Virtual Worlds for Education: River City and EcoMUVE

Shari J. Metcalf
Jody Clarke
Chris Dede
Graduate School of Education
Harvard University

Introduction

Multi-user virtual environments are 3-D graphical worlds used to construct simulated immersive experiences. In a MUVE, each user has a virtual representation, called an avatar, and moves this graphical avatar through the 3-D virtual world. These simulated contexts provide rich environments in which participants interact with digital objects and tools, with each other and with computer-based agents. MUVEs are a rapidly growing platform for entertainment applications such as multi-player Internet games and "virtual places" (e.g., Second Life). MUVEs are also a promising platform for educational applications, in part because MUVEs can simulate environments and experiences otherwise impossible in school settings.

Over the past ten years, we have been exploring the use of MUVEs in education through the River City project, supported by grants from the National Science Foundation. We have found that MUVEs can be an effective platform for providing authentic inquiry in middle school science (Clarke, Ketelhut, Nelson, Dede, 2006). We've recently started a new research project, EcoMUVE, supported by the Institute of Education Sciences in the Department of Education. EcoMUVE focuses on the application of MUVEs to ecosystems education. In this paper, we describe our research with River City and EcoMUVE and discuss the design characteristics of virtual worlds that make them valuable technologies for education.

River City

River City is a MUVE designed to support middle-school students in learning scientific inquiry through problem-solving in a virtual world. The River City "world" is a historical town in the late 1800's, where residents are becoming ill. The students take on the role of 21st century scientists who travel back in time in order to help the mayor figure out what's causing the illness.

Students use their virtual avatars to walk around the town, talk to residents, explore the physical environment, and make observations (see Figure 1). They can visit the town's hospital and see who's getting sick and what their symptoms are, as well as visit the town's library to gather information. They learn to use data collection tools to count mosquitoes and to measure bacteria at different points along the river that runs through the town (see Figure 2). Students generally work in teams, exploring independently but periodically sharing their observations and ideas with their teammates using a chat window.

