QuickWorlds: Teacher-Driven VR Worlds in an Elementary School Curriculum

Andrew Johnson
University of Illinois at Chicago
tile@evl.uic.edu

The QuickWorlds program, a collaboration between university researchers and elementary school teachers, provides elementary school instructors with virtual reality models that enhance the K-6 curriculum.

Almost 100 years ago, the Parent-Teacher Organization at Abraham Lincoln Elementary School in Oak Park, Illinois bought a stereopticon for use by the teachers in the belief that a stereoscopic display might give students insights not available through conventional imagery. Today, researchers from the University of Illinois at Chicago are collaborating with the staff of Lincoln Elementary to explore what learning benefits virtual reality technology may offer children within a school context.

Our long-term goal is to help prepare the nation's schools for the advanced visualization technologies, including VR, that are becoming operative in research laboratories. These technologies offer additional representational bandwidth and support new kinds of interactivity. Whether they will be adopted depends on whether we find more solid evidence of effectiveness for the individual learner, and on whether we can successfully align their use with school goals, curricula, practices, and culture.

In August 1999, we installed an ImmersaDesk in the media center at Lincoln, where it will remain for the next two or three years. An ImmersaDesk in the school allows us to continue our formal learning studies of how VR may benefit conceptual learning,[1,2,3] work with entire classrooms on learning scientific inquiry skills,[4] and investigate how this technology can be integrated into the existing school curriculum. This paper describes our QuickWorlds program, in which teachers request VR models to supplement regular curriculum. In this program, we serve as modelers; the teachers control the selection, specification, and use of the models.

Lincoln is a K-6 elementary school in Oak Park, Illinois, a racially and economically diverse inner-ring suburb bordering Chicago's West Side. Lincoln is attractive as a research site for its size, diversity, and state of technology adoption. It is a large school (620+ students), nearly always allocating four 20-to-30-student classrooms at each of the K-6 grade levels. In addition to a racially and economically diverse student body and faculty, Lincoln offers diversity of subject mastery, as reflected in state and local achievement tests administered at the school. While performing moderately above average as a school, Lincoln has significant representation in all performance quartiles. The school is also about average with respect to technology infusion, with about one computer for every five children, distributed both in classrooms and computer lab settings, and an orientation more toward computer literacy and technology education than conceptual learning.

VR in the School

While the history of meaningful technology adoptions in schools has been discouraging,[5] we have the advantage of the lessons learned from the computing integration efforts over the past two decades. The central theme of that experience has been recognizing the importance of addressing the needs of the individual learner while respecting the constraints imposed by the educational context within which learning occurs.

Among the factors that limit successful integration of advanced technologies in schools[6] are:

- Insufficient resources to support teaching practices constrained by conventional school organization.
- Lack of alignment between technology-based materials and school curriculum/performance goals.
- Lack of authentically motivated teacher preparation and training offerings, and lack of time for teachers to pursue additional training.
- Insufficient technical support, both for maintaining and upgrading hardware and software systems, and for providing assistance on the operation and capabilities of application software.
- Failure to provide specific mechanisms for assessing the pace and effectiveness of technology integration with respect to student learning and school climate.

The uniqueness, cost, size, and fragility of VR aggravate these problems. VR technology will be deployed in considerably fewer numbers than personal computers. The existing learning application base is almost non-existent. There are no standard staff development curricula or off-the-shelf courseware. And technical support requires very specialized expertise.

Our goal is to align our project activities closely with Lincoln's learning goals, curriculum, and practices, so the teachers will feel confident that participation does not add irrelevant activities to an already crowded curriculum. Issues of fairness are also paramount. We plan to give every child in the school at least one VR experience per year, either in one of our larger studies or through the QuickWorlds.

We set up the ImmersaDesk in a room adjacent to the school's Media Center. This allows us to minimize the impact of "pull-outs" from regular classroom activity. Since classes regularly visit the school's Media Center, it is easy to "pull over" students to work individually or in small groups while the rest of their class is doing other activities in the Media Center. An SGI Deskside Onyx commonly drives the ImmersaDesk. Our software uses the CAVE library and SGI Performer. Since the CAVE library and SGI Performer are now available for Linux, we are also investigating the use of a Linux-based PC and passive stereo projection as a route to an eventual low-cost setup.

In preparation for the QuickWorlds program, we had a meeting with all of the teachers at the beginning of the school year to describe our goals, and to encourage their participation. The staff and teachers already knew us from our previous work with a temporary ImmersaDesk setup the year before. During the fall, we met with the local Parent-Teacher Organization and the school district's technology council to show them the ImmersaDesk, discuss what we were hoping to achieve, and answer any questions that they had. We also used this time to distribute permission slips to all of the parents, and to talk to interested teachers about developing several initial QuickWorlds. In the spring, we began regular hours at the school, with personnel on-site every Friday so any interested teacher could make use of the VR facilities.

