Fostering Motivation, Learning, and Transfer in Multi-User Virtual Environments

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Many researchers are currently exploring the rich types of learning that take place in online game environments, including the acquisition of some worthwhile skills (e.g., collaboration) (Gee, 2003; Steinkuehler, 2004). However, the content acquired typically is neither related to national standards for academic content nor useful if applied to real world contexts, and no studies have yet established the transfer of skills mastered in gaming to life situations. With NSF funding, we are designing and studying a multi-user virtual environment (MUVE) that uses digitized museum resources to enhance middle school students' motivation and learning of higher order scientific inquiry skills, as well as standards-based knowledge in biology and ecology. MUVEs enable multiple simultaneous participants to access virtual contexts, to interact with digital artifacts, to represent themselves through "avatars," to communicate with other participants and with computer-based agents, and to enact collaborative learning activities of various types.

Developing effective educational curricula for students who struggle in school settings is challenging. These students are often characterized by high absentee rates, behavior problems, low interest in science, and low self-efficacy in science. We are studying MUVES, designed to be engaging for students – including underperforming and disaffected pupils -- and to help them learn deep content and higher order skills. In this paper, we present findings from implementations involving nearly two thousand urban students and their teachers, delineating what aspects of our MUVE's design support student motivation and learning. In the following sections, we first present the context and background for this study. Then we describe our research design and present our findings and conclusions.

The River City MUVE as a Learning Environment

River City is an 18th century industrial city with a river running through it; different forms of terrain influence water runoff. Typical of an 18th century small city, it has various neighborhoods representing different socioeconomic classes, as well as institutions such as a hospital and a university. Students travel back in time to explore the city where they encounter computer-based agents representing residents of the city, as well as digital objects including historical images, videos with suggestions on doing science, and scientific tools such as a virtual microscope (see figure 1). Content in the right hand interface window shifts based on a participant's interactions in the virtual environment (see figure 2). Chat text and computer agent dialogues are shown in a text box at the bottom; members of each team can communicate regardless of distance, but inter-team chat is disabled to keep students focused on their work as a small group.

Figure 1: Talking to Avatars

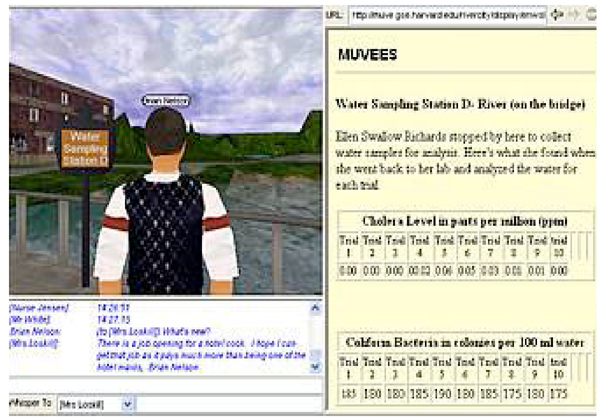

Figure 2: Right Window Interface

Students work in teams of 3 to isolate a problem regarding one of the three strands of illness pervading the city (water-borne, air-borne, and insect-borne). These three disease strands are integrated with historical, social, and geographical content to allow students to experience the realities of disentangling multi-causal problems embedded within a complex environment. Students develop a hypothesis, design and test an experiment, and write a letter to the mayor informing her of their findings. They then compare their research with other teams of students to discover the complex web of illnesses in River City and the many potential hypotheses for investigation.

Theoretical Context

Gee (2003) claims "good" videogames involve distributed cognition, semiotic domains, situated meaning, and meta-reflection. Whereas learning in school is often passive, Gee found "good" videogames allow players to be active producers of their knowledge, capable of customizing their learning experiences. Similarly, in research on MMOGamings (Massively Multi-player Online Gaming), Steinkuehler (2004) has found that learning is a social practice where players engage in complex problem solving and collaborative social interaction. In these games, unlike school, the focus is on the activity with materials providing information (manuals, documents) in a supporting role (Steinkuehler, 2004).

Part of the promise of MUVEs is their capability to create a similar immersive, extended experience but with problems and contexts similar to the real world. MUVEs also provide the capability to create a problem-solving community in which participants can gain knowledge and skills through interacting with other participants who have varied levels of skills, enabling legitimate peripheral participation driven by intrinsic sociocultural forces.

