

Pedagogical Agents in Game-based Mathematics Learning in Virtual Worlds: OpenSim Project Bazaar

Heesung Kim, Taehyeong Lim, Gwynn Grandy, Sungwoong Lee, Fengfeng Ke, Florida State University
hk11f@my.fsu.edu, tl12c@my.fsu.edu, gbg11@my.fsu.edu, sl09d@my.fsu.edu, fke@fsu.edu

Abstract: This study is a part of an ongoing design-based research project to investigate whether a virtual-world game with pedagogical agents can promote the learning of fractions for 5th graders. The OpenSim-based game prototype was tested with participants majoring in mathematics and pre-service teachers in math education to investigate the usability, playability, and learning integration of the game prototype for the math learning of 5th graders. The study results indicate that the math game scenarios are engaging for students, but there are several opportunities for improving the prototype to increase learning integration and reduce extraneous cognitive load.

Introduction

The effectiveness of computer games on learning has been explored since the middle of the 20th century. Recently, virtual online games such as Second Life have shown great promise as learning tools with which learners are able to learn by applying their knowledge learned from the game to the real life. (Jarmon, Traphagan, Mayrath, & Trivedi, 2009). In this vein, Devlin (2011) also contended that computer games are ideal to support situated learning environments that allow learners to interact with something in their daily lives. In addition, computer games play a vital role in improving learners' motivation and presenting multimode representations for learners' engagement in math, and hence support mathematical learning (Ke, 2008; Moreno, 2004). In light of the effectiveness and potential of computer games and virtual online games, this study developed a virtual world environment with two math game scenarios in OpenSimulator (OpenSim). Moreover, a key element of the games is a pedagogical agent and its role in interacting with learners. The pedagogical agent, as another user in the virtual world, can provide learners with the response-specific feedback, which has a large positive impact on learning outcomes (Mason, 2001).

Method

As a part of design-based research, this study adopted expert review and user-testing methods to improve the design of a virtual game prototype (in terms of the embedded learning content, game world design, navigation, and facilitation of the virtual agent) for 5th grader math learning. The major research question is: How can we improve the usability, playability, and learning integration of the game prototype to promote math learning for 5th graders?

Setting and Participants

The study was conducted in the OpenSim-based virtual environment in which users can experience 3D virtual game scenarios that have been developed by the researchers for the purpose of the study. Six volunteers, comprised of 4 undergraduate and 2 graduate students majoring in math education or mathematics, aged 20-25, including 3 males and 3 females, participated in the study. They were given basic instructions on how to operate their avatars in the OpenSim world prior to the usability test.

Math Game Scenarios

The study included two game scenarios, with each taking 20 minutes to complete. In the first game scenario, participants learned drumbeat-making in four, eight, and sixteen beats by applying the concept of fractions. The second game scenario is ordering sushi at a Japanese restaurant. Participants were expected to apply fractions to order and calculate sushi pieces. For each scenario, a researcher controlled an avatar in OpenSim and acted as a facilitator and pedagogical agent (e.g., an experienced beat maker or a waitress) in the virtual world.

Data Collection and Analysis

Substantial data has been collected from: (1) video recording, (2) in-field observation, and (3) semi-structured interview. During the user-test sessions, the participants' game-play screen was video-recorded and the researchers compiled observation notes. After completing the virtual game scenarios, the participants completed a usability survey and answered semi-structured interview questions on their game play experiences and perceptions. A qualitative thematic analysis was conducted from the interview transcripts as well as reviewing the video recordings. The initial analysis from the result yielded an initial list of major categories (content, design, navigation and facili-

tation). Within these categories, consistent themes or patterns were formed and refined through iterative analysis of the data collected via interviews and in-field observations.

Findings

A set of themes on salient game features emerged from the data. First, five design needs related to the learning-play integration were discovered: (1) intuitive game-play instruction for each game scenario, (2) the selection of the appropriate level of vocabulary for both math and contextual information for the actual target audience, (3) options to adapt to diverse learners by adjusting the level of scaffolding and the pacing of learning content presentation, (4) versatility by offering both individual and group play, and (5) learning tasks during game play that are both naturalistic to the setting and engaging. To better support the five design needs, the game world design can be refined by providing: (1) more visual presentation of the learning content, and (2) more naturalistic input control to maneuver a virtual object. Finally, the game design should reduce frustration and distraction caused by navigation errors or virtual-world exploration.

Discussion

The results showed that providing timely instructions for each move (e.g., what to click and where to go) can reduce unnecessary cognitive load for learners during game play. Issues such as navigation, unsuitable vocabulary, or unclear instructions all detract from the delivery of the content. In addition, incorporating peer tutoring as a form of collaborative learning may be a way to increase students' engagement with the game and learning tasks. While all facilitators are confident with their level of expertise in 5th grade fractions, the difference between being able to use fractions in daily life and to clearly communicate fraction concepts at a 5th grade level was highlighted by this usability study.

References

- Devlin, K.J. (2011). *Mathematics education for a new era: Video games as medium for learning*. AK Peters Ltd.
- Jarmon, L., Traphagan, T., Mayrath, M., & Trivedi, A. (2009). Virtual world teaching, experiential learning, and assessment: An interdisciplinary communication course in Second Life. *Computers & Education*, 53(1), 169-182.
- Ke, F. (2008). Alternative goal structures for computer game-based learning. *International Journal of Computer-Supported Collaborative Learning*, 3, 429-445.
- Mason, B. J., & Bruning, R. (2001). Providing feedback in computer-based instruction: What the research tells us. Retrieved February, 15, 2007, from <http://dwb.unl.edu/Edit/MB/MasonBruning.html>.
- Moreno, R. (2004). Decreasing cognitive load for novice students: Effects of explanatory versus corrective feedback in discovery-based multimedia. *Instructional Science*, 32(1-2), 99-113.