Category: Paper

Title: Active Learning in a Digital Dome with the Living Forest

Authors: A. Schloss[1]*, J. Jacobson[2]*, K. Handron[2]*

Affiliations:

[1]Earth System Research Center, Institute for the Study of Earth, Oceans and Space, University of New Hampshire, Durham, NH USA.

[2]PublicVR, 333 Lamartine St., Jamaica Plain, MA, 02130. http://publicvr.org

*Correspondence to: annette.schloss@unh.edu, jeff@publicvr, kerry@publicvr.org

Abstract: The Living Forest is an interactive virtual environment developed for large-screen formats, especially the all-digital portable dome theaters. Our portable Discovery Dome travels to K-12 schools and other settings to host teacher-led learning activities for audiences of up to 30 students. The Living Forest provides a compelling virtual representation of a functioning ecology over 100 years of forest growth. Students and/or the teacher use a standard game controller to navigate, step the forest through its growth stages, and change season. Significantly, participants use simulated measuring tools to gather information about trees and other features much as a forester would in real life. The Living Forest also works on a standard desktop, web-delivered, so that students can go home and continue to work with it. We developed the forest as part of a 3-year "My Dome" project funded by the National Science Foundation and dedicated to interactive learning in digital dome theaters that engages young people in Science, Technology, Engineering, and Math topics. Preliminary evaluations show that the Living Forest is effective for teaching environmental science in the classroom and in informal settings including scout troop activities and in the museum. For more information see http://publicvr.org/html/pro_forest.html.

Summary: The Living Forest is an interactive virtual environment for digital dome theaters that supports active learning of STEM topics such as forest ecology in the environmental and sustainability sciences.

Introduction:

Digital technologies have transformed the traditional planetarium dome experience from a star field and pointer presentation to movies covering the entire hemispherical screen. Compared to a small screen format (e.g., television), immersing the audience in the material has important educational advantages primarily around the feeling of presence in the virtual environment [1]. Perhaps more importantly, a dome or other immersive display can provide an "egocentric" or inside view of some phenomena or objects. Depending on the topic, the visual design can reveal information that is not obvious or accessible on a flat screen [2-3].

Advances in computing, storage, and output have led to improvements in resolution and brightness of the full-color, full-texture 3D moving image, and most importantly, in real-time interaction [4]. Many programs available for digital domes are passive experiences, but now it is possible to give the audience real-time interaction with virtual worlds, objects, and characters. Taking advantage of these new technologies, the partners in the MyDome project have developed a series of interactive learning experiences for the portable dome environment. These programs are designed to engage youth in Science, Technology, Engineering, and Math (STEM) learning through immersive programs that include aspects of popular video games, transforming the digital dome into an interactive immersive learning lab (I2L2). With ongoing advances in portable inflatable domes, we are taking this high-tech experience "on the road" directly to a growing audience [5].

MyDome explores the learning potential of using different approaches to interactive gaming. Our first program, The Ghosts of Tikal, is a scavenger hunt adventure program in which the audience explores the Mayan village of Tikal for clues as to why the civilization collapsed [6]. The Living Forest, our second program, examines virtual measuring tools that mimic those used by real foresters in the field along with the experience of traveling through 100 years as a forest plot changes in time (Figure 1). This paper describes the Living Forest that actively engages learners in the STEM topics of forest ecology and forest succession.

Scope of Work

This 3-year effort is a collaboration of the University of New Hampshire, the Houston Museum of Natural Science, and PublicVR. Before developing the interactive programs, we researched the capabilities of 3D software programs, game controllers, and interaction schemes. The next steps were to 1) design an integrated and active learning experience, a mini-curriculum which employs these tools and other activities, 2) develop the software and curricula, and 3) test and modify each program with formal and informal education audiences.