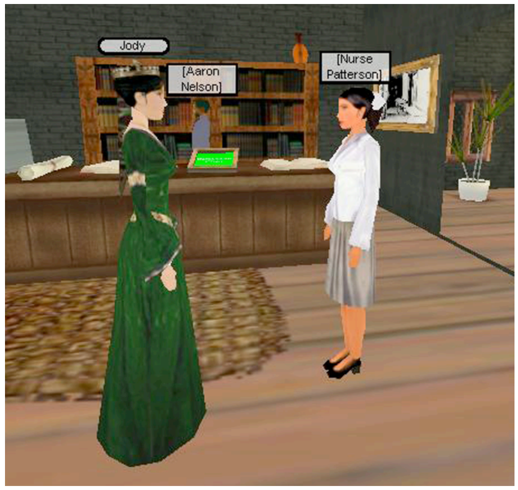

Figure 1. Student avatars interacting with residents of River City

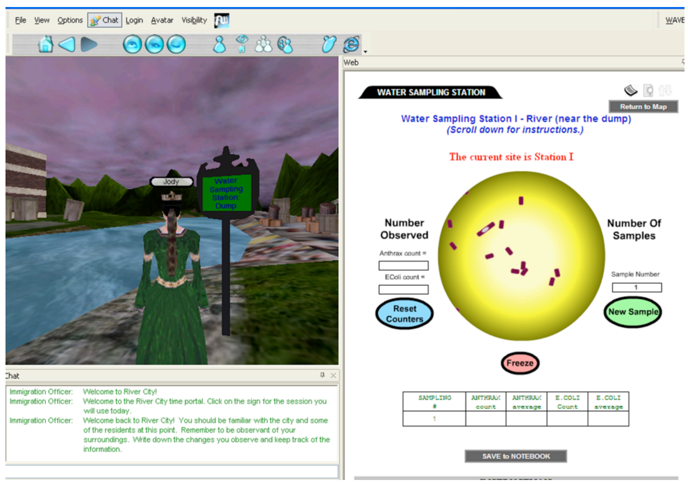

Figure 2: Virtual microscope allows students to measure bacteria in the water

Students visit the town during four seasons – fall, winter, spring, and summer – making observations at each season and seeing the changes in the illness over time. Then they form a hypothesis about a cause of the illness (e.g., "If we cleaned up the trash then there would be less sick people in River City because trash won't be polluting the river"). Once students have a hypothesis, they conduct a controlled experiment with two more visits to the town - to "control" world and "experimental" world – representing the way the town would be if their independent variable (e.g., cleaning up the trash) did or didn't happen. Students are able to collect and compare the control and experimental data, evaluate their hypothesis, and make recommendations.

In the past nine years, thousands of students and hundreds of teachers around the US and in Canada have used River City. Our research with River City has found that MUVEs increase engagement in learning by allowing students to immerse themselves in a virtual world. River City has been particularly effective in motivating students who are usually unengaged and low-performing academically. Controlled studies show educational gains in science content, sophisticated inquiry skills, motivation to learn science, and self-efficacy (Clarke, Ketelhut, Nelson, Dede, 2006).

EcoMUVE

EcoMUVE is an ecosystem MUVE for middle-school science, to support learning about complex causal relationships in ecosystems. Ecosystems are amazingly complex biosystems that are greatly affected by non-obvious as well as obvious variables. To understanding patterns of causality, students need to recognize non-obvious causes and indirect effects, deal with time delays between causes and visible effects, consider population effects versus individual effects, and reason about balance and flux (Grotzer & Basca, 2003).

EcoMUVE is designed to illustrate the complex causality of an ecosystem, with interactive, immersive depictions of plant and animal behavior. Students will "collect data" like scientists by placing simulated measuring tools into the virtual environment. Students will explore the environment, visit at different points in time, and view phenomena at different scales. Students will work together to collect and analyze a variety of data, in order to figure out the complex causes leading to specific ecological events.

Figure 3: Black's Nook Pond in Cambridge, MA

We are developing two ecosystems science curricular modules. The first is a model of a pond ecosystem, based on Black's Nook, a freshwater pond in Cambridge, MA (see Figure 3). Students will explore the pond and the surrounding area, go under the water, and see different organisms interacting realistically in their natural habitats. Students will use a virtual net to capture and see organisms living in the mud, and a virtual microscope to see microscopic organisms. They will look up the organisms they find in a field notebook and create a food web in which they can draw arrows to indicate the energy relationships between the species. The food web tool will also show students the population counts of each species they find. Students will have a set of data collecting tools to measure different variables – e.g., temperature, dissolved oxygen, phosphates, nitrates, pH, temperature – and be able to measure these variables at different places in and around the pond. Figure 4 shows a mockup of the EcoMUVE interface.

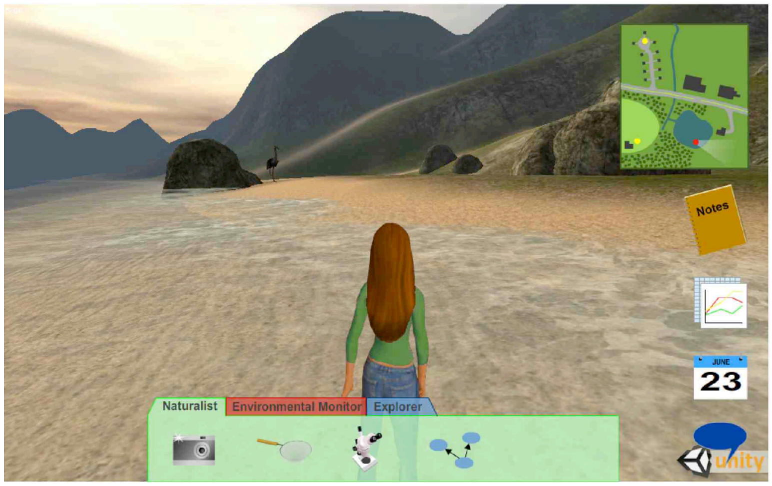

Figure 4: Mockup of EcoMUVE interface

Students will visit the virtual pond at different points in time. Each day the pond or area may look different, there might be people to talk to or things to see, and students will collect data on each day. Students will view the data over time using tables and multi-line graphs. Eventually students will make the surprising discovery that, on a day in late summer, there is a fish kill. Students will be challenged to figure out what happened. They will continue to visit different points in time, collect and analyze data, and gather information to solve the mystery and understand the complex causality of the pond ecosystem.

