DOCUMENT RESUME

ED 407 931 IR 018 332

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TITLE	Student Responses to Their Immersion in a Virtual Environment.
SPONS AGENCY	U.S. West Foundation.
PUB DATE	Mar 97
NOTE	12p.; Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, March 24-28, 1997).
PUB TYPE	Reports - Evaluative (142)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Computer Graphics; *Computer Interfaces; *Computer Uses in Education; Display Systems; Educational Benefits; Educational Technology; Elementary Secondary Education; *Human Factors Engineering; Instructional Design; Interaction; Multimedia Materials; *Orientation; Participant Satisfaction; *Student Reaction; *Virtual Reality
IDENTIFIERS	Interactive Systems

ABSTRACT

Undertaken in conjunction with a larger study that investigated the educational efficacy of students building their own virtual worlds, this study measures the reactions of students in grades 4-12 to the experience of being immersed in virtual reality (VR). The study investigated the sense of "presence" experienced by the students, the extent to which they were able to navigate through a virtual environment (VE), and the extent, if any, of malaise experienced while in the virtual environment. Subjects were 1001 elementary, 922 middle school, and 949 high school students from the states of Nebraska and Washington. Students attended a presentation on virtual reality, participated in a brainstorming session, and then visited an immersive VE. After the visit, students completed a questionnaire featuring a 5-point rating scale. Study results indicate that, with the possible exception of smaller students who had difficulty using the equipment, it is feasible to use virtual reality in the classroom. Negative side-effects resulting from queasiness were negligible. Any potential for helping students learn content is likely to arise from the attributes of presence. For this potential to be realized, and for learning to be enjoyable, designers of hardware, software, and instruction must make sure it is easy to navigate and perform in a VE. Instruction should be underpinned by appropriate instructional and learning theories that effectively take full advantage of the benefits offered by VR technology. (Author/SWC)

Student Responses to their Immersion in a Virtual Environment.

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Presented at the Annual Meeting of the
American Educational Research Association,
Chicago,
March, 1997

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RUNNING HEAD: Virtual Environments

This research was supported by a grant from the US West Foundation.

Undertaken in conjunction with a larger study that investigated the educational efficacy of students building their own virtual worlds (Winn, Hoffman, Hollander, Osberg, Rose & Char, 1997, March), this study was designed to measure the reactions of students in grades 4 - 12 to the experience of being immersed in Virtual Reality (VR). Of particular interest were data on the sense of ``presence" experienced by the students, on the extent to which they were able to navigate through a virtual environment (VE), and the extent, if any, of malaise they experienced while in the virtual environment.

The basic question this study sought to answer was whether it was feasible to have students visit VEs in their classrooms. Beyond the obvious questions relating to practicality, the issues that are reported here addressed primarily human-computer interaction issues that focus on the feasibility of having students work in VEs. The theoretical framework drew from research on how people pick up information from visual displays (could the students see what was going on in the VE?), the extent of their sense of ``presence" while in the VE (did they feel they were in another place?), and their ability to comfortably navigate in the VE (could they comfortably use the input device, did they feel disoriented or queasy, did they enjoy the experience?).

The resolution of images presented in head-mounted displays (HMDs) in this study were noticeably lower than that of human vision. In order to create truly immersive VR, the field of view in the HMD should extend to peripheral vision. To extend angle of view without increasing processing demands, designers of the HMD's often use in design approaches that cause pixels to be stretched rather than added, which results in decreased image quality. For this reason, objects in VEs are designed to be simple and are often schematic abstractions of objects in the real world (Byrne, 1996; Winn & Bricken, 1992). As a result, the user's ability to detect defining features of objects becomes critical to subsequent understanding of what is going on in the VE (Winn, 1994). This study sought information on how easy it was for students to perceive and work with such objects in a VE.

Presence, the sense of being in the virtual world rather than in the classroom with a HMD on, is critical to students becoming engaged and active in the VE (Barfield & Hendrix, 1995; Zeltzer, 1992). Presence is not only related to affective states, but also to such cognitive processes as memory for objects and events in the virtual world (Hoffman, Hullfish & Houston, 1994). We sought to assess how subjects' ratings of presence in VEs was related to their enjoyment of, navigation in and ability to perform tasks in VEs.

Even if students can see what is going on and experience presence, a VE can be a disorienting place (Bricken, 1991). In the VE's utilized in this study, interactions between the student and objects in the world are not subject to the laws of gravity. Students use a pointing device called a wand to "fly" from place to place in the VE and can easily move large objects (boulders, for example) by inserting one's virtual "hand" in the object while depressing a button on the wand. Confusing perceptual cues can create disorientation, stress and even nausea. These problems arise because information obtained by the eyes is at variance with information obtained from other sensory systems, especially the body's sense of its own position, mass and momentum. We needed to determine whether or not such conditions were sufficiently debilitating to preclude the use of VE's for education.

Method

Subjects.

Subjects were 1001 elementary, 922 middle school and 949 high school students. They came from a range of social, economic, ethnic backgrounds and geographic areas in Nebraska and Washington state.

Procedure.

Students first attended a half-hour presentation on virtual reality that illustrated how 3D computing was similar to conventional computing with the exception of the addition of significantly more graphics processing power, a position tracking system, the substitution of the HMD for a flat screen and the use of a wand instead of a mouse. In addition, students viewed a videotape that depicted how virtual reality systems were currently being utilized in research and industry. The presenter then concluded by answering any questions the students might have before moving to a short brainstorming session wherein students were given the chance to discuss what kind of virtual worlds they would build if the opportunity arose.

