Bomb Squad©- The Development and Evaluation of A Dual Play Online Virtual Reality Game That Incorporates Collaborative Problem-Solving Mechanism for Physics Education

Huei-Tse Hou, National Taiwan University of Science and Technology, Taiwan
Kung Ting Chen, National Taiwan University of Science and Technology, Taiwan
Yen-Cheng Lu, National Taiwan University of Science and Technology, Taiwan

The Asian Conference on Society, Education & Technology 2016
Official Conference Proceedings

Abstract
Compared to the traditional lectures and practice in science education, educational games that integrate simulation and manipulation with game-based learning theories may enhance learners' understanding of abstract scientific concepts and their learning motivation. Collaborative problem-solving, CPS, is one teaching strategy that has been emphasized by many learner-centered instructions. The scientific educational games that incorporate CPS may promote learners' discussions and understandings of scientific concepts by peer online interaction in a problem-solving process.
Therefore, this study aims to adopt physics engine to develop an online game, *Bomb Squad* ©, in which two learners play as the members of a bomb disposal team in a 3D virtual reality. Clues related to physics knowledge for bomb disposal can be found in the game and the players need to solve the problems by collaboratively manipulating the objects in the game for the correct mechanics phenomenon. The learners can exchange the clues they found in the online discussion room and use classical mechanics theories for bomb disposal collaboratively. Forty-one high school students participated in this study. The results showed that the learners' learning effectiveness related to physics knowledge was enhanced and they had high degree of acceptance and involvement in the game.

Keywords: Game-based learning, simulation and manipulation, collaborative problem-solving, virtual reality game, physics education

Introduction

In recent years, game-based learning has been widely applied in education (Annetta, 2010), and it has become the trend in the future innovative teaching. Compared to the traditional lectures and practice in science education, educational games that integrate simulation and manipulation with game-based learning theories may enhance learners' understanding of abstract scientific concepts and their learning motivation. Collaborative problem solving, CPS, is one teaching strategy that has been emphasized by many learner-centered instructions. The scientific educational games that incorporate CPS may promote learners' discussions and understandings of scientific concepts by peer online interaction in a problem-solving process.

Therefore, this study aims to adopt physics engine to develop an online game, *Bomb Squad* ©, in which two learners play as the members of a bomb disposal team in a 3D virtual reality. Clues related to physics knowledge for bomb disposal can be found in the game and the players need to solve the problems by collaboratively manipulating the objects in the game for the correct mechanics phenomenon. The learners can exchange the clues they found in the online discussion room and use classical mechanics theories for bomb disposal collaboratively. (As shown in Figure1 and 2)

The context designed in this game encourages the learners to solve problems together and see the viewpoints from peers. The game also helps the development of collaboration ability by encouraging the learners' creativity and the possible solutions based on critical thinking (Lee, Parsons, Kwon, Kim, Petrova, Jeong & Ryu, 2016). In this game, the player needs to remove bombs by understanding and analyzing the object weights and the calculation of gravitational acceleration. The study will preliminary analyze the learners' learning effectiveness after the game.

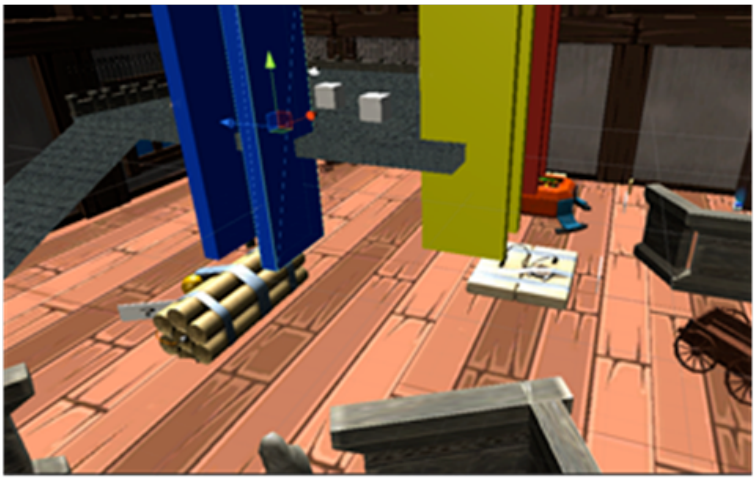

Figure 1. The game interface for two players to solve problems through online cooperation in Bomb Squad

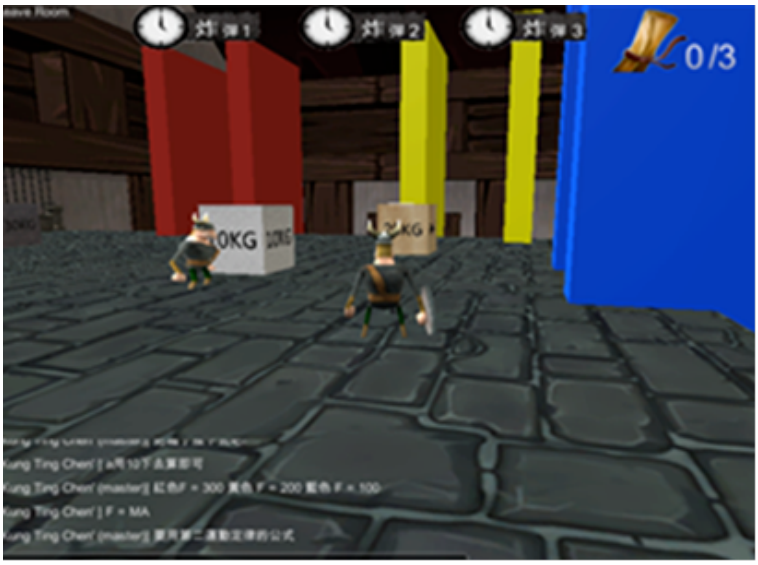

Figure 2. The players were removing the bomb by discussing and manipulating different mechanics phenomena

