visual library beneficial. Interpreters gave a variety of responses when asked what they could accomplish with iPads, seeing value in opportunities to inform visitors about bats and the research program at the Caverns. As Rocko explained, "It allowed me an added bonus of having planned interpretive moments on topics in further depth that I couldn't have built up as well without the benefit of the visual" (9/18/14).

The iSWOOP visual library and professional development equipped interpreters to show compelling visuals that revealed more than visitors could see on their own. Interpreters who roved with the iPads found they could 1) use visual media to shift visitors' attitudes towards bats by adding to their knowledge base about bat behavior, 2) discuss the role for technology both in wildlife research and in the park experience, and 3) showcase parts of the cave system visitors couldn't experience first-hand due to park-imposed limits or visitors' choices or physical limitations. During roves interpreters were sensitive

to location, and initiated conversations in ways that increased the potential for making connections with a receptive audience.

Challenges

Though the visual library and the tablet interface provided new opportunities for showcasing technology, bats, and scientific research, at the time of this article not all iSWOOP-trained interpreters had adopted them for use. Interpreters articulated two concerns: 1) the visual competition with the caverns, and 2) the awkwardness of roving with a tablet.

Echoing the findings of the 21-Tech project, interpreters worried that visualizations intended to complement the main attraction had the potential to upstage it, competing for visitors' time and attention. An interpreter mentioned that a tablet flashing colorful video in the cave was too compelling. She and two other interpreters were reluctant to shift visitors' focus to a screen that could easily detract from visitors' appreciation of the cave.

Unlike an illustrated talk projected on a wall or screen, tablets allowed interpreters to rove with visuals. Yet, when interpreters spoke simultaneously to shorter and taller visitors, struck up conversations in narrow passages, and attempted to expand conversations to enable newcomers to get a view, handling a tablet was tricky. An interpreter wrote: "I found it to be cumbersome…. [I had to] juggle it from hand to hand when I wanted to use my flashlight to point out something in the resource" (Rocko, 9/17/14). On days with high attendance, interpreters had to be especially strategic about where they initiated conversations in order to avoid blocking foot traffic.

An ongoing challenge will be to keep the conversations fresh and interactive. As with any device, there are logistical challenges in managing updates and upgrades. Three interpreters specifically requested additional content, such as visuals on cave formations and White Nose Syndrome. Ideally a park's visual library would contain images on a range of topics from a number of researchers.

Discussion and Next Steps

Tablets and smart phones are increasingly part of the visitor experience at national parks as cameras, field guides for animal and plant identification, and as crowd-sourcing tools for citizen science. Until the iSWOOP project provided two tablets for interpreters' use, visitors' cameras and the park's audio-guides were the most prevalent forms of technology in the dimly lit cave. Interpreters recruited to participate in the project at Carlsbad Caverns National Park in New Mexico forged the iSWOOP approach of integrating handheld devices into the visitor experience. Their survey responses revealed how they characterized the benefits of the iSWOOP visual library, how they began and sustained conversations, and the challenges they met when integrating tablets into their practice. Interpreters with the visual library were able to highlight new perspectives on park-based research. They revealed areas of the cave, offered up-close images of the bats in the roost, nursing, and in flight, and provided examples of the visualizations possible with thermal cameras and laser scanners. A few dwelled on the possibility of detracting from the experience of the cave, while the majority found comfortable locations and strategies for initiating and sustaining conversations with visitors.

Based on this study and articles cited in the literature review, we can expect opportunities for revelation and connections when a portable visual library is placed in the hands of interpreters. Tablets, like flashlights, facilitate new perspectives and

joint looking, making it possible for park interpreters to reveal the natural resources to visitors that they would not ordinarily see. With scientists' visualizations, interpreters can leverage intriguing juxtapositions of current and past conditions, change visitors' perspectives, and reveal non-visible aspects of the natural resource, infusing interactions with novelty and surprise.

