Gender Differences in Usability and Enjoyment of VR Educational Games: A Study of SMILE™

This paper reports the results of a pilot study that investigated gender effects on usability and enjoyment of virtual reality learning game played on three different interfaces. Two of the three interfaces are immersive (PINCH glove interaction and FLEX display system with 6DOF wand interaction), and non-immersive (desktop computer with mouse+keyboard interaction). Findings indicate that girls and boys were equally adept at traveling through the virtual environment using all three interfaces. Girls took longer object manipulation tasks than boys in all three conditions. Ratings of enjoyment, ease of use, and difficulty of the game again differed by gender. With respect to fun, girls rated all three conditions highly, whereas the immersive conditions highly, and rated the non-immersive condition as less fun. With respect to ease of use, the boys and girls had opposite opinions about the FLEX+Wand and the Desktop. For the boys, the Wand was hardest to use and the Desktop easiest. In contrast, for the girls the Desktop was hardest and the Wanda was easiest.

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Gender differences in usability and enjoyment of VR educational games: a study of SMILE™

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Abstract

This paper reports the results of a pilot study that investigated gender effects on usability and enjoyment of a virtual reality learning game played on three different interfaces. Two of the three interfaces are immersive (FLEX display system with PINCH glove interaction and FLEX display system with 6DOF wand interaction), and one is non-immersive (desktop computer with mouse+keyboard interaction). Findings indicate that girls and boys were equally adept at traveling through the virtual environment using all three interfaces. Girls took longer to complete object manipulation tasks than boys in all three conditions. Ratings of enjoyment, ease of use, and desire to play the game again differed by gender. With respect to fun, girls rated all three conditions highly, whereas boys rated the immersive conditions highly, and rated the non-immersive condition as less fun. With respect to ease of use, the boys and girls had opposite opinions about the FLEX+Wand and the Desktop. For the boys, the Wand was hardest to use and the Desktop easiest. In contrast, for the girls the Desktop was hardest and the Wand was easiest.

1. Introduction

Although many research studies have focused on the negative effects of video game playing [1], it is indisputable that computer games are linked to many benefits such as acquisition of general computer-related knowledge and skills [2], improvement of cognitive and attention abilities [1], enhancement of comfort with technology, ability to deal more effectively with situations in the real-world [3], and subject learning, especially math and science [4]. Therefore children who do not play computer games may be at a disadvantage compared to those who are regularly exposed to them. One group at risk of not benefiting from video game playing is girls. Lucas and Sherry (2004) state that “one finding that has been stable throughout the past decade of research is that video games are liked more and played more by males than females” (pp.499-500).

To date, the majority of the research studies aimed at determining the origin of the gender gap in video game play have focused on play preference, game content, character roles, and game access. Few studies have investigated gender differences related to game interfaces, or have identified these differences as possible reasons for girls’ general dislike of computer games. While gender is often controlled in usability evaluations, little is known yet on whether and how differences in gender should influence the design of interactive software interfaces.

This study investigates gender differences in the use of three different interfaces for playing SMILE™ (Science and Math in an Immersive Learning Environment) [5], a virtual reality learning game that employs a fantasy 3D environment to engage deaf and hearing children in K-3 math and science-based educational tasks. Specifically, the study highlights gender differences in travel and object manipulation tasks using 2 immersive interfaces (FLEX display system with PINCH glove interaction and FLEX display system with 6DOF wand interaction), and 1 non-immersive interface (desktop computer with mouse+keyboard interaction). The overall goals are: (1) to determine which interface seems most usable and appealing to girls in the context of SMILE, and (2) to reveal whether interface usability has a significant effect on girls’ enjoyment of the game.

The paper is organized as follows. In section 2 we discuss gender differences in video game play; in section 3 we describe our user study. Findings are reported in section 4; discussion of results and conclusive remarks are included in section 5.

2. Gender differences in video game play
The past few decades have seen a rise in the use of computer and video games in the United States [6]. Historically, digital games have been seen as a male pastime. However, recent data indicate an increasing number of female players, with some estimates as high as 40% [7].

