Virtual Reality and Learning: Cognitive and Motivational Effects of Students' Sense of Presence

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ABSTRACT

College students learned how to design the roots, stem, and leaves of plants to survive in five different simulated environments through a virtual reality educational game. They learned by interacting with a pedagogical agent who spoke to them or received identical explanations as on-screen text. Immersion was varied by having some students experience the virtual environments in a desktop condition (D), a head mounted display condition (H), or a head mounted display and walking condition (W). Students who learned with narration performed better on tests of retention and problem-solving transfer, and rated the overall program more favorably than students who learned with on-screen text. Students who learned in H and W conditions were more motivated than students who learned in D conditions. However, level of immersion did not affect learning performance. The theoretical and educational implications of the findings are discussed.

1. INTRODUCTION

How can we promote science learning using a virtual reality environment (VRE)? Virtual reality environments (VREs) have unique contributions to learning including scientific visualization, science instruction, sensorimotor performance, and training (Psotka, 1995; Sheridan, 1992). However, similar to other innovations where a technology-centered approach was taken, VR technology may begin with grand predictions and hopes and end without having much impact on educational practice (Cuban, 1986). Whereas a technology-centered approach focuses on what can be done with cutting edge technology, a learner-centered approach focuses on what should be done to foster student learning with technology (Mayer, 2001, Moreno & Mayer, 2000). Learner-centered approaches to VR technology require a research-based theory of how students learn in virtual environments.

1.1 AN ENVIRONMENTAL SCIENCE SCENARIO

In this study we examined the cognitive and motivational consequences of learning in various VREs designed to promote an understanding of environmental science. Students learned about the relation between environmental features such as high nutrients or low sunlight and physical features of a plant such as the type of roots, stem, and leaves. The learning environment used in this study is based on a multimedia program called Design-A-Plant in which a pedagogic agent offers individualized advice concerning the relation between plant features and environmental features by providing students with

feedback on the choices that they make in the process of designing plants (Lester et al., 1998). The feedback given for each choice consists of a verbal explanation in the form of narration or on-screen text. For each of the choices of root, stem, and leaves, students are presented with the corresponding library of plant parts' graphics and names, and asked to click on one of the possible options to design their plant.

1.2 PREDICTIONS

The goal of our study was to examine the classic distinction between the role of media versus method in promoting learning (Salomon, 1979/1994). We varied the media by comparing how students learned from the same microworld delivered via a desktop display (D), a head mounted display without walking (H), and a head mounted display with walking (W). We varied the method by comparing how students learned when words were presented as on-screen text (T) or as narration (N). For each delivery medium and instructional method, we assessed students' understanding of the material by retention and problem-solving transfer tests. The motivational consequences of media and method were assessed by asking students to give program ratings.

We tested two hypotheses. First, according to a media-affects-learning hypothesis**,** the delivery medium influences learning. This view predicts a main effect for media favoring more immersive environments and an interaction between method and media. Second, according to a method-affects-learning hypothesis**,** instructional methods influence learning. Past research in multimedia learning has shown that students learn better when the instructional method involves spoken rather than printed words (Moreno & Mayer, 1999; Moreno et al., in press). We refer to this as a *modality effect*. Thus, the method-affects-learning hypothesis predicts a main effect for modality and a lack of interaction between modality and media.

2. METHODOLOGY

A total of 87 college students participated in the study. Seventeen participants were in the narration and desktop group (ND Group), 17 participants in the text and desktop group (TD Group), 13 participants in the narration and head mounted display group (NH Group), 13 participants in the text and head mounted display group (TH Group), 13 participants in the narration and head mounted display plus walking group (NW Group), and 14 participants in the text and head mounted display plus walking group (TW Group). After interacting with the respective computer program, all participants were given a retention test, a 7-page problem-solving test, and a program-rating sheet.

3. RESULTS

In order to determine whether the groups differed on measures of retention, transfer, and program ratings, separate two-factor analyses of variance were conducted for each dependent measure with modality (T or N) and level of immersion (D, H, or W) as between-subject factors, and retention, transfer, and program ratings as the respective dependent measure.

The analyses revealed that groups presented with higher levels of immersion did not differ in the mean number of recalled items, mean number of answers to transfer problems, or mean program-rating scores from those presented with lower levels of immersion. The only significant interaction between immersion and modality was found for students' transfer ($p < 0.05$), where the use of on-screen text proved to be especially detrimental for the W condition. However, students who learned in more

immersive conditions (Groups H and W) more strongly wanted to continue using the program and rated the program as being more friendly ($p = 0.02$), than students in less immersive conditions (Group D). On the other hand, groups presented with narration recalled significantly more items, gave significantly more correct answers to transfer problems, and rated the program more favorably than those presented with the verbal information in the form of text, ($p = .0003$, $p = .0001$, and $p < .05$, respectively).

4. CONCLUSIONS

The reported results confirm the idea shared by most educational psychologists (Jonassen, Peck, & Wilson, 1999; Kozma, 1994), that the same factors that improve student understanding in one medium (such as modality effects in a desktop environment) improve student understanding in another medium (such as immersive VREs). Despite the temptation to take a technology-centered approach to learning, it is necessary to search for empirically-based principles for the design of VREs. As long as instructional methods promote appropriate cognitive processing, then media does not seem to matter.

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