In some sense, explaining features of the park and its bats with a tablet is not such a large departure from interpreters' use of other props at Carlsbad Caverns. Props are a recognizable part of the interpretive toolbox. Skeletons, skins, and puppets help the public learn about wildlife. Tablets are less furry than some of the traditional props, but fulfill a similar function. With them interpreters can reveal aspects of park resources that are out of sight, out of season, notable when juxtaposed with a contrasting example, or too large or too small for the naked human eye to perceive, playing on novelty and surprise to captivate visitors and spark conversations. Tablets, like flashlights, make it possible for interpreters to establish a joint focus for attention. One major difference between flashlights and tablets is that with tablets visitors' attention initially is directed away from their environment and to a screen, whereas a flashlight focuses attention on features of the environment. Interpreters were aware of the potential for iPads to compete with the natural resource and explicitly stated that they wanted visitors to be awed by the cave. Another difference is that the cave was relatively static in comparison to the visual library, which included video, and enabled interpreters to shift visitors' perspectives in surprising ways, i.e., taking a bat's-eye view down a passage. With this control, interpreters showed visualizations in a sequence that made sense in accordance with visitors' questions and interests.

Many visitors whom interpreters treated to the iSWOOP library expressed gratitude, curiosity, pleasure, and astonishment. Conducting think-aloud protocols as visitors watch a fly-through sequence or other visualizations might give interpreters and researchers a better understanding of what was new, compelling, or of value to visitors. This feedback would be useful in the design of visual libraries for other parks. In informal interactions it can feel awkward to ask visitors to explain their reactions, so until we do further research, we can only speculate about the characteristics of a visual library that are most likely to arouse strong positive reactions or contribute to visitors' science literacy. Think-aloud protocols could yield useful information for interpreters—describing the place of visualizations and interpreters' provocative comments for visitors might otherwise silently connect their personal experiences to the scenery or phenomenon at hand.

It is clear, both from the literature and from interpreters' experiences at Carlsbad Caverns, that iPads can stimulate wonder and understanding of how scientists know what they have come to know. In interpreters' hands, scientists' visualizations can advance interpretive goals, but this does not happen magically. As researchers of the 21-Tech project found, interpreters need time to become fluid with the technology (Garibay & Ostfeld, 2013). At Carlsbad Caverns individual interpreters found locations and strategies for initiating conversations. To meet the 21st-century standards for audience-driven interpretation, professional development may need to place an even stronger emphasis on techniques for fostering dialogue.

Based on the responses of nine Carlsbad Caverns interpreters, the data suggest that interpreters with tablets have the potential to increase awareness of parks as sites for research, highlight innovative uses of technology, give visitors reasons to appreciate bats,

and extend a behind-the-scenes look at the park. These are all aspects of revelation that could be described more fully in tandem with the guidelines suggested by Zimmerman and Land (2014), the categories used by Stern and Powell (2013), or the new interpretive competencies (2016). Researchers could then develop measures for the effectiveness of different strategies and techniques in inspiring concern for and connection to the resource. However, parks have limited resources. Bearing this in mind, ascertaining patterns of where and how visitors embrace opportunities for conversation and learning with interpreters can help parks target resources strategically.

In spite of professional development sessions that stressed interaction and questioning techniques, some interpreters and visitors easily fell into the comfortable roles of expert and listener. A benefit of establishing joint attention is its potential to jumpstart conversation, to spur the visitors to comment, observe, and speculate. Additional opportunities to practice this way of interacting may increase the likelihood that interpreters give visitors a chance to connect park-based scientific research to their prior experiences.

