

**Peer Collaboration and Virtual Environments:
A Preliminary Investigation of Multi-Participant Virtual Reality**

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Introduction

The use of virtual reality (VR) in education has in recent years become more commonplace. For example, Youngblut (1998) identifies over forty examples of VR applications that are specifically designed to support learning. In the past, most educational applications of VR have involved a single student interacting with objects within a virtual environment (VE). Advances in VR technologies, however, are opening the doors to a broad investigation of the potential for collaborative, multi-participant VE's designed to enhance educational experiences. As it becomes possible to place more than one student within a VE simultaneously, questions arise regarding the potential impact of the collaborative aspects of the experience on both learning and the degree of presence perceived by participants.

Among Youngblut's (1998) examples of VR receiving classroom use are a number of applications where student collaboration with other learners in the physical classroom is performed in conjunction with their solitary VE activities. However, only three current VR applications in education are reported as being capable of, in very limited ways, supporting multiple users within a single environment simultaneously. This paper describes the progress of a proof-of-concept project designed to provide simultaneous multi-user interaction within an educational VE. Global Change World (GCW) is a fully immersive, multi-participant virtual learning environment designed to investigate the dynamics of peer collaboration.

Investigations involving GCW are being conducted by the Learning Center at the Human Interface Technology Laboratory (HITL) on the campus of the University of Washington in Seattle, and are funded by a grant from the UW Royalty Research Fund. The preliminary study reported here examined how GCW was implemented as an in-school, single location, multi-participant learning experience. GCW has also been tested and run over the Internet with some success. Eventually, the HITL Learning Center plans to use GCW to link place-bound children at Children's Hospital in Seattle to students in Seattle public schools so that they can learn collaboratively.

Using networked Hewlett-Packard workstations running DVISE software, GCW provides a unique collaborative experience by employing headmounted display helmets (HMD'S) which

have been fitted with an intercom system to allow for voice communication. The immersive visual display, combined with voice communication capabilities, enables both students and instructors to easily talk to each other, seemingly from within the three-dimensional environment of GCW. We found this system to be highly appropriate for supporting peer collaboration and appears capable of promoting very high levels of presence within the VE.

Global Change World: An Immersive, Multi-Participant Virtual Environment

GCW was taken to College Place Elementary School in Edmonds, Washington, where the subjects consisted of eighteen 11 and 12 year old boys and girls (9 female, 9 male) from a single sixth grade class. The specific goal of these school visits was to develop a better understanding of how a collaborative VE can be used to assist students in creating a functional awareness of the complex and dynamic forces caused by the ongoing release of greenhouse gases into the atmosphere. In GCW, student dyads enter into a virtual 3-D model of Seattle in the current year. They are able to navigate their way around the environment using a hand held wand while viewing their surroundings through the stereoscopic HMD. Within the world, the virtual representation of each of the participants in the dyad appears to the other as a cartoonish pair of large eyes, spiral ears, a triangular-shaped mouth, and a singular cyber hand with which they can manipulate objects.

As noted earlier, students are able to speak and hear each other by means of an intercom system that is built into the HMD. This allows them to communicate with each other in their normal voice. This appeared to improve communication, facilitate collaboration, and enhance feelings of presence. By connecting a hand held microphone to the intercom system, instructors can guide participants within GCW.

During the initial school visit, the goal was for all students to become familiar with navigating within the VE and to practice using the tools in GCW to take scientific measurements. Activities during the second school visit were designed to engender student interaction while navigating in the VE and collaboration on a series of specific tasks. In GCW, students access a tool kit that allows them to measure air temperature, greenhouse gasses, and yearly rainfall. They are able to adjust such variables as the number of green plant biomass, the number of factories, and the number of automobiles present in the world. After taking measurements and making adjustments, they can then use a "time-portal" to go to a selected year in the future and repeat their measurements in order to determine the impact of their actions on the climate of the future. Each student dyad spent an average of 20 minutes in GCW. Casual observation indicated that all would have kept going if not told when it was time to stop.

Results

Upon exiting GCW, students were given a nine-question survey that employed a Likert-type scale that asked them to rate the quality of their experiences within the VE. The results of the survey indicated that all eighteen students found the experience to be highly enjoyable and most students said they would want to repeat the experience. Only two of the students reported any

malaise (dizziness or disorientation). Some students did report problems using the wand and being able to see clearly while in the HMD, but those issues appeared to diminish as they spent more time in the VE. Ratings of presence were very high for all respondents.

Clearly, the overwhelming majority of students thoroughly enjoyed their experience with GCW and most of the students indicated that they felt a great degree of presence within the VE. Casual observation seemed to indicate that peer collaboration played a significant role in regards to the level of student engagement within the VE. The intercom system that gave students the ability to communicate with each other while in GCW seemed to greatly facilitate peer collaboration. In fact, many dyads were highly communicative. As they navigated through the world or performed the requested tasks they were engaged in near constant conversation regarding where to go, what to do next, and how to do things. While immersed in the VE, many students were physically active as well. Students were observed pointing at virtual objects with their free hand in the real world. Several students were quite surprised that they had walked almost halfway across the room when we removed the HMD. They had assumed that they stood fairly still while they were flying around in the VE.

Time, as well as the scope of this preliminary study, did not allow us to perform a further investigation into the existence or nature of hypothesis generation and testing within GCW. We do know that the students were highly motivated, very willing to work as virtual dyads, interested in exploring virtual space, and capable of performing investigative tasks within GCW. Further research that focuses more closely on the impact of peer collaboration on preconceived or "naive" scientific concepts and the possible conceptual change inspired by collaboration within GCW is warranted.

Concluding Remarks

The collaborative, multi-participant, immersive, and communicative qualities of the GCW combine to create a truly unique approach to educational VE's. GCW's audio communication capabilities successfully allowed students and instructors to talk among themselves from within the GCW environment. While this audio system successfully functioned in mono, the provision of localized, 3-D audio could be expected to further enhance a sense of presence in GCW by giving students additional spatial cues.

The evidence collected so far appears to support our contention that this VR system constitutes an excellent approach to the study of peer collaboration activities within VE's and is capable of engendering very high subjective levels of presence. We believe this preliminary study supports the notion of the general education effectiveness of GCW.

While the potential for VR to facilitate collaborative learning experiences appears to be great, much more research is needed before effective collaborative learning strategies can be developed. It is anticipated that these strategies will vary, depending on the kind of educational experience desired and the learning environment employed. However, for this potential to be realized, designers of hardware, software and instruction must make sure that it is easy for multiple participants to collaboratively navigate and perform tasks in VE's. This requires improvements on today's input devices, including improvements in spacialized 3-D audio

systems, less cumbersome HMD's, simpler wands, and the eventual introduction of haptic (force feedback) devices. This kind of research is essential, considering that the networking of multi-participant, collaborative virtual environments appears to represent a significant trend for future applications of VR both within and outside of the educational domain.

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Summary of main contributions:

- * Global Change World is an immersive multi-participant virtual learning environment
- * Designed with the investigation of presence and peer collaboration within virtual environments in mind
- * Tested in a proof-of-concept preliminary study to demonstrate the general educational effectiveness of a collaborative, multi-participant, and immersive virtual environment
- * Intended to examine how well school children work together to conceive, test, and revise hypotheses regarding environmental factors that affect global climate change