PERGAMON

Computers & Graphics 24 (2000) 289–292

COMPUTERS & GRAPHICS

www.elsevier.com/locate/cag

Education

Enabling educational collaboration — a new shared reality

Judith R. Brown*

The University of Iowa, ITS, 134A LC, Iowa City, IA 52242, USA

Abstract

Educational collaborations enabled by enhanced computer graphics, high-performance networks, and virtual reality technologies enable new and exciting educational opportunities. As these virtual reality tools and interactive technologies find their way naturally from the research lab to the classroom, students distantly located from each other can learn together in a "shared reality".

Keywords: Education; Collaboration; Virtual reality; Tele-immersion

1. Introduction

Educational collaborations, using enhanced computer graphics, high-performance networks, and virtual reality technologies, will enable new and exciting educational opportunities. Tele-immersive collaborations can provide new learning experiences and insights by joining educators and students from remote locations in a shared virtual space. Bringing together students with cultural differences and diverse perceptions of reality into this shared immersive space allows them to see and hear the same objects and sounds and to share their own unique views and perceptions, creating a new, shared reality. My vision of this shared reality for learning is based on three premises regarding research and learning.

2. Premise 1: Methods developed for research naturally find their way into the classroom

The visualization lab has long been the crossroads between research and education. The research component in a university is an important facet of the educational environment and cannot be viewed as separate from "education". Research is dependent upon student assistants, both undergraduate and graduate, many of whose theses will grow out of the research. A professor's research pushes student assistants' learning experiences, and the results from the research by both faculty and students find their way into national presentations and into the classroom.

Besides the fact that research labs provide the educational environment for student assistants, the classroom needs for computer graphics will also push technological limits since student labs and classrooms need the same capabilities as research labs. Interaction is essential for collaboration, and the appropriate user interface is important, lest the computer get in the way of the students' exploration and interfere with students' natural curiosity.

3. Premise 2: Virtual reality, as an interactive technology, is a valuable tool for instruction

As virtual reality technologies have recently enabled scientists to better understand their data by exploring the images of the data, so are these technologies enabling students to better understand the concepts they are learning. Although these concepts may not be new to the world, they are new to the students, and the same joy of discovery takes place.

The University of Iowa is making progress with applications on three ImmersaDesks acquired through National Science Foundation funding for educational purposes and environmental research. When we first started working with our ImmersaDesks, there was very little software for the ImmersaDesks, and our programmers had a long learning curve to get started. Now some

* Tel.: + 1-319-335-5552; fax: + 1-319-335-5505.
E-mail address: judy-brown@uiowa.edu (J.R. Brown)

0097-8493/00/$ - see front matter
PII: S0097-8493(99)00163-6

good tools have been developed and are offered free to the user community. These tools include CAVE5D, a version of University of Wisconsin's VIS5D software for environmental visualization, and Limbo, from University of Illinois at Chicago, that serves as a template for developing tele-immersive applications, providing avatars, pointers, sound, and other tools for working together in a shared immersive environment.

We have ImmersaDesk applications in higher-dimensional mathematics, geography, chemistry, biochemistry, and computational fluid dynamics. Some applications have begun as research and moved to the classroom. Some entire classes come over to the ImmersaDesk, so the students can experience and share the instructor's discoveries. In other cases, graduate students are sent over to work with us.

One of the key projects being developed with the NSF funds is the *ENVISAGE* Project (*En*vironmental *Vis*ualization and *G*eographic *E*xploration.) The purpose of ENVISAGE is to allow students to experience a more complete understanding of geographical processes by having them operate in the semi-immersive 3D visualization environment provided by the ImmersaDesk and high-performance networks. Immersion, for analysis of mapped data and model output, enables students to view relationships that would otherwise remain shrouded by the limitations of widely used graphics technologies. Openshaw and Fisher, for example, assert the following:

> "It is important, therefore, to develop technologies that attempt to understand the data and develop views of the information or database world in which attempts are made by our clumsy spatial analysis tools to find patterns and relationships. Can we look inside spatial databases and walk around in them via virtual reality concepts? Currently we are so blind to many aspects of the data and the data flows being analyzed. We cope by being highly selective and subjective and in the process probably fail to see and find many of the patterns and relationships of potential interest other than those we blindly stumble over by chance!" [1]

It is precisely this type of immersive exploratory learning that we are bringing to undergraduate education so that students will be able to more readily grasp basic concepts that have a pronounced visual component.