Thomas Moher
University of Illinois at Chicago

Jason Leigh
University of Illinois at Chicago

Ya-Ju Lin
University of Illinois at Chicago

QuickWorlds

The QuickWorlds program is intended to provide a fast-turnaround mechanism for teachers who would like to make virtual models available to their students as part of the regular learning program. Educational materials abound with visualizations for good reasons. Visual representations support learning in numerous ways and the more powerful the visualization technology, the more complete the support:

- *Integration.* A visual representation provides simultaneous and parallel access to multiple parts or components of the visualized system, while a text necessarily presents them in some sequence, leaving the learner with the task of integration.
- *Dynamics.* A dynamic visualization demonstrates how components of a system change over time and interact.
- *Reification.* A visualization can convert abstractions into perceivable objects and engage perception in support of conceptual learning.
- *Activity.* Interactive visualizations allow a learner to manipulate a system, and they draw upon the near-universal principle that knowledge is constructed in the course of activity.
- *Immersion.* High-end visualizations combine all of these features to let learners feel as if they are directly experiencing the visualized system, thus drawing upon children's natural capacity for experiential learning.

However, recognizing the power of advanced visualizations to support learning does specify which visualizations are most useful for teaching a particular topic. Working closely with the teachers and creating the visualizations that they believe will be beneficial helps direct this inquiry. During regular meetings, the teachers submit requests for models, specifying the object(s) to be modeled and the facets of those models most important to the underlying learning goals. One of our art students then creates the necessary models, and our personnel assist the teacher in the presentation of the models to his or her students.

The first set of QuickWorlds that we have developed covers a wide spectrum. Each of these worlds took one to two weeks to develop, with the bulk of the development effort focusing on building the models. The models are then loaded into a common viewing program that allows stereo head-tracked viewing and interaction. This common viewing program allows several sites to remotely collaborate in viewing and manipulating the same model — a capability that we plan to leverage in future years. The first six QuickWorlds are shown in Figure 1.

The models that have been developed range from simple static models such as a wood ant and the interior of the Earth, to more complicated dynamic models such as the volcano, iceberg, human heart, and solar system.

- The ant was created as part of the school's units on insects. It is magnified to be six feet long, to make the 3D structure of the ant easier to see.
- The interior of the Earth, created on request of a fourth-grade teacher, shows the Earth as a four-foot-diameter sphere. Kids can use a dynamic cutting plane to cut through the planet and see the internal structure.
- The volcano, created as part of the school's unit on earth science, shows Mount St. Helens before and after the eruption of 1980. It allows the children to look under the surface of the ground, and to use the cutting plane to see what the internal structure of the volcano looks like.
- The iceberg was created as part of the school's unit on the polar regions, allowing the students to see the structure of a small iceberg both above and below the water. Animated seals, penguins, and whales help give a scale to the iceberg and lead the children from the visible iceberg to the larger mass of ice beneath the water.

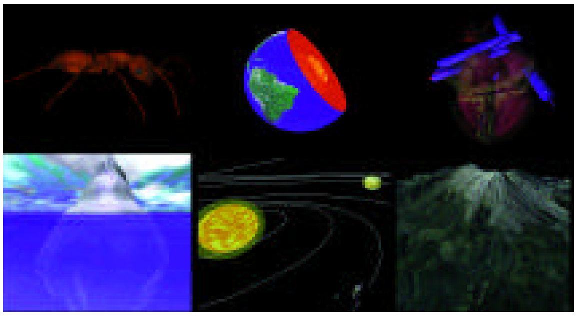

Figure 1: A selection of QuickWorlds that have been developed. Top row: a wood ant, the interior of the Earth, the human heart. Bottom row: an iceberg, the solar system and a volcano.

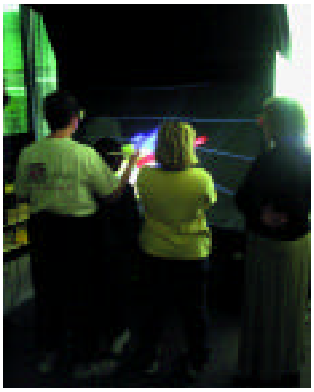

Figure 2: Kathy Madura, physical education teacher, discussing the human heart with her students using the ImmersaDesk at Lincoln.

- The solar system, created at the request of a fourth-grade teacher, allows the students to see both the moving solar system in scale (with the sun and planetary diameters in the same scale as their orbits) to get a feeling for the vast scale of the distances involved and an enhanced view with the planets and their moons enlarged to allow the students to investigate the similarities and differences between the planets. The sun, planets, and major moons rotate and revolve at a rate where one second in the virtual world equals one day in real life.
- The human heart, created at the request of Kathy Madura, the physical education teacher, is an animated beating heart with arrows showing how the blood flows through its various chambers. Optional transparency allows the students to see the 3D nature of the blood's passage through the heart, and a movable clipping plane allows easier viewing of the internal structure.

