The Port Royal Project. A Case Study in the Use of VR Technology for the Recontextualization of Archaeological Artifacts and Building Remains in a Museum Setting*

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Abstract

This paper presents an account of a project jointly undertaken from 2001 to 2003 by UCLA and the Ocean Institute (Dana Point, California) to create an interactive virtual reality exhibit about archaeological objects found at Port Royal, Jamaica. The intended users of the exhibit were schoolchildren and other visitors to the Ocean Institute. The goal of the project was to facilitate learning through arousal of curiosity about Port Royal, the major English colony in the Caribbean during the seventeenth century.

Keywords

VR, 3D model, museology, education, undewater archaeology

1. Background

The Port Royal Project resulted from the collaboration of the UCLA Cultural Virtual Reality Laboratory (hereafter: CVRLab; www.cvrlab.org) and the Ocean Institute in Dana Point, California (hereafter: OI; www.oceaninstitute.org/). The work was initially sponsored and conceived by Charlie Steinmetz, a supporter of the lab and one of its project managers. Additional support was received from Spiegel TV. The chief modeler and researcher for the project was Natalie Tirrell. Training and supervising her was CVRLab Associate Director Dean Abernathy. Information about Port Royal was kindly provided by Laurel Breece (Long Beach City College), an archaeologist who has worked at Port Royal; and by Donny Hamilton, the Director of the Texas A&M Port Royal Project (http://nautarch.tamu.edu/portroyal/).

Port Royal was the principal English colony in Jamaica in the seventeenth century. The original settlement was begun as a naval base for British operations against the Spanish during the wars that continued for many decades in the 1600s in the Caribbean and elsewhere. Almost immediately, a small settlement of traders clustered around the fort, whose name was changed from Cromwell to Charles after news of the Restoration reached Jamaica in 1660. In that year, we also get our first census, which records 690 freemen and 50 slaves. In the next two decades, Port Royal became a crucial British naval base against the Spanish Main. Since the British Admiralty could not afford to send an adequate number of warships to Jamaica, the governors of Port Royal were forced to rely on the assistance of pirates like Henry Morgan in their prosecution of the war against Spain. Such pirates were called privateers, and with the peace treaty of 1680, the naval forces at Port Royal turned on their erstwhile allies, rid the area of pirates, and secured the Caribbean for commercial trading ships. Not surprisingly, the volume of trade and the size of the town mushroomed. By 1670, the census counted 2,181 inhabitants; twenty-two years later that number had grown to an estimated 6,500.

* After peer review, this article was originally accepted for publication in F. Niccolucci and S. Hermon, editors, *Beyond the Artefact – Digital Interpretation of the Past. Proceedings of CAA2004, Prato 13–17 April 2004* (Archaeolingua, Budapest). Owing to an editorial error, it was inadvertently omitted from the volume. The editors of the Proceedings of CAA 2004 and co-authors of the present paper express their thanks to Erzsébet Jerem for agreeing to remedy this situation by publishing the paper in the *Proceedings* of CAA 2008.

Much of this growth reflected the increasing number of slaves brought from Africa. The slaves were needed both at Port Royal and on the interior plantations of Jamaica. The port served the interior plantations by exporting their rum and sugar while importing nearly everything else including silver, pewter, luxury clothing from Europe as well as timber from North America and even silk and ceramics from faraway China. After the earthquake, the site was abandoned and was used only as a naval station. The town of Kingston was founded on the mainland and quickly grew to take Port Royal's place (on the history of Port Royal see Pawson and Buisseret 2000, 7–108).

A great deal of documentation survives that can be brought to bear on a model of the seventeenth-century town: maps, views, property records, wills, and archaeological finds. In fact, it is possible to reconstruct not only the street grid but even to identify many of the structures by owner, function, chronology, and architectural style (see Pawson and Buisseret 2000, 109–164). Long after 1692, substantial remains of the town could be seen below the water in Kingston Bay. The first sightings are recorded in the nineteenth century, but the first serious survey of the remains was not undertaken until 1959. In the 1960s further studies were undertaken by Norman Scott and Robert Marx. In the late 1960s, Philip Mayes surveyed the remains on land and worked out a sequence of scaled maps showing the development of the dockyards of Port Royal, which he then excavated in 1970. His work was continued by Anthony Priddy (for the history of archaeological investigations, see Pawson and Buisseret 2000, 203–210). From 1981 to 1990 Donny Hamilton and a team of underwater archaeologists from Texas A&M came to Port Royal to initiate new underwater studies. They focused on a small cluster of

2. Sponsor's Goal for the Project

As project sponsor and manager Charlie Steinmetz notes, there has been much discussion about using VR in museums but very few concrete projects involving true VR (as opposed to computer animations; on the distinction see, e.g., Vince 1998, 3–6). This lack is doubtless in large part the result of the high cost of VR systems, at least until Desktop VR became a reality in the last few years (cf., e.g., Pimentel and Teixera 1995). But another factor is the very conception of the museum, its mission in educating the public, and its understanding of how this role might best be accomplished (see, most recently Antinucci 2003, where strong arguments in favor of the use of VR are presented).

