Project Summary

How can museums use technology to create uniquely human experiences? Balboa Park Online Collaborative, Inc. (BPOC) and the San Diego Air and Space Museum (SDASM) worked to answer this question with the IMLS Sparks grant-funded *Museum at Your Fingertips* project. This project tested the ability of a telepresence robot, the BeamPro by Suitable Technologies, to provide meaningful and engaging remote tours to classrooms that lack the resources to visit museums in person.

What is a telepresence robot? *The Economist* titled an article on the technology, "Your Alter Ego on Wheels," and explained that these devices allow "people to move virtually through a distant building by remotely controlling a wheeled robot equipped with a camera, microphone, loudspeaker and screen displaying live video of its pilot's face." Many telepresence robots were designed for telework and the corporate world, but other types of organizations, including disability advocates, hospitals, and schools quickly saw the potential of this new tool to increase accessibility. BPOC was originally founded to serve Balboa Park's twenty-seven museums and cultural institutions with the mission to connect audiences to art, culture, and science through technology. SDASM celebrates aviation and spaceflight history and aims to inspire excellence in science, technology, engineering, and mathematics. The two organizations worked together to design a tour program that took full advantage of the BeamPro's capabilities to provide unique opportunities to students to access the museum.

The American Alliance of Museums' *National Standards and Best Practices* states that museums should show "a commitment to providing the public with physical and intellectual access to the museum and its resources." As such, museums must give special consideration to accessibility. Tangible efforts have been made at expanding accessibility to include ramps and elevators in buildings, closed captioning on videos, and websites that generously share information.

Field trips are an important way for museums to extend access, welcoming students whose families or schools could not otherwise visit and enhancing their classroom learning experiences. The intellectual, social, and emotional benefits of museum learning are well documented: according to numerous studies, museum experiences have the ability to motivate and excite learners of all ages while providing them with new insights and experiences. A spike in fuel prices and an increased focus on testing in recent years has resulted in the reduction of student field trips across the country. A University of Arkansas study found that more than half of American schools cut a planned field trip during the 2010-2011 year. The socioeconomic

impact has raised the question: "How can museums recapture these audiences, ensuring that they remain accessible to all young learners?"
Telepresence robots are an exciting new tool capable of expanding museum access. San Francisco's de Young Museum's Beam Tour program lets visitors with limited mobility take museum tours via robot. New York's American Museum of Natural History uses their robot to bring distant subject experts into the galleries to share their knowledge with visitors. While many museums are using telepresence robots with adults, little has been done to test telepresence tours with young classroom learners. BPOC and SDASM focused on this specific demographic through *Museum at Your Fingertips,* to understand how to recapture this specific audience.

With *Museum at Your Fingertips*, BPOC and SDASM worked to answer three key questions: 1) What are the technological capabilities and limitations of the BeamPro?; 2) How useful is the device as a learning tool in the classroom?; and 3) Is this project replicable in other museums across the country? Throughout the project, BPOC tested the technological capabilities of the BeamPro, while SDASM developed an educational tour, generated curriculum-related content, and scheduled formal tests in ten local classrooms. To create an engaging experience, BPOC designed a companion website that would show classrooms where the BeamPro was located in the museum and provide students with supplemental content. While challenges forced BPOC and SDASM to adapt the *Museum at Your Fingertips* project, the final project stayed true to the original spirit and ended up better suiting the needs and abilities of museums and classrooms. The *Museum at Your Fingertips* project proved that telepresence tours are a viable option for students who are unable to make it to museums for field trips.

What are the technological capabilities and limitations of the Beam?

The first step for this project was to test whether the technological capabilities of the BeamPro would accommodate classroom tours. The BeamPro is a fully interactive tool that moves, sees, and speaks on command through the use of wide-angle cameras with tilt and zoom capabilities, a microphone that cancels echo and reduces background noise, and a powerful built-in speaker. The BeamPro operates using WiFi. While BPOC provides free WiFi throughout Balboa Park, the project team needed to ensure the BeamPro had strong signal throughout the whole museum. BPOC determined the BeamPro moved better when there were fewer visitors using the WiFi. To improve this signal, BPOC moved the BeamPro to a password-protected private network for its exclusive use. In addition, the BeamPro's manufacturer, Suitable Technologies, explained that a mobile WiFi hotspot could be attached to the robot to improve service. This hotspot would need to be paid for through an internet service provider. In this case, the SDASM SSID was enough to get the BeamPro to move through the entire museum with ease.