A variety of explanations for the male dominance of computer games have been offered. Male/female attitudes toward science and technology begin to differ as early as elementary and middle school. It is during this period that girls develop an understanding of what social roles are appropriate for them [8; 9]. They have reservations about what seems to them a male “computer culture” as they see boys using computers for violent games [10; 11; 12]. There is little software in the schools that appeals to them and the tendency of boys to monopolize the computers is not always vigorously challenged [13]. As a result, girls do not take advantage of after school computer clubs or enroll in higher-level computer classes at the same rate as boys do, and therefore have had less experience with computers [13]. Girls’ absence from computer classes does not appear to stem from disinterest in computers but rather from applications that seem more attuned to the interests of boys [12; 14].

Looking at computer games themselves, female players are often required to play from a male perspective, with males being the heroes and females the victims. In regard to game content, research shows that girls are interested in social interaction and meaningful dialogue, and are less attracted to action-oriented tasks with taciturn people who ignore each other. They prefer activities such as mysteries to be solved requiring players to return to landmarks for clues, identify objects that have disappeared, or decipher mysterious messages, rather than competitive tasks such as sports contests, armed duels, car racing, or economic rivalry [2]. They also prefer realistic settings, non-gender-specific characters, little violence, and no negative feedback for incorrect choices [15]. They like to collaborate, have vicarious adventures, and participate in rich narratives with roles that involve positive action. They want to be able to create, communicate, and use strategies [12].

Gender differences also exist in user interface and interaction style. Research on biological sex differences [1] shows that males are better than females at tasks such as mental rotation of 3D objects, 3D navigation (e.g., through a maze) and target-directed motor skills (e.g. intercepting bullets). In contrast, females are better at landmark memory (e.g., remembering details of things seen along a route), object displacement (noticing if an object is missing or has been moved), and perceptual speed (e.g., identifying matching objects). Additionally, several research studies have revealed the existence of gender differences in the way children interact with computers [16; 17; 18]. For example, Inkpen [19] showed that, for girls, the point-and click interactive style was more effective and resulted in a higher level of motivation to continue playing than drag-and-drop.

Relatively few studies have examined gender differences in playing educational, or what is often called serious games. Malone [20] found one significant difference between what boys and girls preferred in games. While boys enjoyed popping balloons as a reward for performing correctly, girls did not, and while girls enjoyed music as a reward, boys found no appeal in that.

More recently, attention has been on the new genre of multi-player online games that appear to have great potential as platforms for teaching. Multi User Virtual Environments (MUVEs) can simulate complex problems, and stimulate student’s interest in various disciplines. The collaborative nature of MUVEs allows players to negotiate with peers, and to interact synchronously. A growing body of literature indicates that MUVEs are relatively girl-friendly environments.

Using a MUVE designed to increase interest in computers, 475 children were observed over a 5-year period. While gender was found to have no effect on programming performance, of interest was the fact that girls spent far more time communicating in this environment than did boys [21].

Nelson [22] examined patterns of use and potential impact of individualized, reflective guidance in a MUVE. A guidance system was embedded within a MUVE-based science inquiry curriculum called River City. Students were able to either use the guidance system or opt out. Test scores revealed that girls outperformed boys, even those boys who used more guidance.

3. Description of the study

3.1 Participants

21 children ages 6½-11 years; 7 deaf, 14 hearing; 13 males, 8 females.