4. Premise 3: Enhanced computer graphics and tools for interaction, along with high-performance networks, enable a shared learning environment

We have learned a great deal in the last year by participating in tele-immersive applications of others and are now developing our applications. Early research applications have emerged as tools for instruction.

Fig. 1. Boy in the NICE garden. Image courtesy of the Electronic Visualization Laboratory, University of Illinois at Chicago, 1997. The NICE Project: Narrative, Immersive, Constructionist/Collaborative Environments for Learning in Virtual Reality, developed by Maria Roussos, Andrew Johnson, Jason Leigh, Craig Barnes, Chris Vasilakis, and Tom Moher.

Networked, collaborative learning can begin at a very young age, as shown by the Narrative Immersive Constructionist/Collaborative Environments (NICE) project between the Electronic Visualization Laboratory and the Interactive Computing Environments Laboratory at the University of Illinois at Chicago. In NICE, children can collaborate to plant and cultivate a virtual garden and to create stories from their interactions (Fig. 1).

As universities have connected to the very high-performance backbone network service (vBNS), they have looked for high-profile applications to show faculty and administrators the value of these new educational and research networks. Applications that show an ability to link with other universities and explore together in shared virtual space have been popular. As part of the Pennsylvania State University Internet2 Days, we explored a model of the city of Berlin with an additional proposed building designed by a Penn State professor of architecture, as shown in (Fig. 2). Boston University produced a wonderful, whimsical Art World, and we appeared as avatars to play in that world during the Supercomputing 98 conference. One of the 3D models from Art World is shown (Fig. 3).

What we learned from these experiences, we can now apply to our applications and build new collaborations worldwide. We have been working with the National High Performance Computing Center of Taiwan and helped them celebrate the connection of their national high-performance network, TAnet, to the vBNS and other national and international high-performance networks. Because the time for their planned celebration was 3 a.m. our time, they recorded our tele-immersive

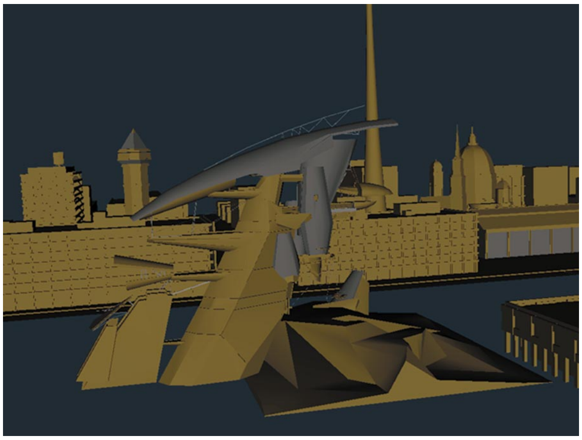

Fig. 2. CAD model of Berlin with sculpture building as proposed by Lebbeus Woods. Modeled by Reggie Aviles, Pennsylvania State University (Penn State) Architecture Student. Translated for use on the ImmersaDesk by Ray Masters, Center for Academic Computing and Affiliate Associate Professor of Architecture, and George Otto, Manager of the Center for Academic Computing Visualization Group at Penn State.