Design Principles for Virtual Worlds for Education

Why use MUVEs for education? As the examples of River City and EcoMUVE demonstrate, we propose the use of MUVEs for education for the following reasons.

- MUVEs allow simulated experiences otherwise impossible in school settings.
- MUVEs increase engagement in learning by allowing students to immerse themselves in a virtual world.
- MUVEs support new forms of interaction and collaboration.
- MUVEs can increase students' knowledge, skills, and self-efficacy.

In particular, the immersive nature of a virtual world can add significantly to the learning experience. For example, in River City, students can get clues by talking to residents or reading notes, but there are also tacit clues within the environment. They can hear the mosquitoes buzzing, and the buzzing is louder when there are more mosquitoes around. They can experience the landscape by walking through it – the river starts uphill in the wealthier parts of town, then flows downhill to the low-income tenements, potentially bringing contamination from sewage. Students see and hear the spring rains, and may wonder how the runoff affects the water supply. We are designing the EcoMUVE to promote similar feelings of immersion in nature.

MUVEs are also useful in providing pedagogical support for learners, as follows.

- Scaffolding. Like other computer-based educational materials, MUVES can provide scaffolding, tailored supports for learners. MUVEs can contain embedded hints and tutoring delivered via situated, just-in-time processes.
- Jigsaw Pedagogy. Jigsaw pedagogy is an approach in which each student in a team gathers separate information - they might even have access to information that the other students do not – and then they come together as a team to piece together what they've learned in order to solve a problem. MUVEs can give students specialized abilities, areas to explore, or missions, so that they learn to problem-solve collaboratively.
- Roles. MUVEs allow students to assume different roles. For example, in River City, students were "21st century scientists" traveling back in time. As scientists from the future, the students were more knowledgeable than the residents - e.g., they knew about microbes, and had microscopes as tools. We suggest that when students are able to learn about science by being scientists, they are more likely to think of themselves as scientists.

In addition, MUVEs have particular advantages when used for science education.

- MUVEs can slow down or speed up the passage of time.
- MUVEs can zoom in or out to display phenomena at various scales.
- MUVEs can help students understand spatially distributed phenomena by enabling movement through space.
- Students can collect data by placing simulated measuring tools into an virtual environment.
- MUVEs can support microworld simulations in which students can make predictions, then change a variable or rule and observe what happens.

MUVEs allow for the design of situations that are not possible or practical in the real world. Through the affordances of a MUVE, we can create scenarios with real-world verisimilitude that are safe, cost effective, and directly target learning goals. Like other computer-based simulations, MUVEs can also allow students to explore in ways that would not be possible in the real world, through manipulating time and space, or doing experiments that would be dangerous or impossible in real life.

In River City students jumped from fall to winter to spring to summer to see changes over time. They also performed what-if experiments and were able to see both the control and experimental outcomes, and make comparisons. In EcoMUVE students will see the microscopic organisms that live in pond water. With MUVEs, the opportunities to explore virtual environments are limitless – students could shrink to the size of an atom or molecule, travel through the solar system, or explore the human digestive system.

Concluding Remarks

MUVEs are part of the future of education. The 21st century pedagogy includes the affordances provided by new technologies. Rather than learning by listening to lectures or reading textbooks, students will increasingly be able to access new ways of learning that include virtual world simulations. Students will have the opportunity to learn science by exploring and solving problems in realistic environments. Project-based learning can be made accessible to all students, through the experiences and tools that are possible in virtual worlds. Our research is documenting the strengths and limits for education of these immersive, interactive media.

References

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