Usage

The teachers are responsible for structuring the learning experience, and they guide the actual sessions using the models. Typically, we initially operate the controller for the teachers, but as they gain experience, they take over the controller themselves.

A typical pattern of usage can be seen in a recent experience with the heart model. The physical education teacher had previously used Heartland, a model of the human heart realized as a collection of kid-sized carts, pulleys, balls, hoops, and tunnels laid out on a gymnasium floor. The kids wheeled about on the carts, picking up corpuscles and moving from one chamber to another.

This teacher used the heart QuickWorld to reinforce that earlier learning. The teacher ran sessions of approximately 10 minutes with three fifth-grade students at a time. She began each session by reminding the students of Heartland and relating the anatomical elements of the heart (chambers, valves, aorta, etc.) and the animation of blood flow to that experience. She often began by relating functionality played out in the Heartland model (for example, oxygenation) and seeing if her students could relate that process to the QuickWorlds model. She used about a half dozen different clipping planes during each session. Students readily agreed when directly asked whether the model has improved their understanding; not unexpectedly, the students were impressed with the technology.

Experience and Future Work

The students are certainly excited about this addition to the curriculum, and we continue to get many requests from interested teachers (for example, adding lungs, cholesterol, leaky valves to the heart model; atoms; more insects.) In future semesters, as we continue the QuickWorlds work, we will be creating more models, and adding more details to the existing models.

It is still too early to give any conclusions about whether these worlds are effective. We believe that the appropriate path this year is to generate a variety of QuickWorlds based on the teacher's requests, make them available to the teachers and their students, and see which ones the teachers feel are most effective. This experience will then drive the kind of QuickWorlds and their attributes developed in the second year, with the eventual goal of empirically investigating learning effectiveness relative to unsupplemented instruction and non-immersive interfaces. The novelty effect is also very strong, as the children are very excited ("sweet!" was a common exclamation when first seeing the virtual heart) about this new technology. This has advantages and disadvantages. The children are excited by the experience but may not be focused on the lesson to be learned. We would like to reach the point where the ImmersaDesk hardware loses its novelty for the children, and the visualizations themselves become the focus.

We currently have at least one person on hand at the school for one day per week to run the VR equipment for the teachers, and talk to them about any new QuickWorlds requests. This will expand to two days a week in the next school year. We are in the process of making the models from the existing QuickWorlds available in VRML-1 format on our Web pages, so other educators can download them and use them in more conventional VRML browsers.

Acknowledgements

This research was made possible through major funding from the National Science Foundation, specifically EIA-9802090, EIA-9720351, and DUE-9979537.

The virtual reality research, collaborations, and outreach programs at the Electronic Visualization Laboratory (EVL) at the University of Illinois at Chicago are made possible by major funding from the National Science Foundation (NSF), awards EIA-9871058, ANI-9712283, ANI-9730202, and ACI-9418068, as well as NSF Partnerships for Advanced Computational Infrastructure (PACI) cooperative agreement ACI-9619019 to the National Computational Science Alliance. EVLalso receives major funding from the US Department of Energy (DOE), awards 99ER25388 and 99ER25405, as well as support from the DOE's Accelerated Strategic Computing Initiative (ASCI) Data and Visualization Corridor program.
www.evl.uic.edu/tile

References

1. Johnson, A., Moher, T., Ohlsson, S., Gillingham, M. (1999). The Round Earth Project: Collaborative VR for conceptual learning. In *IEEE Computer Graphics and Applications, 19* (6), 60-69.
2. Johnson, A., Moher, T., Ohlsson, S. (1999). The Round Earth Project - Collaborative VR for elementary school kids. In *SIGGRAPH 99 Conference Abstracts and Applications*, 90-93.
3. Moher, T., Johnson, A., Ohlsson, S., Gillingham, M. (1999). Bridging strategies for VR-based learning. In *The Proceedings of CHI 99*, 536-543.
4. Moher, T., Johnson, A., Lin, Y., Cho, Y. (2000). Systematic observation in a synthetic environment. In *The Proceedings of the Fourth International Conference of the Learning Sciences, June 14-17, 2000*.
5. Cuban, L. (1986). *Teachers and machines: The classroom use of technology since 1920*. New York: Teachers College Press.
6. Herman, J. (1994). Evaluating the effects of technology in school reform. In B. Means (Ed.), *Technology and education reform: The reality behind the promise* (pp. 133-167). San Francisco: Jossey-Bass, 1994.