Hirashima,T. et al. (Eds.) (2010). Workshop Proceedings of the 18th International Conference on Computers in Education. Putrajaya, Malaysia: Asia-Pacific Society for Computers in Education.

The Impact of Animated Worked Examples on Students' Cognitive Load During Problem Solving in Game-Based Learning

Chun-Yi SHEN, Hui-Chun TSAI
Department of Educational Technology, Tamkang, University A, Taiwan
cshen@mail.tku.edu.tw
ss884011@yahoo.com.tw

Abstract: This study investigated the impact of animated worked examples on students' cognitive load during problem solving in a game-based environment. Participants were 45 college students and divided randomly into experiment group and control group. After solving the problems in the first round of game playing, the experiment group was given animated worked examples while the control group was given static worked examples. After the second round game playing, they completed cognitive load index. Results showed that there was no significant difference on cognitive load between the two groups. Discussion and possible reasons were provided.

Keywords: Problem solving; game-based learning; worked example; cognitive load theory

Introduction

Most of the existing instructions on problem solving are presented using a combination of graphics and words or purely words. Mayer argued that procedural knowledge (such as problem solving) should better be instructed using animations with narrations [1]. Van Gerven, Paas, Van Merrienboer, and Schmidtsuggested that worked examples could promote acquisition of complex cognitive skills for adults by reducing their cognitive load and irrelevant information [2]. In this paper, we design two types of worked examples, one with graphics and words and the other with animations and narrations, to test whether animations and narrations-based worked examples could reduce their cognitive load.

2. Literature Review

a. Game-Based Learning

Computer games have been used for training in many different environments, such as academic [3], business [4], and medical [5]. Researchers pointed out that games are widely accepted as a powerful alternative to traditional ways of teaching and learning, with the merits of facilitating learning by doing [6]. In addition, problem solving may be effectively improved by computer games [1].

b. Problem Solving

As Mayer [1] defined, problem solving is cognitive processing pursuing to accomplish a goal without obvious solutions. Researchers suggested that problem solving is more like a conscious, deliberate process governed by a naturally occurring sequence of steps [7]. Recently, the researchers agreed that problem solving is cognitive processing directed at achieving a goal when no solution method is obvious to the problem solver [1].

c. Worked Example

A number of researchers investigated the efficacy of using worked examples in classroom instruction and provided evidence in the effectiveness of worked example instruction [8]. According to Sweller, Van Merriënboer, and Paas, a worked example is a procedure that focuses on problem states and associated operators (i.e. solution steps), enabling students to induce generalized solutions or schemas [8].

d. Cognitive Load Theory

According to the results of worked example studies, and Sweller and Chandler developed the cognitive load theory to explain the limitation of cognitive resources during problem solving [9]. Sweller also used the schema theory to demonstrate the cognitive architecture in designing worked example instructions [10]. According to Vygotsky, there is a zone between what learners can do by themselves and with assistance [11]. The effective worked examples instruction should provide appropriate help and involve in the zone of proximal development [12].

3. Methodology

a. Participants

Our research sample consisted of 45 undergraduates, randomly divided into the experimental group with 22 students and the control group with 23 students. This research was intended to compare the effects of two different combinations of information representation methods (animations+narrations vs. graphics+words) on cognitive load, so we adopted a true-experimental design with random classification of participants into the experimental and control groups and test of their performances before and after the experiment.

b. Computer Game

SafeCracker, a puzzle-solving game was decision by Wainess and O'Neil since it does not require special background knowledge or extraordinary visual-spatial skill [13]. A player in SafeCracker is a candidate for a position as a head of security development at a world famous firm of security systems, therefore needs to accomplish a task given by the boss.