Our evolving design of River City (Nelson, Ketelhut, Clarke, Bowman, Dede, 2005) is built around theories of situated learning and motivation. Brown, Collins, & Duguid (1989) and Lave & Wenger (1991) define situated learning theory as embedded within and inseparable from participating in a system of activity deeply determined by a particular physical and cultural setting (Chaiklin & Lave, 1993; Lave, 1988). The unit of analysis is neither the individual nor the setting, but instead the relationship between the two, as indicated by the student's level of participation in the setting (Barab & Plucker, 2002). Greeno (1997) indicates that the power of situated learning is derived from a person learning to solve problems as part of a community in the authentic context confronting these challenges, a difficult environment to develop in a classroom yet possible in a MUVE. Specifically, The River City curriculum unit is based on students participating in an elaborate context modeled on the real world, interacting with novices and experts who are part of its culture. Learners are not passively observing this situation, but actively investigating multivariate problems with aid from community members who have various types of expertise

In order to engage students in the activity of solving a problem, we needed to ensure that the design itself is motivating for students. Research on motivation suggests autonomy (de Charms, 1968; Malone and Lepper, 1987; Ryan and Deci, 2000; Lepper & Henderlong, 2000) and optimal level of challenge (sometimes referred to as competence) (Malone and Lepper, 1987; Ryan and Deci, 2000; Lepper & Henderlong, 2000) are critical elements in students' motivation for learning. These are critical design elements in our River City MUVE.

We also wanted to ensure that the design was equally engaging for girls as it is for boys. Aware of the lack of female role models in science, three key figures in the MUVE curriculum are all female. The design is also built around collaboration, a feature that girls tend to like in video games and computer science classes (Clark, 1999).

Research Design

The research questions that guide this study are:

- What features of the design do students find motivating?
- How do these features support student learning?

For over two years and in four different states, we conducted large-scale implementations with more than 2000 students in primarily urban classrooms with high proportions of ESL and free-and-reduced-lunch students. To control for threats to validity, our computer-based treatments, each providing a different pedagogy, were randomly assigned to students within each classroom, with teachers instructed to minimize cross-contamination of treatments. In year one, students used MUVEs based on social constructivist (GSC) and Expert mentoring and Coaching (EMC) pedagogies. In year two, we added an additional treatment, a Legitimate Peripheral Participation (LPP) pedagogy modeled on Lave and Wenger's (1991) notion of community of practice. In both years, a paper-based control treatment similar in pedagogy to the GSC treatment was randomly assigned to whole classes. Each teacher offered both the computer-based treatments and the control.

Data Sources

Data for this study came from student interviews, student focus groups, surveys, classroom observations and log files of students' activities in River City. Over two years, a total of 22 students were interviewed, both pre-and post-intervention, using a semi-structured interview protocol. In year one, six girls and six boys stratified with both low and high achievement were identified by their teacher to be interviewed. In year two, two students (1 girl and 1 boy) were randomly selected from each River City treatment (6 total). Student interviews were conducted in the school, audio recorded, and transcribed verbatim.

Also, at the end of year one, focus groups were conducted with about 40 students using a semi-structured protocol. These groups were video and audio-taped. At the end of year two, students responded to open-ended questions in an online survey using Survey Monkey (www.surveymonkey.com).

The River City MUVE program automatically generates log files of students' chat transcripts and interactions in the computer environment. In addition, observations were conducted in various classrooms over the two years.

Data Analysis

Open coding techniques (Strauss and Corbin, 1998) were employed to code all of the interview transcripts. In order to provide thick description data from the focus groups (Geertz, 1973), surveys , observations and log files were triangulated with data from the interviews. Cross-case analyses were conducted to compare patterns and themes that emerged. We then compiled cases of individual students to illustrate these themes.

Quantitative analysis was conducted using multi-level modeling in order to minimize the effect of treatment being confounded by classroom groupings.

Findings

Our quantitative findings thus far have shown that students' self-efficacy in science increases through interaction with River City, as does their thoughtfulness of inquiry. In this section we highlight findings from our qualitative studies and present major themes of the design that students find motivating and how these features support learning.

The Mystery of River City: Capturing Student Curiosity

Designing River City around a mystery helped maintain student curiosity, an important feature of designing for motivation (Lepper & Malone, 1987). Students liked "exploring the unknown" of why people were getting sick in River City, whereas regular science is "exploring the known." As one student said, "I got pretty interested in the mystery and how to solve it." Students felt that they were "discovering science" because each time they went into River City it was different. Not only is the season of the year different on each of their six visits, but they also learn new information from the residents each time. According to one student, "when I was making the experiment and going around asking everything I kind of felt like a detective." Needing to figure things out also helped students "pay more attention" and therefore "learn more."