Steinmetz came to the Port Royal Project through three overlapping interests in the educational work of the OI, in archaeological education, and in the promotion of literacy. Knowing that the Ocean Institute was keenly aware of its responsibility to educate the public, and that its approach to learning could be ultimately traced to the constructivist theories of Jerome Bruner and others (see, e.g., carbon. cudenver.edu/~mryder /itc_data/ con structivism. html), Steinmetz thought that it would be the most appropriate venue in Southern California for an experiment to see if VR could live up to its promise in a museum setting. His buildings at the intersection of Queen Street and Lime Street just to the north of the area explored by Marx. The excavations brought to light many buildings and articles of everyday life (see the excellent project Web site at: http://nautarch. tamu.edu/portroyal/).

As Pawson and Buisseret note, "the history of Port Royal is better documented than that of most English towns of comparable size for that period" (Pawson and Buisseret 2000: xiii). Study of the town's history can thus shed a great deal of light on the everyday life and customs of the first British settlements in the New World. Since Texas A&M generously lent a number of its typical small finds to the Ocean Institute, it was natural that the Institute would take a special interest in this history and in ways of presenting it to its primary audience of schoolchildren from all over the Southern California area.

hunch was that because of its immersivity, interactivity, and ability to provide a compelling simulation of the lost world such as seventeenth-century Port Royal, VR could be a useful tool for arousing students' curiosity about the Port Royal underwater excavations some of whose small finds are on display at the Ocean Institute. He also thought that curiosity arousal might be a stimulus to improved reading skills, on the assumption that once a student was exposed in an effective way to new information about Port Royal, their appetite would be whetted, and they would pursue this new interest in the topic through reading. Steinmetz notes that there is very little research on the relationship between curiosity arousal and literacy (for an analogous project which uses real objects instead of VR models to arouse curiosity and hence reading, see Lewis and Fisher 1999), and so a secondary goal of the Port Royal

Project was to see, on the anecdotal level, if such a research program was potentially useful.

3. The UCLA CVRLab

The UCLA CVRLab (www.cvrlab.org) was founded in 1997 with the mission of creating scientifically authenticated real-time 3D computer models of cultural heritage sites around the world. Such models have been found to have useful applications in education, research, and commerce. Thus far the lab's models have ranged in time from the Iron Age in Europe and the Near East to the colonial period in the New World; and, in terms of space, from Peru to Israel. The Port Royal Project relates to the lab's longstanding interest in the use of visualization to promote learning through curiosity arousal (cf. Frischer 1982, 272–282; and note that CVRLab Associate Director D. Favro supervised Snyder 2003 and Abernathy 2004 on the use of VR technology in architectural education). Given the time and budgetary constraints on the project, the CVRLab could not utilize its normal modeling methodology, which is heavily reliant on the active participation of world-recognized authorities (see Frischer forthcoming). Instead, the roles of model-maker and expert had to be played by Natalie Tirrell, a student in Art History at UCLA. Some expert information was provided by a number of sources, including staff at the OI, Laurel Breece (an archaeologist with field experience at Port Royal), and Donny Hamilton (Director of the Port Royal Project).

4. The Ocean Institute

The non-profit Ocean Institute is located in Dana Point, California, USA at the base of the Dana Point Headlands and the entrance to the Dana Point Marine Life Refuge. The OI annually hosts over 90,000 kindergarten through college-age students in innovative learning experiences that increase competencies in science, technology, engineering and math. The center serves as a field trip destination site and a laboratory for developing, testing and disseminating new educational programs that help teachers and students meet state and national content standards. Programs range in length from two hours to five days and take place in the Institute's facilities including the 130' tallship Pilgrim, tallship Spirit of Dana Point, 70' research and education vessel R/V Sea Explorer, Ocean in Motion traveling classroom van, Chaparral to Ocean residential science camp and the new 33,000 sq. ft. Ocean Education Center (opened in 2002). With the opening of the new Ocean Education Center, the Ocean Institute has been able host over 50,000 general public visitors per year through a range of weekend exhibits, programs and informal learning experiences.

