Effects of platform (immersive versus non-immersive) on usability and enjoyment of a virtual learning environment for deaf and hearing children

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Abstract
We report a user study focusing on the effects of platform (immersive, non-immersive) on usability and enjoyment of a deaf-accessible game for K-5 math and science education. The study highlighted hearing status and gender differences in using the two systems. Twenty-one children played the SMILE game [AVW07] in a FLEX immersive display with wand interaction and on a desktop computer with mouse and keyboard interaction. They were tasked with traveling to two different locations in the virtual environment, and with constructing an object (e.g., baking a cake). Their speed and accuracy in the tasks were scored, and they completed a survey with rating questions on game fun and ease of use in both platforms. Measured task times (travel and object construction) did not differ consistently with platform. Object construction took longer in the FLEX whereas non-immersive search travel took longer on the desktop. Hearing Status was significant for cake baking and approached significance for travel. Deaf children took longer and made more mistakes than hearing children on both platforms. Gender was not significant for the travel but was significant for object construction with girls taking longer than boys on both systems. Increased video game familiarity was correlated with reduced travel times and reduced errors on both platforms. Platform differences were seen in the rating of ‘fun’, with the FLEX rated significantly more fun than the desktop by all subjects.

Categories and Subject Descriptors (according to ACM CCS): K.3.1 [Computer Uses in Education]: Computer-assisted instruction (CAI); H.5.2 [User Interfaces]: User-centered design

1. Introduction
The display system (or platform) is an integral part of a Virtual Environment (VE). Many VE are categorized based on the platform they use (e.g., Fish Tank-application, CAVE-application, desktop VR-application, etc.) [BDR*02]. Key differences among different VE systems include level of immersion, field of view (FOV), resolution, stereo/non-stereo mode, user interface [RPJ99]. Here we are concerned with the differences between immersive and non-immersive platforms. According to Slater et al. [SLUK96] immersion is a quantifiable characteristic of a technology, defined by the extent to which displays are extensive, surrounding, inclusive, vivid and matching. VE displays are considered extensive if “they can accommodate many sensory systems”; surrounding if the information arrives at the participant’s sensory organs from any (virtual) direction; and inclusive to the extent that all sensory data from reality is excluded. Vividness refers primarily to resolution and quality of the visual display, as well as richness of the information content, and matching refers to the correspondence between the “participant’s proprioceptive feedback about body movements and the information generated on the displays”.

The concept of immersion can be translated into a set of system characteristics, which the Virtual Reality Laboratory at University of Michigan [Uni] has defined as follows: head-referenced viewing, stereoscopic viewing, direct, natural interactions with virtual objects with 6DOF input devices or data gloves, display of the virtual world in full scale and properly related to human size, auditory, haptic, and other non-visual feedback.

Although several researchers argue that there is a relationship between immersion and user task performance in VE, the benefits of immersive versus non-immersive systems on children’s learning are, so far, primarily anecdotal [Grub04]. This paper adds to the relatively small body of literature by reporting a study quantifying the effects of immersive versus non-immersive platforms on children’s appeal and task performance in a deaf-accessible virtual learning environment (VLE). In the study we compare a Spatially Immersive Device (SID), e.g., the Fakespace FLEX [Fak06] with wand interaction, to a non-immersive desktop computer with mouse+keyboard interaction for playing a math and science educational game. In addition to measuring the effects of platforms on task performance and user enjoyment of the game, we highlight hearing status and gender differences in using the two VE systems.

The paper is organized as follows: in section 2 we discuss related work; in section 3 we describe the user study, in section 4 findings are reported; and in section 5 we discuss results and provide conclusive remarks.

2. Related work
There is evidence that immersive VE provide an improved system for display and interaction with 3D worlds [PPW97]. Ruddle et al. [RPJ99] compared travel in a virtual building walkthrough using a head mounted display (HMD) and a desktop computer. Their results showed that participants who were immersed in the environment using the HMD traveled through the building 12% faster. Pausch et al. [PPW97] compared head-tracked versus non-head tracked modes for a search task to determine if a specific alphabet letter was drawn on one of the walls of a virtual room. Results showed that, when the letter was present, detection of target absence was substantially faster in the immersive environment than in the non-immersive display. Slater et al. [SLUK96] compared playing three dimensional chess in an IVE with data glove touch interaction and on a workstation screen with mouse interaction. Results suggested that increased immersion (egocentric rather than exocentric viewpoint, and greater vividness) improved performance in a task involving comprehension and memory.