Once the project team established a quality WiFi connection, they began assessing the experience from the driver's side. SDASM provided a list of ten possible tour stops and BPOC performed test runs of the BeamPro through the museum. Despite BPOC's initial concern, the BeamPro had no difficulty navigating different surfaces and ramps. The most important finding from these test drives was that, while the BeamPro camera has pan and tilt options, it could only view up to five meters high. SDASM has a number of aircrafts that hang from the ceiling to simulate flight. BPOC recommended choosing objects placed on the floor as tour stops. Looking at the selected airplanes through the BeamPro, another issue arose: glare. SDASM uses natural ambient light throughout the museum which presents a challenge for computer screens. The team worked to establish marks where the BeamPro should stop for glare reduction and optimal viewing. Noise was another technical consideration. SDASM is a lively, dynamic museum, and its many videos and interactives initially made for a poor acoustic experience for the driver. BPOC discovered that, in addition to having microphone and playback volume control, the BeamPro software also has a party mode, tailored for loud environments. Party mode allowed both the driver and tour guide to hear and be heard during tours. With these technical aspects addressed, BPOC turned its attention to other aspects of the project.

Museum at Your Fingertips originally included plans for a GPS-enabled, map-based website that students could use alongside the BeamPro. The website would give students a better sense of their location in the museum and provide supplemental educational information. During the testing phase, the project team discovered the BeamPro had no GPS capabilities, and the manufacturer, Suitable Technologies had no near-term plans to support this. BPOC hypothesized that beacon technology might achieve the same effect as a GPS-enabled map. Beacons, a sonar-like system, are placed throughout a space that radiates bluetooth signals and that signal is picked up by a receptor. The receptor uses the relative strength of these signals to determine its location in the space. The challenges with implementing Beacons in the museum space, such as finding appropriate places for beacons and finding ways to regularly update their firmware, are relatively well documented, so BPOC looked into geolocation technology as a way to track the BeamPro as it moved through the museum.

Geolocation technology uses both WiFi and GPS satellite signals to plot a smartphone's location. To test geolocation technology, BPOC attached smartphones, first an Android and then an iPhone, to the back of the BeamPro, via its USB port. These tests documented coordinate points at fifteen-second intervals, capturing roughly one hundred coordinate points from a short walk around the museum. The diagrams below, showing SDASM at the center, demonstrate the disparity of location accuracy with different smartphones, some appear inside the museum, but many are outside, and even across the nearby highway. With unsuccessful results, and a commitment to the initial focus of the grant, the project team decided to put the power of location in the hands of the tour guide.

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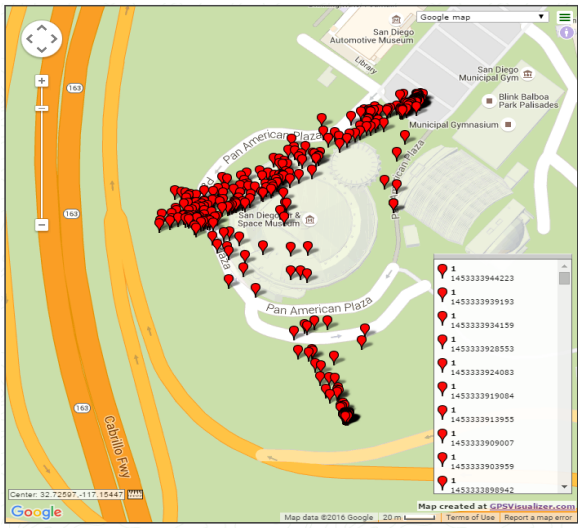
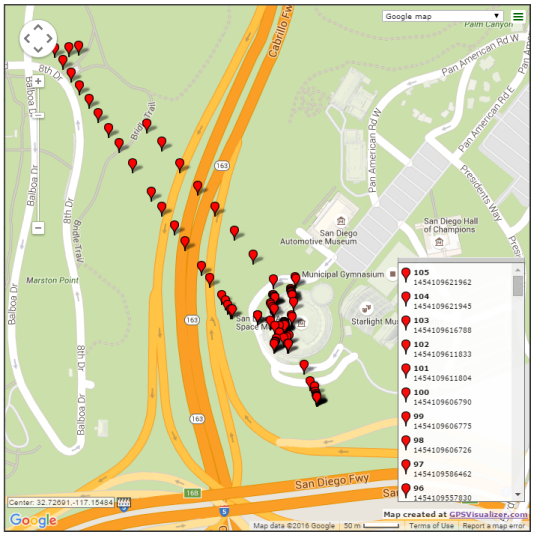


Geolocation results with an Android phone



Geolocation results with an iPhone

The original vision for *Museum at Your Fingertips* included a tour guide accompanying the telepresence robot, guiding students through the museum and providing educational content. The project team decided the simplest, most effective solution would be to build a mobile app that allows a tour guide to manually trigger location updates to tour-takers' maps. BPOC hoped to incorporate the website map with the BeamPro driver screen, but the BeamPro software prohibits design modifications for security reasons. BPOC overcame this limitation by designing a separate interactive website. The screenshots below show the side-by-side design of the interactive website and the BeamPro control software. When accessed, the website connects with the phone app carried by the tour guide, who can update the tour's location on the map to display supplemental images and videos. While this method of location tracking differed from

A screenshot showing the side-by-side design of the tour map and the BeamPro's control window

the initial plan, it still fulfilled the original vision for the project, and provided a more robust method for determining the tour's location.