Features of the Living Forest

The *Living Forest* is a virtual representation of a temperate forest typical of the Northeastern USA (Figure 1 and Figure 2). The program represents secondary succession where the forest grows from a disturbed area such as a cleared site or an abandoned field into a mature forest with changes in species composition and canopy closure taking place over many years. Students explore using a game controller, look down on the forest from the tower, and make measurements using a set of virtual tools. Students can be divided into teams or work as a single group. Teams may include Foresters, Ecologists, Wildlife Specialists, and Natural Resource Planners. One student or the instructor is the "driver" and controls the action with a game controller while the other students decide where they want to go and record and interpret data.

In the dome, students practice and sharpen their powers of observation, make predictions about what will happen during succession, and then review and revise their predictions based on evidence gathered during the simulation. Features include those shown in Figure 2:

- A 30 by 30 meter forest plot including an observation tower to view from above the canopy.
- Trees that can be examined at 10 years, 50 years, and 100 years of growth.
- Five species of trees that change in size and abundance over time: Paper Birch, Pin Cherry, Eastern White Pine, American Beech, and Sugar Maple [7-8].
- Tools for measuring, including a diameter at breast height (DBH) measuring tape, which is the standard method foresters use to measure trees [9].

Depending on the local curriculum, classes doing field studies can connect their field site to the big picture as they interpret their real-life observations in the context of forest age, structure and function, and forest health – and predict how their site might look in 50 or 100 years or in winter (Figure 3). In this way, the program integrates technology with traditional teaching methods

Results

Formal Education – Fifth Graders. Fifth graders in Massachusetts participated in preliminary tests of the virtual forest (preliminary evaluation data n=43). These students were placed into teams of 3, and each team was given a lighted clipboard and task sheets. Team activities were to identify trees and count the number of each of the five tree species they found at each age of the forest; to observe changes in light in the forest at three growth stages (10 years, 50 years, 100 years); to write down DBH measurements of some trees; and to carry out some pencil-and-paper activities during the immersive experience. Students had learned about forests in their fourth grade classes and were able to identify major tree species in the virtual forest. Overall, students were engaged and worked together to identify and measure trees. Many told us they "*did not know that trees grow*" or that trees in the forest changed so much over time. The program was well received by both students and their teachers, but we did determine that some activities (e.g., filling in their light grids) were too complicated to be carried out by students of this age while in the dome, or were not the best use of the limited time in the dome (e.g., identifying trees).

Formal Education – Sixth Graders. Sixth grade students in a public school in Pennsylvania participated in the virtual forest exploration (preliminary evaluation data n=82). They were grouped by 2 or 3 and first worked through a tree identification activity examining bark and leaves that was new material for these students. The students identified trees and counted them by species at the three growth stages and as a class determined a rough species succession estimate. Some of the groups were successful with estimating the canopy closure, but failure by others pointed to the need for more programming to make the Living Forest support this learning goal more successfully. The students took turns with the controller, were engaged (though loud at times), despite the timing of the program very close to winter break.

Formal Education – Eigth and Twelfth Graders. Students in an eigth grade ecology class, working in pairs, needed only a quick review of tree identification and were able to obtain good data for tree succession and canopy closure. Engagement was mixed with some classes focusing very well and others on an intermittent basis. A senior level college prep course on environmental studies in the same school came in knowing tree identification and with a reasonable idea of succession. They focused on measuring the trees and working out a changing biomass by using DBH to estimate the mass of trees by species.

Informal Education – Teen docents at Carnegie Museum of Natural History. This is a highly self-selected group of teens who choose to both study scientific topics in the natural world and share them with public audiences. They tried early versions of the Living Forest and were highly engaged, contributing many ideas of what could be better. They showed no signs of wanting to stop, even after 90 minutes, suggesting that half-day or longer museum programs using the dome, such as summer camps, can be effective learning tools.