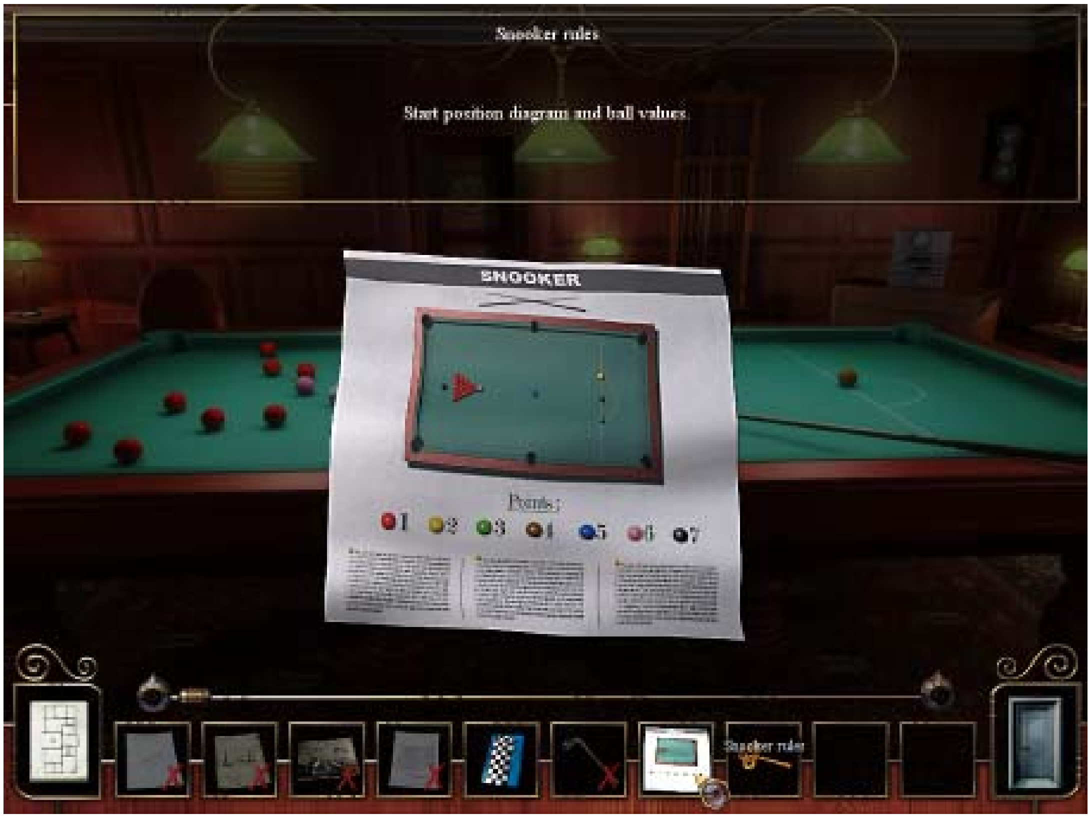

Figure 1: Interface of SafeCracker

c. Worked Example

In the experimental group (animations+narrations), participants were given worked examples presented with videos and narrative explanations about how to solve the puzzles edited using digital teaching material production software. On the other hand, the participants in control group (graphics+words) were given worked examples presented using PowerPoint. The worked examples for the two groups are completely the same in terms of contents but presented in different ways. In terms of the interactivity of the learning materials, participants in both groups are allowed to go to the previous or the next page, and only the participants in the animations+narrations group can pause or resume the video at will.

d. Procedure

First, the researcher explained the goal of the game. After providing an introduction of the game, participants began the first round of the game for 15 minutes. After first round game playing, participants in the experimental group were given worked examples presented with animations and narrations, and participants in the control group were given worked examples presented with static graphics and words using PowerPoint. All of them were given 10 minutes to watch the worked examples. Then, participants were asked to play the second round for 15 minutes. After the second round game playing, participants were required to fill out a cognitive load questionnaire to measure their cognitive load.

e. Instrument

The instrument we used to measure participants' cognitive load was adapted from NASA-TLX (Task Load Index). The Cronbach alpha of NASA-TLX was .81.

4. Results

Table 1 shows the descriptive statistics of cognitive load of the two groups. The result of independent t-test shows that there was no significant difference between two groups, $t(43)=0.157$, $p=0.876$.

Table 1. Descriptive Statistics of Cognitive Load

	Mean	Standard Deviation
Experiment Group	63.227	11.988
Control Group	62.696	10.645

5. Discussions and Conclusion

The results indicated that the difference was not significant, meaning that the effects of the two types of multimedia worked examples on learners' cognitive load are not significantly different. Two following is possible reasons. First, conveniences of instant replay of the two worked examples were different. Participants in the control group would directly access the worked examples to find answers when they encountered any difficulty in the game. Because the worked examples they were given were created by PowerPoint, they could easily and directly jump to a particular page. In contrast, participants in the experimental group had to spend much time on seeking the video section they needed. Second, learning styles may affect learning effectiveness during problem solving [1]. Third, the two groups spent differently on watching worked examples. Although all participants were given 10 minutes to watch our worked examples, we found that participants in the experimental group had to spend nearly 10 minutes on watching all the three worked examples just once. They did not even have enough time to watch any of the examples again. In contrast, most participants in the control group spent about 5~6 minutes on viewing all the worked examples, so they still have time to review any of them 2~3 times. Future researchers can also design fading worked examples, i.e. incomplete worked examples, to lead learners to solve problems on their own. We suggested that worked examples with animations and narrations could be made into several clips, one clip for one step. Besides, an index of worked examples, including those presented with graphics and words could be provided at the first page of the handout to allow participants to easily find the needed section. Therefore, the future researchers take convenience for learners into consideration in design of learning materials.

References

[1] Mayer, R. E. (2005). The Cambridge handbook of multimedia learning. Cambridge: Cambridge University Press.

[2] Van Gerven, P. W., Paas, F. G. W. C., Van Merrienboer, J. J. G., & Schmidt, H. G. (2002). Cognitive Load Theory and Aging: Effects of Worked Examples on Training Efficiency Learning and Instruction, 12(1), 87-105.

[3] Adams, P. C. (1998). Teaching and learning with SimCity 2000 [Electronic Version]. *Journal of Geography, 97*(2), 47-55.

[4] Washbush, J., & Gosen, J. (2001). An exploration of game-derived learning in total enterprise simulations. *Simulation & Gaming, 32*(3), 281-296.

[5] Ruben, B. D. (1999). Simulations, Games, and experience-based learning: The quest for a new paradigm for teaching and learning. *Simulation & Gaming, 30*(4), 498-505.

[6] Mayer, R. E., Moutone, P., & Prothero, W. (2002). Pictorial aids for learning by doing in a multimedia geology simulation game. *Journal of Educational Psychology, 94*(1), 171-185.

[7] Brunning, R. H., Schraw, G. J., & Ronning, R R. (1999). *Cognitive psychology and instruction* (3rd ed.). Upper Saddle River, NJ: Merrill.

[8] Sweller, J.; Van Merriënboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 1*0(3), 251-96.

[9] Sweller, J., & Chandler, P. (1994).Why Some Material Is Difficult to Learn. *Cognition and Instruction, 12*(3), 185-233.

[10] Sweller, J. (1990). Cognitive Processes and Instruction Procedures. Australian *Journal of Education*, *34*(2), 125-30.

[11] Vygotsky, L. S. (1989). Concrete human psychology. *Soviet Psychology*, *27*(2), 53-77.

[12] Rosenshine, B., & Meister, C. (1992). The use of scaffolds for teaching higher-level cognitive strategies. *Educational Leadership*, *49*, 26-33.

[13] Wainess, R., & O'Neil, H. F. Jr. (2003). Feasibility study: Video game research platform. Unpblished manuscript: University of Southern California.