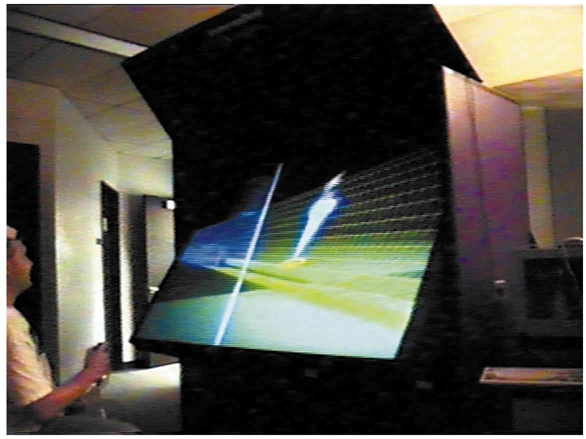

Fig. 4. Image of the ImmersaDesk showing the pressure fields on a high-speed train as it goes through a tunnel, the avatar of the remote collaborator, and the pointer of the University of Iowa participant. This image illustrates a tele-immersive application between the National Center for High-Performance Computing of Taiwan (NCHC) and Advanced Research Computing Services and Visualization, Information Technology Services, The University of Iowa.

Fig. 3. Image of the Martian Landscape from Art World, courtesy of the Scientific Computing and Visualization Group at Boston University. The following artists contributed to the scene: Matt Harter, Paul Haman, Tom Coffin, Jeong-Hoon Lee, and Karlo Takki.

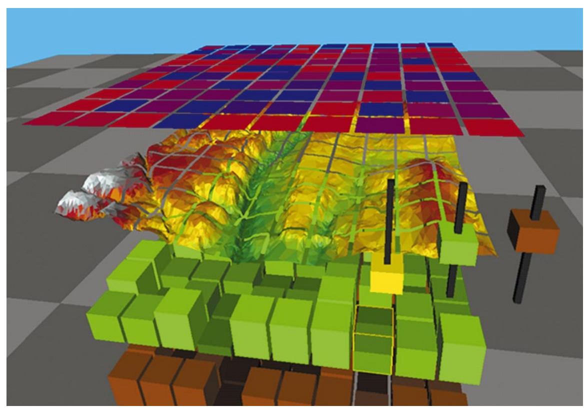

Fig. 5. A model of a plot of land showing four layers: soil, vegetation, the terrain, and the total value of the first three layers, based on the value of each component in the layer and the relative weight given to the layer. Students can assign values to each component and the weights of each layer by moving the sliders. Image courtesy of Advanced Research Computing Services, Information Technology Services, The University of Iowa. Software interface developed by Bob Kooima.

session earlier. For this presentation, we investigated together the pressure fields on a high-speed train going through a tunnel, shown in (Fig. 4). We are currently working on geographic and computational fluid dynamics applications.

For the geography project, a collaboration between The University of Iowa and Pennsylvania State University, we have developed a slider interface so that students at the two universities can jointly explore and change the values on characteristics of land, such as soil, vegetation, and slope, as shown in Fig. 5.

There are still some issues with wide spread use of these collaborative technologies:

1. Cost — Shared immersive technology is expensive
2. Accessibility — The size of the equipment requires large spaces. The interfaces are not readily accessible by persons with disabilities.

3. Distance — Time zone differences make same-time collaborations difficult in the Taiwan example, we settled on 6 p.m. our time on a Tuesday, 8 a.m. Wednesday in Taiwan.
4. Network performance — Complicated graphics and sound require fast networks and low latency. In the Taiwan experiment, the graphics were good, but the six second time lag for the sound was disconcerting.

Collaboration in education was a recurrent theme at the Eurographics/SIGGRAPH Workshop on Graphics and Visualization Education held in July 1999 in Coimbra, Portugal. These collaborations range from simple group projects in a class to shared, tele-immersive environments across disciplines, distance, and cultures. Local, national, and international networks play a key part in these collaborations, and computer graphics plays a unique role in both content and supporting technology.

Acknowledgements

This work is supported by the National Science Foundation, Division of Undergraduate Education, under the grant DUE-9750537 and by the National Science Foundation, Advanced Network Infrastructure, under the grant NR-9613871. All opinions, findings, conclusions and recommendations in any material resulting from this work are those of the principal investigators, and do not necessarily reflect the views of the National Science Foundation.

References

[1] Openshaw S, Fisher MM. A framework for research on spatial analysis relevant to geo-statistical information systems in Europe. Geographical Systems 1995;2(4):325–38.