By Chris Dede

Multi-User Virtual Environments

In a decade or two, three complementary interfaces will shape how people learn with computers and telecommunications.[1] These interfaces will supplement, but not replace, face-to-face learning, infusing all forms of education:

- *The familiar "world to the desktop" interface,* providing access to distant experts and archives and enabling collaborations, mentoring relationships, and virtual communities-of-practice. This type of interface is evolving through initiatives such as Internet2.
- *The "ubiquitous computing" interface,* in which portable wireless devices provide virtual resources as users move through the real world. The early stages of augmented-reality interfaces are characterized by research on the role of smart objects and intelligent contexts in learning and doing.
- *The "Alice-in-Wonderland" multi-user virtual environments interface,* in which participants' avatars interact with computer-based agents and digital artifacts in virtual contexts. The initial stages of studies on shared virtual environments are characterized by advances in Internet games and work in virtual reality.

The following vignette gives a view into the future of the third interface: multi-user virtual environments (MUVEs) for learning:

In the computer lab at her elementary school, Consuela was threading her way through a complex maze. The maze was not in the lab but in the "Narnia" MUVE (a text-based MUVE developed around the stories by C. S. Lewis). Her classmates and fellow adventurers Joe and Fernando were "with" her, utilizing their Web-TV connections at their homes, as was her mentor, a small bear named Oliver (in reality, a high school senior, interested in mythology, who assumed a Pooh-like avatar in the virtual world of the MUVE). Mr. Curtis, the school principal, watched bemused from the doorway. How different things were in 2009, he thought, with students scattered across grade levels and dispersed throughout the city—yet all together in a shared, fantasy-based learning environment a full hour before school would even start! (The school building opened at the crack of dawn to enable lab-based Web use by learners like Consuela, whose family had no access at home.)

"The extra effort is worth it," thought Mr. Curtis. Seven years into the technology initiative, student motivation was high (increased attendance, learners involved outside of school hours), and parents were impressed by the complex material and sophisticated skills their children were mastering. Even standardized test scores—which measured only a fraction of what was really happening—were rising. Most important, young girls such as Consuela were more involved with school. Because of their culture, Hispanic girls had been very reluctant to approach adult authority figures, like teachers, but the MUVE altered that by providing a costume-party environment in which the children's and teachers' avatars, wearing the "mask" of technology, could mingle without cultural constraints. "I wonder what this generation will be like in high school—or college?" mused Mr. Curtis.[2]

Although children's use of MUVEs is portrayed in this vignette, many applications for adult learning are emerging as more mature students are increasingly able to take better advantage of the myriad capabilities of virtual environments.

This rosy picture of the future of MUVEs in education is based on promising early research results. With NSF funding, my colleagues and I have created, implemented, and studied graphical MUVEs that use digitized museum resources to enhance middle-school students' motivation and learning about science and its impact on society.[3] The educational environments of our project extend typical MUVE capabilities in order to study the science learning potential of immersive simulations, interactive virtual museum exhibits, and "participatory" historical situations. The River City curriculum unit is based on students collaboratively investigating a virtual world consisting of a city with a river running through it, different forms of terrain that influence water runoff, houses, industries, and institutions such as a hospital and a university. The learners themselves populate the city, along with computer-based agents, digital objects (which can include audio or video clips), and the avatars of instructors. River City contains over fifty digital objects from the Smithsonian's collection, plus "data collection stations" that provide detailed information about water samples at various spots in the world.

Figure 1 shows nineteenth-century laboratory equipment representative of what students encounter in River City. The content in the right-hand interface window changes based on what the participant encounters or activates in the virtual environment. Dialogue is shown in the text box below these two windows. As an aid in their interactions, participants also have access to one-click interface features that enable the avatar to express (through stylized postures and gestures) emotions such as happiness, sadness, agreement, and disagreement. Students must collaborate to share the data that each team collects. Beyond textual conversation, students can send to each other "snapshots" of their current individual point of view (when someone has discovered an item of general interest) and also can "teleport" to join anyone on their team for joint investigation. Throughout the world, students encounter residents of River City and "overhear" their conversations with one another. These computer-based "agents" disclose information and indirect clues about what is going on in River City (see figure 2).

