A Virtual Reality System for Learning Science in a Science Center

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INTRODUCTION

Current trends in informal science learning tend to place more emphasis on science centers as tools to bridge the technological gap for their visitors (Salmi, 2003; Sandifer, 2003). In line with compelling evidence in the multimedia literature, which shows that technology-based environments do provide good instructional support for meeting learning needs (Kim, 2006; Lim, Nonis, & Hedberg, 2006), it would be useful to investigate the potential of technology-based exhibits at science centers to create new multisensory experiences for learning science topics in a way that is different from traditional methods of teaching. This can provide pointers for schools to see how such attractions can be used to assist or complement the formal science learning in schools.

The principal objective of this research is to investigate the effectiveness of technology-based exhibits in promoting affective learning outcomes among students of mixed ability visiting a science centre. The chosen exhibit is the CAVE (cave automated virtual environment), a supercomputer-based multimedia system.

BACKGROUND

The CAVE is basically a virtual reality system. Its genesis can be traced to the need to develop compact virtual reality systems that can overcome the inconvenience of using head-mounted display sets and the limitations of single-user interaction at a time, both of which have plagued earlier versions. The ideas of Thomas DeFanti and Don Sandin of the Electronic Visualization Laboratory at the University of Chicago, in 1991, provided the basis for the development of the first working model of the CAVE by Carolina Cruz-Neir in 1992 (Cruz-Neir, Sandin, DeFanti, Kenyon, & Hart, 1992; Defanti, Sandin, & Cruz-Neira, 1993).

Relying on the use of computer-generated graphics and multisensory digital data, the CAVE provided, for the first time, the relishing of virtual reality as immersive and interactive experiences for a group of people in a specialized setting. Soon, the scope for using the CAVE as a platform to simulate complex scientific phenomena, as well as for generating walkthroughs in a range of virtual environments, was recognized. Over the years, several applications have been modelled to exploit the unique features of the CAVE. Some of these include

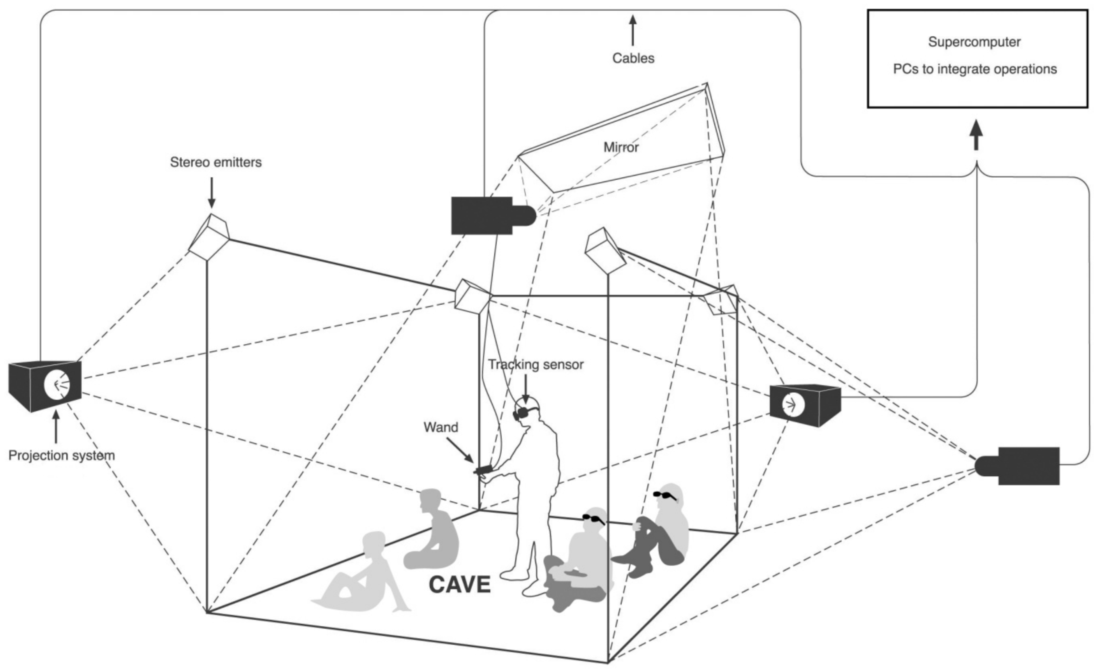
a. Exploration of a sprawling virtual plains inhabited by diverse vegetation (Moher, Johnsoon, Yongjoo, & Ya-Ju, 1999)
b. Collaborative construction, cultivation, and tending of a healthy virtual garden by young children (Roussos, Johnson, Leigh, Vaslakis, Barnes, & Moher, 1997)
c. In-depth probing of an ant, the inside of the Earth, an iceberg, a volcano, the solar system, and the human heart (Johnson, Moher, Ohlsson, & Gillingham, 1999)

The CAVE

This study focuses on the CAVE (Tan, Subramaniam, & Anthony, 2005) at the Singapore Science Centre. It is of interest to note that the only other CAVE to be set up outside a research laboratory in the world is the one at the National Museum of Emerging Science and Innovation in Miraikan, Japan.

Modelled as a cube of area 27 m^3, the CAVE comprises display screens mounted at right angles to the plane of image projection, acoustic speakers placed at the upper vertices to produce sonic effects, stereo emitters situated at the edges to ensure proper mapping between the frame rate and the configuration of the stereo glasses used by participants, tracking sensors on the stereo glasses used by the lead user to ensure that what the lead user sees is also what the participants wearing stereo glasses see, and a supercomputer (Silicon Graphics Onyx 2 Reality engine) to coordinate the overall operations. Navigating through the virtual environment is facilitated by the joystick on the wand held by the lead user,

Figure 1. Architectural elements of the CAVE



while the three buttons on the wand can be used to set off various acts of interactivity The stereo glasses used by the participants produce the 3-D effect, and this allows them to be immersed interactively in the virtual environment.

Figure 1 shows the principal elements of the CAVE.

CAVE Program on Water

The program that is the focus of this study is on the molecular structure of water. Appreciation of the following 3-D scenarios is made possible in the CAVE with this program:

- Coupling of two hydrogen atoms and one oxygen atom via covalent bonds to form a molecule of water; this exists as a 3-D structure in the space of the CAVE and can be "touched"!
- Motion of electrons going around the nucleus of the hydrogen and oxygen atoms; it is possible for participants to walk through into the interior of these atomic configurations and get a nuanced view from any perspective!
- Excursion into the interior of the crystal structure of ice.
- Clustering of H_2O molecules in various packing densities to form the three states of matter: ice, water, and vapour.

To enhance the reality of the immersive and interactive experience, suitable sound effects are produced when various modes of interactivity are triggered, and participants are also able to "touch" the 3-D images in the CAVE.

Samples for this Study

In the present study, all participants were from the Primary five level (Grade 5). One group was a class of 35 students (16 males and 19 females) from the EM1 stream. The second group comprised a class of 33 students (16 males and 17 females) from the EM2 stream, while the last group comprised 34 students (16 males and 18 females) from the EM3 stream. All three groups were from different schools,

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