Collaborative Network-Based Virtual Reality: The Past, the Present, and the Future of the Virtual Solar System Project

Kenneth E. Hay, Dean M. Elliott, Beaumie Kim

University of Georgia

khay@coe.uga.edu delliott@coe.uga.edu bkim@coe.uga.edu

ABSTRACT

This paper and presentation describe an ongoing research and development effort to create a virtual reality environment in which students cohabitate, collaborate, and co-construct shared meanings of astronomical phenomena in an undergraduate introductory astronomy course. Initial versions of this environment addressed face-to-face and asynchronous methods of collaboration. The most recent iteration of our work incorporates the use of advanced networking technologies to enable synchronous collaboration between students in two primary collaborative learning activities: co-construction and co-habitation of virtual models of the solar system. Co-construction refers to multiple students working together to construct a common virtual model. Co-habitation refers to the ability to simultaneously experience the same virtual model from either common or multiple perspectives.

Keywords

Virtual reality, modeling-based inquiry, solar system

INTRODUCTION

Consider a scenario where groups of students studying solar eclipses collaboratively co-construct a shared world within a 3D Virtual Reality (VR) modeling environment. After creating the world, students position themselves to view the eclipse from different perspectives: one on the Sun, one on the near side of the Moon, one out in space, and four others at differing latitudes on the surface of the Earth. Visualization techniques they are using show the umbra and penumbra shadows of the moon as it approaches the earth. Similarly, they see the orbital paths of the moon and earth as well as the line of nodes. These students talk to each other on a networked party line where they describe their perspectives to each other in real time while watching the eclipse. They can tell each other what they see and when an eclipse is happening, and describe this to each other not simply in terms of the eclipse they see unfolding but in terms of their positions and the elements of their model that they have visualized. At critical times they stop the model and call everyone over to their perspectives, they lead each other from perspective to perspective exploring the interrelationships between the elements of their model. In the future they extend this collaborative exploration into collaborative prediction where they predict if an eclipse comes, and if it does, what kind it is, when it occurs, how fast it travels, and what kind of path it takes. The preceding scenario is our vision of what we are developing in the context of a collaborative, inquiry-based undergraduate astronomy course using non-immersive VR modeling and visualization software. This paper and presentation will begin by describing the theoretical and empirical foundations of an ongoing research and development effort to explore the educational potential of virtual reality in learning environments.

Virtual Solar System Project

The Virtual Solar System (VSS) project (Hay & Barab, 1998) is an education reform effort in undergraduate one-credit astronomy laboratory course. Students in the course create virtual 3D computational models of the solar system within a Modeling-based Inquiry pedagogical framework. Core inquiry activities currently include three themes: phases of the moon, eclipses, and seasons. Each activity begins with inquiry questions such as, “Can you create a model of a Sun-Earth-Moon system in which the Moon keeps the same face to the Sun throughout an entire Earth year?” It should be quite clear that students are unable to simply look up an answer to such a question in a textbook. Instead, they plan how they will build an appropriate model and determine what data they need. Next, students build their model, validate it, and revise it as necessary until the model works as planned. At this stage, the students’ focus shifts to creating visualizations of the model that validate the model’s suitability for answering the inquiry questions. Finally, they create a report containing their warranted conclusions, which must be supported with appropriate data and visualizations. Throughout the evolution of the VSS, we have used computer technologies to enable face-to-face, asynchronous, and synchronous collaborations among the students and the instructor.

RESEARCH: VSS + ASYNCHRONOUS COLLABORATION

Our investigation of whether asynchronous collaboration enhanced this learning environment began with a group of four learners in an exploratory study of asynchronous computer-supported collaboration. This group worked in a classroom setting for the first few weeks, then began working independently from home. In order to provide appropriate technology

supports, we developed a course website that contained a range of course resources, grading utilities, assignments, asynchronous collaboration tools and communication facilities. The communications facilities included "ask the professor", a professor course messaging system, and a group threaded discussion area. This exploratory study indicated that students could effectively work independently in this environment and could effectively use the model building tools and access the informational resources. Much to our dismay, the students did not use the asynchronous collaboration tools at all. They reported that in order to use the VR software effectively they needed at least one hour of uninterrupted time, preferably two. They wanted help immediately when they encountered difficulties in order not to lose the flow they had established. The learners' solution to this collaboration problem was to use asynchronous communications to set a time for a phone call between classmates and to use that time to talk each other through problems while each was actively engaged with the software.

DEVELOPMENT: VSS + SYNCHRONOUS NETWORK-BASED COLLABORATION

We believe the immediacy of communication is related to the high level of learner engagement needed to work effectively in this complex cognitive environment. Once students were engaged they did not want to disrupt their flow. In order to resolve these issues, we are currently developing advanced network technologies that enable students to interact synchronously with their classmates and instructors. This model of computer-supported synchronous collaboration is designed to accommodate an anytime, anywhere learning model. Access to other students and the instructor will be possible in real-time, when their actual demands for collaboration arise. Using these synchronous technologies, students will also be able to co-habitate and co-construct within the same virtual world. Co-construction is similar to Resnick's (1996) third stage of distributed constructionism, collaborating on constructions. Co-habitation extends the learning experience by allowing students to gain multiple perspectives at the same time (re. earlier example). We have identified three primary types of network-based interactions: one to one interactions, small group interactions, and presentation interactions. One to one and small group interactions will be the primary interactions as students explore questions or as professors/teachers support students, and will be analogous to the current small group interactions that are found when students and teacher work together in our test bed at UGA. The presentation interaction will also be analogous to the current practices; nevertheless, they will require new networking strategies. In the presentation mode, students will present their findings to their entire class via the network. The size of the class could be anywhere from 20 to 300. The teacher would also be interactively engaged with the student, asking questions, probing ideas, and clarifying concepts.

CONCLUSIONS

We have made significant progress in the development of this technology. The initial stages were focused on developing the VR environment and curriculum to the point that students could efficiently and effectively construct their own models to answer inquiry-based questions. The focus of the past two years has been to examine the extent to which computer-supported collaboration allows learners to co-construct and co-habitate shared virtual worlds while investigating astronomical phenomena.

REFERENCES

Hay, K. E & Barab, S. A. (1998, April). *Building Worlds: Tools of Virtual Practice*. Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Resnick, M. (1996). Distributed Constructionism. In D.C. Edelson & E.A. Domeshek (Eds.), *Proceedings of the Second International Conference on the Learning Sciences*, Charlottesville, VA: AACE.