5. Sea Floor Science: Context for the Port Royal Exhibit

In 2003, the OI was successful in attaining National Science Foundation support for a three-year project called Sea Floor Science, which develops more effective tools for translating current science to public audiences. The informal science education community con-sisting of museums, science centers and nature centers has been challenged with a number of perennial problems: exhibits that hold visitor's attention for only a short time (often less than 1 minute); exhibit and program materials that do not reflect current science; and exhibition spaces that cannot be updated. Sea Floor Science responds to that challenge by developing exhibits that have the capacity to be converted from introductory presentations for general audiences to in-depth teaching stations for an 18-hour, inquiry-based middle school program. In addition, Sea Floor Science develops and tests new processes to help researchers effectively translate science concepts for informal learning environments. Finally, Sea Floor Science explores new ways to add updatability to museum settings. Sea Floor Science opened with three collaborators: Texas A&M/ Institute of Nautical Archaeology (INA), Jet Propulsion Lab in Pasadena, California, and Scripps Institution of Oceanography in La Jolla, California.

The work with Texas A&M was focused on translating the archaeological research from INA and, in particular, on the sunken city of Port Royal, Jamaica, where Dr. Donny Hamilton of INA had conducted underwater excavations. This was a compelling choice because middle school students in California are tested on their understanding of plate tectonics. Port Royal, a wonderfully colorful city whose short history is filled with pirates and merchants, was destroyed in 1692 when a sea floor earthquake liquefied the sand, and a significant portion of the town slid into shallow water. Researchers at INA assisted with the development of convertible exhibit solutions, checked texts for accuracy and authenticity,

facilitated the acquisition of artifacts, maps and resources for exhibit and program designers, and contributed to teacher workshops and staff training. The resultant exhibit focused on a replicated 1-meter quadrant from the underwater excavation that afforded students the opportunity to learn underwater survey, mapping and recovery techniques. Students take data on underwater dive slates, build and test their own magnetometers and imitate diver protocols employed by INA. A conservation lab was set up where students build electrolysis tanks, make plaster casts and interpret and label artifacts.

6. The Introduction of the Port Royal Model by UCLA's CVRLab

In the Fall of 2003, a new collaboration between UCLA's CVRLab, MIT's DeepArch Lab, Texas A&M/Institute of Nautical Archaeology and the OI was born to further explore tools and techniques in underwater archaeology in a 4month public presentation called Explorations! UCLA's CVRLab had the task of developing an exhibit update in the form of an interactive computer model for Port Royal that depicted the town (just before the earthquake) as well as the underwater excavation site. The new computer model met the overall Sea Floor Science goals by having the capability of being converted from a public exhibit to an in-depth teaching station for middle school students. In addition, the computer model allowed students and visitors access to current research on how complex data sets are assembled and turned into interactive archaeological research tools. What emerged was an elegant solution that housed computer equipment, Port Royal artifacts, texts and monitors in a large 3'x 3'x 7' furniture-quality crate (*Fig. 1*). The front section of the crate attractively displays Port Royal artifacts and contains electronic equipment and a computer cabinet. Mounted on the top of the crate is a 43" plasma screen monitor that crisply depicts movement within the model to larger audiences.

To be truly convertible, and serve a broad audience, the computer model needed to meet a range of scalable visitor challenges. Public visitors needed the opportunity to virtually walk along the various streets, to examine the architecture, to enter some of the structures, and to find various locations. Middle school students needed all these experiences and they needed the opportunity to "swim" within the underwater archaeological site in search of the real artifacts that were on display. They were challenged to find the artifacts, discuss their location and the possible context of their use. Students began to develop spatial relationships that were difficult to grasp with 2-D maps and to use the computer model in the same way as UCLA CVRLab scholars.

7. Reaction of OI Staff and Visitors to the Port Royal Model

The UCLA CVRLab model made a strong and successful contribution to both the weekend public and middle school overnight programs. Evaluations showed that the model helped translate current science by allowing visitors to understand how today's archaeologists employ technology to describe and understand sites. The interactivity of the model and the ability for visitors to explore houses and shops helped make the Port Royal story relevant to visitors and, therefore, lengthened stay-times and facilitated inquiry-based investigation and discussion. The Port Royal computer model was also successful in the Overnight Program as evidenced each morning with students able to accurately explain the role of computer models in describing and understanding spatial relationships at archaeological sites.