With a website and app designed, developed, tested, and ready to launch, BPOC set out to reduce the time required by teachers to familiarize themselves with this new technology. BPOC created an in-depth user guide and made classrooms visits to help set up, test and train on the software. These tests brought to light the biggest technical issue: school firewalls, intended to police access to inappropriate content, also blocked access to the BeamPro. These security issues took time up-front to resolve, but once identified, BPOC was able to address them as soon as schools scheduled their tour. These tests proved that these types of classroom tours are possible from a technical standpoint.

How useful is the device as a learning tool in the classroom?

Throughout the process of testing and enhancing the BeamPro's technical abilities, the project team kept educational goals at the forefront. SDASM's education team took the lead on this, and began by picking the tour stops. While technical limitations changed some of their initial selections, SDASM chose aircrafts and developed content that could flex to fit school curriculums for a variety of subjects. Selected objects highlighted the diversity of flight pioneers, including a replica of Amelia Earhart's plane, a plane flown by Tuskegee Airmen, and a replica of the Apollo 9 Space Module (see Appendix for a complete list of tour stops). The tour itinerary, like the museum itself, represents a journey through time, beginning with early flight and ending with space exploration. The resulting tour script was educational, exciting, and adaptable.

The BeamPro wearing its flight suit

Drawing on classroom experience, SDASM educators were explicit that the interactive website would need to grab the attention of children, and working with BPOC designers came to the conclusion that a cartoon-style museum map would be the most successful. Additionally, because the telepresence robot itself so fascinated the students, educators decided to personify the BeamPro and provide it with a flight jacket. The BeamPro's outfit was a hit with classrooms and museum visitors alike.

The tour guide's ability to trigger content from the phone app proved to be another opportunity to capture classroom interest. Research shows that visuals are a significant component of

online learning. One study explains, "As 65 percent of the population are visual learners, images are clearly key to engaging people in eLearning courses." SDASM provided archival photos, videos, and aeronautical 3-view drawings that the tour guide could push to school screens. Prepared with an educational and engaging tour and website, it was time to bring the *Museum at Your Fingertips* project to the students.

Tour guide Ross Davis talks to a classroom

To assess the BeamPro's educational value, SDASM reached out to its Title I partner schools, leveraged social media and handed out flyers with program information. The project team tested tours in five schools, with ten classrooms; most wanted the tour in multiple classrooms. The project ultimately served ten classrooms from seven local schools and students from grade levels three to six participated. The tours themselves were exciting to observe. Students audibly "oohed" and "ahhed" as their teacher drove the BeamPro around the museum. Excitement, attention span, and focus differed from classroom to classroom, but in general, younger students were more engaged than older students and focus tended to decrease towards the end of the 45-minute tours. Despite this, students in all classrooms actively asked questions and jumped at the chance to drive the BeamPro themselves when it was offered towards the end of the tour.

It became clear during the classroom tests that the tours were succeeding, in large part due to the knowledgeability and enthusiasm of the SDASM educator and tour guide, Ross Davis, pictured here. Davis jumped over museum stanchions to spin propellers on replica airplanes. He asked students questions and gave them ample chance to ask their own. Davis' boundless energy traveled through the technology and into the classroom, confirming that a positive museum experience, in person or from afar, still depends largely on people. One student remarked on Davis' account of historical events, "it's like he is reliving everything all over again." In general, student comments were positive, though one made a telling remark: "I wish we could be in the museum right now." This experience, while exciting for students, could not take the place of an in-person visit.

Once the classrooms completed their tours, teachers provided feedback via email and survey. The teachers, like the students, gave positive feedback, with most saying they would participate in similar tours in the future. One teacher commented that the tour "offers an encouraging demonstration of how technology can be infused into museum education and virtual learning,"

and affirmed that the BeamPro absolutely "has the potential to be a vital learning tool in the classroom." Another teacher noted, "I imagine that this program will be a HUGE success for students that are unable to come to the museum in person!" Teachers also included useful feedback about how to improve the experience and better keep student attention. One wrote, "It could be helpful for the students to have something to do during the tour (maybe being able to type in questions from a device." The teacher further suggested that having some sort of collection-like item for students to touch and engage with during the tour would further help keep their attention. Altogether, classroom tests, student reactions, and teacher comments proved that, while there may be room for improvement, telepresence tours can provide memorable, effective and educational classroom experiences.