Collaboration with Teammates

Designing River City around collaboration was motivating for students and felt authentic to them, as most learning outside of school is collaborative (Resnick, 1987; Brown, Collins, Duguid, 1989). For some students, the opportunity to work in teams was "different" because they usually work "independently" in science class. In addition to having the opportunity to work in teams, River City allowed some students to "work with people I didn't really talk to." Many students thought it would have been difficult to solve the problem on their own without their teammates because "you get more information than you would with one person." However, the extent to which these participants benefited from sharing and distributing the work among a team depended on how motivated they were to work with their teammates. There were some students who would have preferred choosing their own teammates with whom to work. Some students did not like their teammates and therefore, did not work with them.

Autonomy: Exploring on our Own

Oftentimes in science class, students work from a book or are told what their hypothesis will be. River City is designed for students to identify a problem to explore on their own. This feature has been very successful for student motivation and learning. Students like that it is "more independent working…rather than having him instruct us and telling us what to do and guiding us." They claim, "it was different by exploring by myself not being told what things to test out." Students also liked that they get to choose their identity in the world. There is a list of avatars that students can choose from.

Communicating with Residents of River City

Learning is a social process (Lave, 1987; Brown, Collins, Duguid, 1989; Steinkuehler, 2004), and being able to communicate with the residents of River City was motivating for students. Students could ask residents "what's new" and received a different response each time. "Talking to people" in River City made it easier to find clues and information about the problem. Some students compared research in the MUVE to using books: "They are actually doing it [research] by talking to people instead of learning it through books." Other students talked about it as "collect[ing] a lot of information from them [the people in River City]. Talking to the residents also helped students feel like they were "really there" in River City and "just like a real place is. It had a mayor and shops and things that we have in real life." Talking to residents made the MUVE interactive and therefore more "fun."

The Right Challenge: Making us Think More

Many students said that they liked the fact that it was more "difficult" and "more challenging" than their regular science class. Having to solve the problem and "figure out" why people were getting sick made students "think more" and as a result, learn more. "Thinking more" is related to "figure out" and having to "figure out" means that they think hard. One student claimed, "we had to figure out things and ask questions and use our brains and think really hard... because we had to figure out what was wrong."

Visualization of Information

Being able to "see things" helped many students understand better. One student claimed, "we actually got to see where everything is, where the dump is and the tenements and the scenic lookout where … the sewage pipe was going into the water." Some students extended this by saying that it allowed them to "really look" and make observations. Being able to "see where everything is... instead of just imagining it" helped them learn.

Actively Walking Around the MUVE

In addition to seeing, actively walking around the MUVE helped students feel like they were "actually doing something" rather than sitting in the classroom and taking notes: "Because we didn't sit around and just take notes we got to actually do stuff like walk around and ask questions." Moving around the world created a sense of authenticity where the students could actively try to figure out why people were getting sick. It also helped them "to better understand the entire scientific method."

Working like a scientist and using tools

Many students claimed they felt like a scientist for the first time in science class because they were "doing tests and stuff to see what was causing the sickness." River City has an online microscope and a bug catcher tool that students can use to take water samples and count the number of mosquitoes in an area. These tools helped students feel like they were "actually conducting an experiment." Having to come up with a hypothesis and design an experiment was motivating. Being able to "pretend to be a real scientist" allowed some students to take on a new identity as an effective science learner.

Conclusion

When we look inside science classrooms in schools, we often see students being lectured on abstract ideas and concepts. We often see students copying down notes about crafted problems with fixed meanings. Very rarely do we see students engage in the practice of science in the science classroom. Yet, when we look at how students are interacting with videogames and online MMOGaming, we see that they are engaging in learning that is characteristic of situated learning (Gee, 2003; Steinkuehler, 2004). We don't want to bring these games into classrooms, but would like to find ways to create similar learning and engagement around scientific content.

Our goal for River City is to design an environment that is able to simulate an authentic experience that allows students to explore and make sense of complex science phenomena. So far, our conversations with students and teachers suggest we have been successful in doing this. Students interact with residents, walk around, explore, see the change of seasons, see the results of the experiments, and build understanding of scientific method. Despite the challenges of implementing in classrooms, we have seen absentee rates go down and seen students who tend to be bored by science become engaged and feel better about their ability to learn science. As our research shows, MUVEs can be powerful environments for engaging students in learning.

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