We believe tablets are a worthwhile focus for continued use and study. Further research could investigate and confirm that roving with tablets shifted where and how interpreters approached visitors, increased the number of contacts, added value to visitors' experience, and increased two-way communication about the relevance of scientific research to visitors. iSWOOP project leaders will be talking about possibilities in consultation with interpreters and supervisors at Carlsbad Caverns and other parks in the near future with support from another National Science Foundation grant (DRL# 1514776). The tablets have proved themselves as a tool that advanced interpreters' mission to reveal the aspects of the park's resources to visitors. With collaborative effort and plans we hope to document further the short- and medium-term impacts of tablet-based technology in interpreters' hands, more precisely describing types of revelation interpreters readily use, learning which visualizations visitors find most compelling and why, as well as how opportunities for increased science learning can dovetail with visitors' interests and motivation.

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References

Benne, M., Pattison, S., Rubin, A., & Dierking L. (2016, March). *Researching the Value of Educator Actions on Learning (REVEAL): Studying staff-facilitated museum exhibits*. Poster session presented at the Advancing Informal STEM Learning PI Meeting, Bethesda, MD.

Bonnell, M. (2015). Resource Protection Through Roving. *Legacy* (Roving Interpretation), January/February 26(1), 26–28.

Char, C. (2015). *To be more inquisitive in the natural world: Evaluation of the Interpreters and Scientists Working on Our Parks (iSWOOP).* Retrieved from iSWOOP webpage: http://iswoopcave.com/?page_id=32

Charmaz, K. (2006). *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis*. London: Sage Publications.

Dillon, C. (2011). Making a Difference. In D. Larsen (Ed.), *Meaningful Interpretation: How to Connect Hearts and Minds to Places, Objects, and Other Resources*, 2nd ed. (pp. 154–155). Fort Washington, PA: Eastern National.

Falk, J.H., & Dierking, L.D. (2010). The 95 Percent Solution: School is not where most Americans learn most of their science. *American Scientist, 98*(6), 486–493.

Firestein, S. (2012). *Ignorance: How It Drives Science*. New York: Oxford University Press.

Forist, B., &, Knapp, D. (2014). A New Interpretive Pedagogy. *Journal of Interpretation Research*, 19(1), 33–38.

Forist, B., &, Knapp, D. (2013, November 8). *Leaving Muir and Tilden Behind: Visitor-Centered Interpretation Through Dialogue*. Presentation at National Association for Interpretation National Workshop, Reno, NV. Retrieved from http://www.storylinedesigns.co.uk/blog/files/tilden-forist-knapp-ppt.pdf

Garibay, C., & Ostfeld, K. (2013). 21-Tech: Engaging Visitors Using Open-Source Apps. *Exhibitionist, 32*(2), 32–36.

Goodwin, H. (2013). American Sign Language and Audio Description on the Mobile Guide at the Museum of Fine Arts, Boston. *Curator, The Museum Journal. 56*(3), 369–370.

Ham, S. (1992). *Environmental Interpretation: A Practical Guide for People with Big Ideas and Small Budgets*. Golden, CO: Fulcrum Publishing.

Hoskin, R. (2012, March 3). *The Dangers of Self-Report*. [Blog post]. Retrieved from http://www.sciencebrainwaves.com/the-dangers-of-self-report/

Knackmuhs, E. (2015, September 3). *Guest Blog: Exploring Two-Way Interpretation at Cape Hatteras National Seashore*. [Blog comment]. Retrieved from https://eppley.org/guest-blog-exploring-two-way-interpretation-at-cape-hatteras-national-seashore/

Larsen, D.L. (2003). Be Relevant or Become a Relic. *Journal of Interpretation Research, 7*(1), 17–23.

Linzer, D. (2013). Learning by Doing: Experiments in accessible technology at the Whitney Museum of Art. *Curator, The Museum Journal, 56*(3). 363–368.

MacArthur, C. (2014). *Changing Lives, Saving Paper and Engaging Visitors: Technology and the Acadia Experience*. Final Report on Summer 2014 Research Studies. Retrieved from http://api.ning.com/files/kV4MbYiv7oT1o2MtPdOIBXZmHYj1xG8GySMTGBkAgPmuh3uWqAsB3oO5z-a76htUKN1urVBafeGck6LDHIiNTYCq0rY65vPe/FinalReport.pdf

Miller, J. (2015). Reverse Roving. *Legacy* (Roving Interpretation). January/February 26(1), 12–13.