Is this project replicable in other museums across the country?

The *Museum at Your Fingertips* project developed a model of telepresence tours that can be replicated nationwide. They require four components to succeed: a telepresence robot, a museum with robust WiFi, a computer with webcam connected to the internet, and most importantly great people. Additionally, BPOC recommends a companion website to enhance the experience. While a number of companies offer telepresence robots at a variety of price points, this project used the BeamPro from Suitable Technologies, based on a number of factors that uniquely position it for a museum environment, including the party mode, the ability to run the BeamPro control window side by side with the companion website and the collision detection system that prevents the device from bumping into people and objects. While cost may be prohibitive for nonprofits, grant-givers and partner organizations may look favorably on similar projects; since a one-time fee can provide access to unlimited schools and audiences worldwide over the long-term.

The essential factor that makes this project successful is staff and is perhaps the most difficult to ensure. Without the energy, enthusiasm, and knowledge of SDASM's tour guide and educator Ross Davis, these virtual tours would not have been nearly as successful. The same should be said of the teachers who drove the BeamPro around the museum and simultaneously facilitated discussion among students. Technology may solve the basic problems of museum accessibility, but person-to-person interaction remains the foundation of quality learning experiences. While docents and volunteers are often high-quality tour guides, implementing a similar program involves significant museum staff time. Each museum will have to determine how this commitment fits their individual financial model. BPOC and SDASM are still working out this aspect of the project, and are hoping to create more definite recommendations on creating a sustainable tour program that continues to serve students, both locally and globally.

BPOC and SDASM would like to find ways to continue growing this program around San Diego and the nation. Independent of *Museum at Your Fingertips* tests in schools, SDASM implemented a BeamPro program for individuals with lower mobility. BPOC and SDASM hosted a series of four Twitter chats during the project, using the hashtag #EduBeam to raise interest in and awareness about the project. These chats attracted feedback and input from museum educators nationwide and proved that museums are interested in telepresence tours. BPOC demonstrated its BeamPro project at the Balboa Park Educators Committee and the annual Balboa Park Garden Party. Having seen BPOC and SDASM's work with *Museum at Your Fingertips*, other Balboa Park organizations have expressed interest in potential partnerships for future projects and initiatives using the BeamPro. Their only hesitation is lack of a proven model that covers the cost of both the telepresence robot and staff time. BPOC continues to investigate this issue, looking into how to share costs, searching for interested grantees, and soliciting feedback from the maker of the BeamPro, Suitable Technologies.

Museums interested in telepresence tour programs can use lessons from *Museum at Your Fingertips* to launch their tour projects and create quality educational experiences. After undertaking the *Museum at Your Fingertips* project, BPOC and SDASM believe in the power of telepresence robots to expand classroom access to the powerful experience of museum learning.

Conclusion

*Museum at Your Fingertip*s proved that telepresence robots can create meaningful museum tour experiences. Museum telepresence tours are technologically possible, educationally valuable, and easily replicable. Though in some aspects, the project took a different form than planned, it stayed true to its initial goals. While the plan to incorporate GPS did not work, it lead to a simpler and more robust solution. Docents, tour guides and schools alike appreciated the companion website, with its map and supplemental content. Issues with schools' firewalls showed this concern would need to be addressed as soon as tours were scheduled. Feedback from teachers about students' interest levels proved the potential need for additional activities during a tour. There is still room for perfecting telepresence tours, and each museum attempting to implement similar programs should customize the experience based on their mission, content, and operations.

While tests were successful, they also showed that virtual tours cannot take the place of actual museum visits when that option is available. Students who said they wish they could be at the museum in person proved this. However, when money, time, distance, or a combination of factors prevents students from getting to the museum, telepresence tours are reasonable alternatives. A tour like this also has advantages for students studying technology and robots. Students' "oohs" and "ahhs" showed that there is something unique about visiting a museum through a controllable robot. Fun elements, such as dressing the robot up and giving it a name,

helped make tours unique experiences in their own right. One of the biggest takeaways was that, whether it be through a robot or an in-person visit, the quality of a museum experience depends largely on the effort of the staff involved. An energetic, engaging educator on the other end of the robot goes a long way towards making a quality tour. Technology cannot take the place of human experiences, but it can make these experiences stronger and spread them further.

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