Subsequently, each student then visited an immersive VE. This was usually a commercially-produced world in which a number of the latest features of VR were demonstrated. In some cases, it was a VE that our Laboratory had constructed to meet particular curricular goals. Before entering the world, each student was briefed about how to navigate and interact with the VE and spent between seven and ten minutes visiting the world. The experience was fully immersive which meant that the student wore a HMD and used a ``wand'' to interact with objects in the VE.

Data Sources

Upon leaving the VE, each student completed a questionnaire which featured five-point scales that asked students to rate such things as their enjoyment of the experience, their sense of ``presence", whether or not they were disoriented or felt queasy, and whether it was easy to move around and interact with objects in the VE. Descriptive statistics were compiled for each scale. The significance of the associations between ratings of enjoyment, presence, disorientation and queasiness tested by applying the chi-square test to cross tabulations. Finally, a factor analysis of the questionnaire was performed to reveal any fundamental structure to the VR experience.

Results

Enjoyment

Predictably, all students reported enjoying the experience of VR. The following table shows the percentage of student's ratings from 1 (low enjoyment) to 5 (high enjoyment) averaged over all questions asking about enjoyment.

Table 1
Percentage Ratings for Enjoyment

Nebraska

1	2	3	4	5
0.0	0.1	0.3	8.0	91.6

Washington

1	2	3	4	5
0.0	0.0	0.0	17.5	82.5

However, when enjoyment ratings were compared across type of school, chi-square revealed significant declines in enjoyment from elementary to middle and from middle to high school students (all p's < .05). Also, data collected from Washington public school students indicated that boys enjoyed immersion in VR more than girls.

Presence

Students experienced a high degree of presence in VR. A majority of students agreed with the statements that ``virtual" reality became ``real" for them and that they felt they were ``in a different place" when they visited the VE. However, these convictions were significantly more marked in the younger than the older students. The degree to which students reported feeling present in the VE appear in the next table.

Table 2
Percentage Ratings for Presence

		Nebraska		
1	2	3	4	5
1.4	5.6	2.4	44.6	46.0
		Washington		
1	2	3	4	5
4.5	4.0	14.0	32.5	41.5

Navigation

A number of questions related to students' ability to navigate and perform tasks in the virtual world. The difficulty students reported in performing tasks in the VE appear in the next table. Here, 1 represents rating task performance easy, 5 indicates a difficult task rating.

Table 3
Percentage Ratings for Difficulty of Working in a VE

Nebraska

1	2	3	4	5
18.8	34.1	2.2	43.4	1.5

Washington

1	2	3	4	5
31.7	35.2	19.6	11.1	2.5

As is evident from this table, responses concerning the difficulty of working in a VE are more evenly distributed. This suggests that, for some students, it was not all that easy. Our observations seemed to support this, particularly in the case of the younger students, who often had to use two hands to manipulate the wand.

Another navigation question asked students how difficult it was to see objects in the virtual environment. In the following, 1 is easy and 5 is hard.

Table 4
Percentage Ratings for Ease of Seeing Things in a VE

Nebraska

1	2	3	4	5
47.4	32.8	4.7	14.6	0.5

Washington

1	2	3	4	5
37.0	32.0	11.5	11.6	16.1

Although a preponderance of students found it easy to identify objects in the VE, some students had trouble seeing objects in the virtual world they visited.

The final question that dealt with navigation issues asked students to rate their feelings of disorientation while in the VE. 1 represents "not disoriented" and 5 "very disoriented".

Table 5
Percentage Ratings for Disorientation

Nebraska

1	2	3	4	5
30.0	32.6	33.2	2.3	1.0

Washington

1	2	3	4	5
39.2	29.1	18.1	7.0	6.5

Malaise

As noted earlier, this study was also concerned about the potential side effects of VR for children. As the following table indicates, few students were affected by queasiness. Here, 1 is "no queasiness" and 5 is "very queasy".

Table 5
Percentage Ratings for Queasiness

Nebraska

1	2	3	4	5
85.9	6.3	0.8	6.4	0.7

Washington

1	2	3	4	5
71.5	15.0	3.6	7.3	2.6

Cross Tabulations

Cross tabulations were carried out on a number of pairs of questions. This allowed us to determine whether associations between pairs of factors in the VR experience were significant. The following finding are based on Chi square values significant at the .01 level computed from two-by-two contingency tables.

- A high level of presence is associated with a high level of enjoyment.
- A high level of presence improves the ability to perform tasks and reduces disorientation.
- Presence is improved when it is easy to see objects.
- Malaise reduces the sense of presence.
- Malaise reduces enjoyment.

Finally, a principal components factor analysis with varimax rotation was performed on three correlation matrices computed separately for elementary, middle and high school responses. The same three factors (eigenvalues > 1.0) appeared for each group: 1) Disorientation and physical discomfort, 2) enjoyment and the sense of presence, 3)understanding how to perform tasks and seeing what was going on. Thus, in all three groups, the VR experience appeared to have physical, cognitive and affective dimensions.

Educational and Scientific Importance

This study demonstrated that, with the possible exception of smaller students who had difficulty using the equipment, it is feasible to use virtual reality in the classroom.

Also, negative side-effects, resulting from queasiness, were negligible. Any potential for helping students learn content is likely to arise from the attributes of presence. However, for this potential to be realized, and for learning to be enjoyable, designers of hardware, software and instruction must make sure that it is easy to navigate and perform in a VE. This requires improvements on today's input devices, including both HMD's, wands and the eventual introduction of haptic (force feedback) devices. Research into 3D interface design should attend to the development of strategies that positively support human-computer interaction. Instruction should be underpinned by appropriate instructional and learning theory that effectively take full advantage of the affordances offered by VR technology. Moreover, it is important that researchers begin to identify and solve these problems now so that VR can be used to its best advantage by all students in the future.

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