Conclusions

The Living Forest is engaging and inspiring for students of all ages. Because the dome hosts group activities, the curriculum must be appropriate to the amount of time spent in the dome and to the ages of the students. Testing revealed scheduling difficulties in meeting all of the learning objectives in a 45-minute class period, which has to be addressed for this to fit smoothly in many school schedules. For example, identifying trees can be carried out ahead of time, so that in the dome students can spend more time experiencing the changes in the canopy as the forest ages while they record data on tree size and canopy closure. The program was shown to be highly flexible with activities appropriate to differences in the ages, maturity level, and prior knowledge of the participants. Preliminary evaluations now underway indicate this use of the dome to be effective and possibly superior to flat screen presentations. This will provide important information to add to existing theory [2][10] guiding the educational use of immersive media.

References and Notes

[1] Fraser, J., Heimlich, J., Jacobsen, J., Yocco, V., Sickler, J., Kisel, J., et al. (2010). Giant screen film and science learning: Edgewater, MD: Institute for Learning Innovation.

[2] Dede, C., Salzman, M. C., Loftin, R. B., Sprague, D. (1999). Multisensory Immersion as a Modeling Environment for Learning Complex Scientific Concepts. In Computer Modeling and Simulation in Science Education. Springer-Verlag.

[3] Jacobson, J. (2011). Digital Dome Versus Desktop Display in an Educational Game: Gates of Horus, *International Journal of Gaming and Computer-Mediated Simulations (IJGCMS), Special Issue on Educational Applications,* Spring, 2011, IGI Global.

[4] Lantz, A. W. (2011). Planetarium of the Future. *Curator: The Museum Journal*, 54(3), 293-312.

[5] Sumners, C., Reiff, P. & Weber, W., (2008). *Learning in an Immersive Digital Theater*. Advances in Space Research, V42, p1848-1854.

[6] Sumners, C., Schloss, A., Handron, K., Jacobson, J. (2012). Immersive Interactive Learning Labs for STEM Education, *Annual Meeting of the Society for Information Technology and Teacher Education (SITE),* Austin, Texas, USA, March 5-9.

[7] Lanier, J. W. (2004) Managing Regenerating and Young Forest Habitat. http://www.state.nj.us/dep/fgw/pdf/mgtguide/ch05_managing_young_forest.pdf

[8] New York Natural Heritage Program. 2011. Online Conservation Guide for Beech-Maple Mesic Forest. Available from: http://www.acris.nynhp.org/guide.php?id=9988

[9] Teck, Richard M.; Hilt, Donald E. 1991. Individual tree-diameter growth model for the Northeastern United States. Res. Pap. NE-649. Radnor, PA: US. Department of Agriculture, Forest Service, Northeastern Forest, Experiment Station. P. 11

[10] Jacobson, J. (2011). Dome Theaters for Education, *ADL Newsletter for Educators and Educational Researchers*, October. http://ymlp.com/zdxLpK

Acknowledgments

The MyDome project was funded by the National Science Foundation grant HCC – 0916098 to Dr. A. Schloss, principal investigator, general manager, and content expert. Dr. Jeffrey Jacobson led the team that built the virtual environment. Kerry Handron is doing the actual testing and much of the development of the curriculum. David Hopkins did most of the artwork and animation. David Heimann did most of the programming. Calvin Diessner assisted with curriculum development and testing. Tony Butterfield created the warp camera for Unity, which allows the forest and other myDome projects to display in the dome. Dylan O'Ceallaigh did some additional programming and created the artwork for winter. Carolyn Sumners, the principal in other areas of the MyDome project, has made an indirect but important contribution. Similarly, Judah LeBlang and Elizabeth Osche provided useful insights in assessment.

Evaluations are still underway. The forest is available for download from the project website. Also, the dome is available for bookings in the Pittsburgh and New England areas. For more information see http://publicvr.org/html/pro_ddome.html.

Figure 1. Opening scene of the Living Forest, warped for display in the dome. The forest is a representative temperate forest typical of the Northeastern USA.

Figure 2: The tool bar is shown at the bottom of the scene. Students use the toolbar to move among forest ages (young, middle, old), and to take measurements with the DBH tape measure and other tools.

Figure 3: The Living Forest in (virtual) winter.