One of the interesting findings is the strong appeal this particular format has for teenage students. Because the technology is so very suitable for this age group, it is not a surprise that our high school interns, serving as exhibit facilitators for weekend public exhibits, were interested, motivated and easy to train. The technology, in fact, serves as an excellent bridge for all of our teen audiences. It is common to find teens teaching teens, teens challenging each other with what they can find and teens coming up with

Fig. 1. Port Royal display case at the Ocean Institute (visitor, left; docent, right).

new ways to use the model. The comfort level with this technology for our young audiences makes this a particularly attractive vehicle for communicating science in informal environments.

8. Port Royal Model Installation

The model is run using an SGI Open GL Performer on a Dell Dimension 8300 series computer (Intel Pentium IV, 2.60 GHz, 512MB RAM, 128MB ATI Radeon 9800 graphics card, 80 GB hard drive) and displayed on a 43" Pioneer DPD-433CMX plasma screen. The interface is achieved using a Gyration Ultra GT cordless optical mouse. The Gyration mouse allows the operator to stand at any distance up to 30' from the CPU and navigate the model with simple hand movements, eliminating the need for a tabletop or other surface to operate the mouse. The Ultra GT can also be operated as a standard optical mouse, allowing visitors, students, and those otherwise unfamiliar with the Gyration technology to navigate the model with a more familiar mouse interface. Occasional keystrokes are achieved using a standard wireless keyboard.

As for software, the Port Royal model was created by the CVRLab using MultiGen Creator (http://www.multigen. com/products/ database/ creator/index.shtml). The Creator OpenFlight file format is then explored by the user by means of UCLA's vrNav scene navigation program (http://www.ats.ucla.edu/at/vrNav1/default.htm). Normally, CVRLab models are georeferenced by on-site survey and given a radiosity solution with Autodesk's Lightscape before they are considered complete and ready for release; but, in the case of the Port Royal Project, constraints of time and budget forced us to eliminate these elements of the model-making process.

The physical requirements of a successful public exhibit are often different from those of a successful student-centered teaching station. Meeting the needs of one while not compromising the other presented some of the greatest challenges. Our student programs require the use of reading materials, Internet access, digital media, equipment storage and reduced or eliminated signage. The public presentation, however, must provide a more "user-friendly" interface that can function effectively with no staff or volunteer mediation. In this mode, visitors will approach and interact with the exhibit entirely on their own. This requires some form of instructional and interpretive signage, an easily understandable interface, and reduced or eliminated access to stored equipment and other program-related functions. The exhibits must also be able to function effectively with varying degrees of staff or volunteer mediation and in this way be a fully scalable experience. The approach of the OI to meeting this challenge was to consider the student-centered teaching station as the highest level of the scalable experience and to create a continuum of degrees of interactivity and instructional mediation that ranged from entirely visitor-operated, through varying degrees of staff or volunteer mediation, and finally to a teaching station capable of serving an 18-hour overnight program. The model's installation reflects this approach.

The system is installed into a 3' x 3' x 7' wooden case modeled after a shipping crate with the face removed. Built into the crate are two primary components: an acrylic artifact display case (*Fig. 2*), and an electronic equipment rack with a darkened acrylic door (*Fig. 3*). The case stands directly over network and internet access ports and a false front below the artifact case allows easy access to these ports. Artifact lighting is provided from within the crate, mounted above the acrylic case. A 43" plasma monitor is mounted on top of the crate with an articulated swivel arm to allow for adjustments as necessary.

The equipment rack houses the model's computer, a second computer for program use, a second monitor, and program materials. The darkened acrylic front allows the second monitor to be viewed by the public when desired but effectively hides other equipment and materials. This case is opened for educational programs and remains closed during public visitation. Signage intended for public visitors is mounted on the door and is effectively hidden when the door is opened for educational programs.

Fig. 2. Artifact on shelf of display case.

Fig. 3. Computer hardware in the display case with darkened acrylic door open. Note shelves with artifacts on left.

The artifacts on display were recovered during an excavation of Port Royal and are on loan from Texas A&M and the Jamaican National Trust. These include an onion bottle, chamber pot, Chinese porcelain bowl, cannon balls, locks, and a few epoxy molds of keys and an iron. These artifacts can be found in the excavation model (*Fig. 4*), allowing students to conduct archaeological investigations based on the context in which the items were found and a study of the artifacts themselves. The context itself is easily scaled in terms of time and space. The CVRLab model permits the artifact to be seen in the immediate surroundings of the site as it appeared during the modern underwater excavations or at the same spot in the reconstructed seventeenth-century city (*Fig. 5*). The historical spot can itself be contextualized within the larger urban fabric of streets, buildings, docks, etc. (*Fig. 6*).