Mony, P., & Heimlich, J. (2008). Talking to Visitors about Conservation: Exploring Message Communication through Docent-Visitor Interactions at Zoos. *Visitor Studies, 11*(2), 151–162.

National Park Service. (2012). *A Call to Action: Preparing for a Second Century of Stewardship and Engagement*. Retrieved from National Park Service website: http://www.nps.gov/calltoaction/

National Park Service, Interpretive Development Program. (2016). *Foundations of 21st Century Interpretation (Version 2016): Foundational Competencies for NPS Interpreters*. Retrieved from http://idp.eppley.org/sites/default/files/Foundations%20of%20Interpretation-Version%202016-NPS-IDP-with%20cover%20%281%29.pdf

National Park System Advisory Board Education Committee, the National Education Council, and George Washington University. (2014). *Vision Paper: 21st Century National Park Service Interpretive Skills*. Retrieved from National Park Service website: http://www.nps.gov/resources/upload/REPORT-Interpretative-Skills-05-22-14.pdf

National Research Council. (2009). *Learning Science in Informal Environments: People, Places, and Pursuits. Committee on Learning Science in Informal Environments*. Philip Bell, Bruce Lewenstein, Andrew W. Shouse, and Michael A. Feder, Editors. Board on Science Education, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Pattison, S.A., & Dierking, L.D. (2013). Staff-Mediated Learning in Museums: A Social Interaction Perspective. *Visitor Studies 16*(2). 117–143.

Perdue, B.M., Stolinski, T.S. & Maple, T.L. (2012). Using Technology to Educate Zoo Visitors About Conservation. *Visitor Studies 15*(1). 16–27.

Povis, K.T., & Crowley, K. (2015). Family Learning in Object-Based Museums: The Role of Joint Attention. *Visitor Studies, 18*(2), 168–182. doi: 10.1080/10645578.2015.1079095

Rudy, J. (2014, October). *Why: Facilitated Dialogue in the National Park Service*. Presentation at Interpreting Critical Issues Using Civic Engagement and Facilitated Dialogue Techniques conference, Valley Forge National Historic Park, Valley Forge, PA.

Sexton, P. (2015). Structured Randomness. *Legacy* (Roving Interpretation), January/February 26(1), 23–25.

Stern, M.J., & Powell, R.B. (2013). What Leads to Better Visitor Outcomes in Live Interpretation?. *Journal Of Interpretation Research, 18*(2), 9–43.

Swift, F. (2013). Connecting Londoners with Their City Through Digital Technologies. *Journal of Museum Education, 38*(1), 60–68.

Tilden, F. (1957). *Interpreting Our Heritage*. Chapel Hill, NC: University of North Carolina Press.

Zimmerman, H.T., & Land, S.M. (2014). Facilitating Place-Based Learning in Outdoor Informal Environments with Mobile Computers. *TechTrends, 58*(1), 77–83. doi: 10.1007/s11528-013-0724-3

Appendix A: iPad Reporting Form Prompts

1. *Images / Animations used*
   Please say which images and animations you used (fly through sequences only, other iSWOOP cart images, etc.)

2. *Interactions with visitors*
   Did you usually start conversations with visitors, or did they usually approach you first? What percent of interactions would you say are initiated by you, versus by visitors?

   What questions did you ask to initiate a conversation with a visitor?

   Give examples of questions that generated dialogue.

3. *Visitor Responses*
   What kind of responses did you hear to information you gave to visitors?

4. *Challenges and opportunities*
   Using iPads on roves is new. What challenges do you see? (For example, showing the screen to very tall/ very short people, or trying to have an educational interaction in this way.)

   What value do you see in this approach? Would you say it changed your roves? How so?

   If there are things you're looking forward to trying or refining, please describe them.