3.2 The SMILE™ game

Participants played the SMILE™ game prototype designed and developed by two of the authors [5]. SMILE™ employs a fantasy
environment and a bilingual interface to engage deaf and hearing students in math and science formal learning. It includes an imaginary town populated by fantasy 3D avatars that communicate with the participant in written and spoken English, and American Sign Language (ASL). SMILE™ has an overall story with an overarching goal (restore the willingness to smile in the city of ‘SMILE Ville’) which creates a boundary condition uniting all learning activities. The user can explore the town, enter buildings, select and manipulate objects, construct new objects, and interact with the characters. In each building the participant learns standards-based math/science concepts by performing hands-on activities developed in collaboration with elementary school educators (including deaf educators). SMILE™ can be displayed on both immersive and non-immersive platforms. A demo of SMILE™ is available at: http://www2.tech.purdue.edu/cgt/i3/smile/

3.3 The interfaces

**FLEX Display with glove interaction.** The Fakespace FLEX™ system is a spatially immersive device (SID) comprised of three ten-foot by eight-foot panels for rear projection of large-scale 3D images; it includes a tracking system that allows for correct perspective rendering and direct interaction with the virtual environment (fig. 1, center). The glove interaction system used for SMILE™ includes a pair of Fakespace PINCH cloth gloves and an INTERSENSE wrist tracker. The gloves have electrical sensors in each fingertip; contact between any two or more digits completes a conductive path and a complex variety of actions based on these simple "pinch" gestures can be programmed into applications. In SMILE™ the user can (1) grasp and release objects within reach by pinching the thumb and forefinger together; (2) input the ASL numbers 0-9; and (3) travel through the environment. To move in a specific direction, users touch the palm with the pinky, ring, and middle fingertips and point in that direction; to rotate the environment they pinch their ring finger and thumb together and rotate their arm.

**FLEX Display with Wand interaction.** The Intersense I-900 wand used for the experiment is essentially a 3D mouse with a 6DOF tracker. The wand contains six buttons and a pressure sensitive joystick that can be programmed to serve a number of uses. In SMILE™, the user stands in the middle of the FLEX display and uses the joystick for travel through the environment. Direction of motion is specified by wand orientation, and velocity is proportional to the displacement of the joystick from its origin. Rotation is accomplished by pressing one of the buttons (green) and rotating the wand in the desired direction; grasp and release of objects are accomplished by pressing and releasing the trigger on the back of the wand.

**Desktop computer with mouse+keyboard interaction.** For our study, SMILE™ was displayed on a Dell Precision Workstation 690 with a 22" Dell E228WFP Wide Flat Panel Monitor with a resolution of 1280x800 pixels. All participants interacted with the game with mouse and keyboard. Specifically, they used the keyboard to travel through the city of ‘SMILE Ville’ and they used the mouse to manipulate the virtual objects.

3.4 Procedure

Participants came to the Envision Center and took part in the experiment individually. They were presented with a brief overview of the game and were given a demonstration showing how to use the immersive interaction devices. Prior to the hands-on session, all subjects were asked to rate their familiarity with video games. The hands-on experiment included a travel test and an object manipulation test. The travel test required the subjects to perform one primed search and one search with unknown location of the target; the object manipulation test required them to construct an object. Both tests (travel and object
construction) were administered as cross-over design tests, with 7 subjects using the FLEX with PINCH gloves first, 7 subjects using the FLEX with wand first, and the other 7 using the desktop with mouse and keyboard first. The sequencing of the 2 tests was randomized among interfaces and subjects. The subjects’ time required to perform the travel tasks, the time to complete the object construction activity, and the number of errors while constructing the object were recorded and results were calculated via a general linear model with a repeated measures model.

After completing the tests using each interface, subjects were given a survey with questions related to game appeal, ease of use, desire to play the entire game again, and desire to perform certain activities again. All children used a pictorial Likert scale with 4 smiling faces to rate their response to each question. In addition, all testing sessions were recorded on video and the footage was scored with reference to a set of positive and negative instantiations.

4. Findings

4.1 User Task Performance

Travel - primed search

There was no significant effect of Gender (fig. 2). However, in the FLEX+Wand and Desktop conditions, video game familiarity was significant or nearly so, and to the extent that girls have less video game playing experience, they may be adversely affected in primed travel.

Travel - unknown location of target

There was no Gender effect (fig. 3) and also no video game familiarity effect.