9. Future Improvements and Follow-up Research

Currently, public visitors can navigate the Port Royal model only with assistance from OI staff or volunteers. OI high school interns show visitors how to operate the mouse to travel through the city, or the interns act as navigators under visitors' direction.

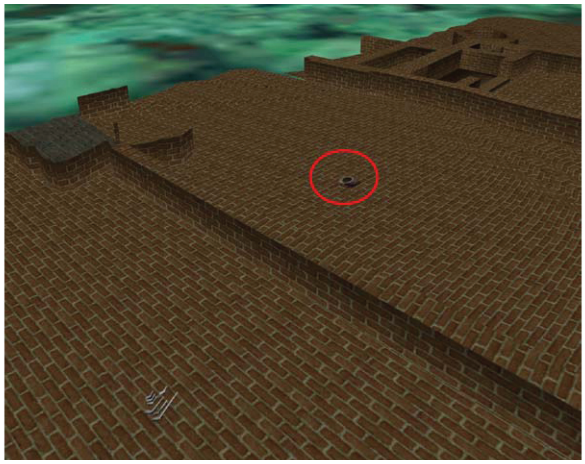

Fig. 4. Screen shot of the CVRLab model showing 20th-century find spot of the chamber pot from Port Royal.

Fig. 5. Screen shot of the same spot in the CVRLab model of 17th-century Port Royal.

Fig. 6. Screen shot of the same spot as seen in Fig. 5. *in its wider urban context.*

The goal of the OI is to provide a public interface that allows visitors to navigate the model with no direct assistance. This will require an intuitive "public-proof" interface and a certain degree of self-correcting behavior within the model so that visitors cannot find

themselves inadvertently below ground or lost near the outer edges of the model. The OI is currently testing joystick and other gaming-type interfaces.

At UCLA, D. Favro will be undertaking new research on the effectiveness of the model as a learning tool for visitors to the OI. Given the fact that the model of Port Royal was not created according to the methodology developed by the CVRLab in terms of lighting, georeferencing, and scholarly oversight, we end by expressing the hope that the model is not considered finished but will be continued to be enhanced in the coming years as a 3D database containing information needed to illuminate the history a site that has sometimes justly been called "the Pompeii of the New World."[1]

Bibliography

Abernathy, D. (2004). *Computer Visualization and Simulation as a Medium for Architectural and Urban History Pedagogy*. Dissertation UCLA.

Antinucci, F. (2003). *Comunicare nel museo*. Rome and Bari: Editori Laterza.

Frischer, B. (1982). *The Sculpted Word*. Berkeley and Los Angeles: University of California Press.

Frischer, B. forthcoming. Mission and Recent Projects of the UCLA Cultural Virtual Reality Laboratory. In: *Acts of Virtual Retrospect 2003, Biarritz, France 6–7 November 2003*. 10 pp. available online at http://www.cvrlab.org/ research/ images/Frischer VirtRetro 2003. pdf (seen July 20, 2004).

Lewis, M. and R. Fisher (1999). Curiosity Kits. *Literacy Today* 20 (September 1999); available online at http://www. literacytrust. org. uk/ Pubs/curiosity.html (seen July 20, 2004).

Pawson, M. and D. Buisseret (2000). *Port Royal, Jamaica*. second edition. Barbados, Jamaica, Trinidad and Tobago: The University of the West Indies Press.

Pimentel, K. and K. Teixeira (1995). *Virtual Reality through the New Looking Glass*. second edition. New York: McGraw Hill Inc.

Snyder, L. M. (2003). *The Design and Use of Experiential Instructional Technology for the Teaching of Architectural History in American Undergraduate Architecture Programs*. Dissertation UCLA.

Vince, J. (1998). *Essential Virtual Reality fast*. London: Springer-Verlag.

[1] Bernard Frischer, founder and Director Emeritus of the UCLA CVRLab, had the idea for this article and for the related talk, which he and Charlie Steinmetz presented at CAA 2004 in Prato, Italy. Frischer recruited the team of authors and edited their contributions. He is the primary author of sections 1, 2, and 4. Charlie Steinmetz was the primary contributor to section 3. Harry Helling and Eric Solomon are responsible for sections 5–9. All the authors contributed something to section 10.