Figure 1: Lab Equipment inside a Building

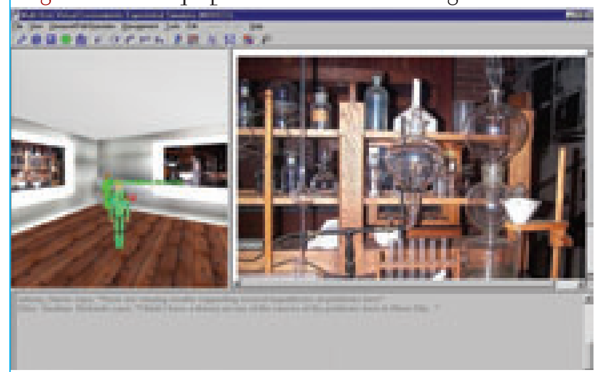

Figure 2: A Computer-based Agent Conversing

In our pilot implementations of River City, using three public-school classrooms in Boston, we examined usability, student motivation, student learning, and classroom implementation issues. One sixth-grade and one seventh-grade classroom in different schools with high percentages of ESL (English as a Second Language) students were identified as having access to the needed technologies. Approximately 75 percent of the students were on free or reduced lunch, indicating a high proportion of at-risk students. Control classrooms were arranged with a similar, but technology-free, curriculum designed for them. There were forty-five students total in the two experimental classes and thirty-six total in the control classes, all evenly split by gender. Both qualitative and quantitative data were collected from students and teachers over the three-week implementation period. Students found the MUVE interface readily usable and the learning experiences motivating, even after repeated exposures. Once the MUVE software was configured to work with the firewalls idiosyncratic to each school, teachers reported no problems in implementation.

Preliminary results indicate the MUVE is motivating for all students, including lower-ability students typically uninterested in classroom activities. Six out of seven experimental students scoring less than 35 percent on the content pretest improved their content knowledge above that level, whereas only two of five control students did so. In addition, controlling for collaboration and science interest, the experimental group, on average, had more positive changes in motivation mastery (as measured by the PALS assessment) than did the control group. Subtest averages for students' perceptions of academic efficacy also showed significant differences ($t=3.36$, $p<.05$) between the two groups, with the experimental group showing an increase of 1 point out of 5 on average, as opposed to the control group's decrease of .31. Additionally, our data show that there were no differences in performance between ESL and non-ESL students.

Overall, these findings encourage further refinement and experimentation with MUVEs as a learning modality that can help instructors reach students who struggle with motivation, self-worth, and lack of content knowledge. These data are promising, but they are not conclusive about the educational value of this curriculum or the effectiveness of MUVEs for learning. By examining students' interactions with the pilot curriculum, we saw ways to strengthen our content and pedagogy. We also saw teachers struggle with facilitating the whole-class interpretive sessions that alternated with MUVE experiences, an indication that we need to extend our professional-development experiences.

Studies of MUVEs and similar emerging interactive media address issues of fundamental research on learning theory, the development of new methodologies for studying learning and teaching, and the enhancement of students' abilities to apply academic knowledge in real-world contexts. MUVEs may be a promising complement to more conventional kinds of computer-based instruction, particularly for low-performing students unmotivated by conventional pedagogy and skeptical about their ability to learn. Research on educational MUVEs may also provide insights into virtual environments for "edutainment," enabling home-based educational usage of the many entertainment media utilizing virtual contexts and communities. Finally, this interactive medium may be a powerful supplement to conventional face-to-face educational activities.

Notes

1. C. Dede, "Vignettes about the Future of Learning Technologies," 2020 *Visions: Transforming Education and Training through Advanced Technologies* (Washington, D.C.: U.S. Department of Commerce, 2002), <http://www.ta.doc.gov/reports/TechPolicy/2020Visions.pdf> (accessed February 26, 2003).
2. C. Dede, "Emerging Technologies and Distributed Learning in Higher Education," in Donald E. Hanna and associates, *Higher Education in an Era of Digital Competition: Choices and Challenges* (Madison, Wisc.: Atwood, 2000), 71–92.
3. C. Dede, D. Ketelhut, and K. Ruess, "Motivation, Usability, and Learning Outcomes in a Prototype Museum-based Multi-User Virtual Environment," in P. Bell, R. Stevens, and T. Satwicz, eds., *Keeping Learning Complex: The Proceedings of the Fifth International Conference of the Learning Sciences (ICLS)* (Mahwah, N.J.: Erlbaum, in press). See also the project Web site: <http://www.gse.harvard.edu/~dedech/muvees>.

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