Object construction

The difference in completion time between girls and boys was significant in both the FLEX+Wand (F(1,17)=5.71, p=.029) and the FLEX+Glove (F(1,17)=6.6, p=.02) conditions, but not in the Desktop condition. Girls consistently took longer to complete the activity than boys (fig. 4).

Number of errors

There was no significant Gender effect for number of errors in all three conditions. Boys and girls made significantly more errors with the Wand than in the other two conditions, F(2,16) = 11.31, p=.001 (fig. 5).
4.2 Enjoyment of the game

Gender Differences in ratings of fun and ease of use

With respect to fun, girls rated all three platforms equivalently and highly. Boys rated the FLEX+Wand and FLEX+Glove equivalently and highly, and rated the non-immersive Desktop less fun (fig. 6).

There was a significant interaction between the ratings for ease of use and Gender, F(2, 16)=7.01, p=.007 (fig. 7). Girls rated the FLEX+Wand the easiest, and the FLEX+Glove a close second, but rated the Desktop as much harder than the others. In contrast, boys rated the Desktop as easiest, and both the Wand and Glove much harder. The Gender difference was significant for ratings of the FLEX+Wand (Wald $\chi^2=4.2$, p=.04), which boys rated as harder to use, and the Desktop ($\chi^2=38.84$, P<.001), which girls rated as harder to use. Comparison of ratings of ease of use with ratings of fun indicates that the children are clearly able to separate their enjoyment of the game from any difficulties they may have encountered while playing. For example, the boys rated the Desktop as the easiest to use and the least fun.

Gender differences in ‘returnance’ (e.g., desire to play again)

The Gender difference for desire to play the game again was significant, F(1,17)=5.91, p=.026. For girls, the opportunity to play the game again was independent of which platform it was presented on despite their lower ratings of ease of use of the Desktop, suggesting that the game itself is what appeals to them. For the boys, the opportunity to play the game again was more appealing in the FLEX, with either the Wand or the Glove, than playing it again on the Desktop. Note that this appeal is in spite of the fact that the boys rated the FLEX+Wand as most difficult to use. This suggests that in addition to the game itself being appealing to the boys, the full virtual reality immersive experience was also a strong attraction feature.

There was no significant Gender difference for desire to perform the object construction task again, indicating that the task was appealing to both boys and girls. The boys were less eager to return to the activity if presented on the Desktop as compared to either condition in the FLEX, confirming their ratings for fun.

There was also no Gender difference in desire to return to the bakery room again. However both groups preferred the immersive FLEX to the non-immersive Desktop presentation.

Clearly, boys and girls all enjoyed the opportunity to navigate through the town in SMILE Ville and were interested in returning to that activity. Ratings indicate that for the girls, the full immersive experience of navigating through the town in the FLEX (Wand or Glove) was a more attractive option than navigating through the town on the Desktop. The boys were eager to return to the town regardless of platform presentation, which contrasts with their feelings about returning to other aspects of the game.

5. Discussion and conclusion

In this paper we have reported a pilot study that investigated gender differences in playing a VR educational game using three different interfaces (two immersive and one non-immersive).

Two important results emerged from this study: (1) girls found the immersive interface (FLEX+wand) easier to use than the non-immersive one, especially for object manipulation tasks (although they took longer than boys to perform the object construction activity), and (2) girls were eager to play the game again regardless of interface, whereas the boys were much less eager to play the game again on the Desktop than they were in the FLEX with either the Wand or the Glove.
Finding (1) suggests that girls might perceive immersive interfaces easier to use than non-immersive ones. This result encourages us to continue the development of SMILE™ on immersive platforms and takes us one step closer to answering our main research question: What are the benefits of immersion and for whom? Finding (2) suggests that, overall, girls are more interested in game content than technology, whereas boys rate display platform and interaction mode important components of the game experience.

We believe that results of more studies like the one presented in this paper can guide game developers toward the design of ‘girl-friendly’ games with interfaces that capitalize on the preferences and interests of female players, thus increasing girls’ interest in both educational and recreational games.

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References