Method

Participants in this study were 41 senior high school students in northern Taiwan (24 males, 17 females, their average age was 15.07). The learners' flow were evaluated with the questionnaire developed by Kiili (2006). The Chinese version of the questionnaire was translated and edited by Hou and Chou (2012), mainly focusing the two dimensions of flow antecedent and flow experience.

The learners' technology acceptance was evaluated with the scale by Davis (1989), including two main dimensions of perceived usefulness and perceived ease of use. Both questionnaires were Likert five-point scales, with 23 questions for the flow and six questions for technology acceptance. According to the sample collected in this study, the reliability of the technology acceptance questionnaire (Cronbach's alpha=0.95) and of the flow questionnaire (Cronbach's alpha=0.85) showed high internal consistency.

The pretest and posttest with the same content were applied for the evaluation of learning effectiveness. The testing materials were adapted from the past college entrance exam in Taiwan, including 20 questions related to the knowledge of Newton's laws of motion. The reliability of the pretest and the posttest was Cronbach's alpha=0.745. The participants firstly had the pretest (15 minutes), and played the game (30 minutes), which was followed by the posttest (15 minutes) and the technology acceptance questionnaire and the flow questionnaire (10 minutes).

Results and Discussions

To evaluate the learners' learning effectiveness, a paired-samples t-test was used to compare the pretest and posttest. The results (see Table 1) showed that the students' posttest scores were higher than their pretest scores, suggesting that this game improved the learners' knowledge of Newton's laws of motion. The study further divided the students into high and low achievers based on whether their posttest scores lied within the first 27% or the last 27% of all the participants for an independent t-test. The results showed no significant difference in their flow and technology acceptance, and this game thus helped raise learners' motivation despite their different levels.

As for the flow and technology acceptance (see Table 2), the mean of the overall flow scores was 3.79 (3.8 for the flow antecedent and 3.79 for the flow experience). The mean of technology acceptance was 3.56 (3.59 for the perceived usefulness and 3.51 for the perceived usefulness). All of them were higher than the median 3 in the Likert scale. These results showed that the learners could get involved in the game and have high acceptance. Furthermore, the results of the independent t-test showed no significant difference between males and females in their technology acceptance and flow. Last, a positive correlation was found between the overall technology acceptance and the overall flow (r=.70), which suggested that the learners' technology acceptance may possibly relate to the degree of their involvement in the game.

Table 1. Pair t-test for pre- and post test

Variable	Posttest (n=41)		Pretest (n=41)			
	M	*SD*	*M*	*SD*	*t*(36)	*p*
Posttest–Pretest	77.32	16.00	73.05	15.656	21.85	.022

Table 2. Descritive analysis of flow and technology acceptance

	M	SD
Usefulness	3.5976	.80986
Ease of Use	3.5122	1.01132
TAM	3.5610	.81403
Game Elements	3.6280	.81800
Flow Antecedents	3.8000	.81394
Flow Experience	3.7907	.82414
Flow	3.7949	.77267

Conclusion and Suggestions

The study designed and developed a 3D educational game for physics instruction that integrated cooperation learning with the physics engine of unity, Bomb Squad ©. The study found that this collaborative learning game helped improve the learners' knowledge of Newton's laws of motion according to the learners' higher posttest scores. The game used the two-player dialogue and the mutual help modes to encourage problem solving in collaboration. The players followed the rules and find the clues in the game to remove the bombs, and they could be more familiar with the issue and had better learning performance with their received feedbacks as cognitive scaffoldings. The results showed that the average scores of the overall flow, technology acceptance, perceived usefulness, and perceived ease of use were all above the median. This suggested that the content of the game and the easiness to handle the game were highly accepted by the learners, so that the learners could get involved in the game that also met their learning needs.

Acknowledgments

This research was supported by the projects from the Ministry of Science and Technology , Republic of China, under contract numbers MOST- 104-2511-S-011 -003 -MY3 and MOST- 105-2511-S-011 -006 -MY3.

References

Annetta, L. A. (2010). The "I's" have it: A framework for serious educational game design. *Review of General Psychology*, *14*(2), 105.

Nunan, D. (1992). *Research methods in language learning*. Cambridge University Press.

Lee, H., Parsons, D., Kwon, G., Kim, J., Petrova, K., Jeong, E., & Ryu, H. (2016). Cooperation begins: Encouraging critical thinking skills through cooperative reciprocity using a mobile learning game. *Computers & Education*,*97*, 97-115.

Kiili, K. (2006). Evaluations of an experiential gaming model. *Human Technology: An Interdisciplinary Journal on Humans in ICT Environments*, *2*(2), 187-201.

Hou, H. T., & Chou, Y. S. (2012). Exploring the technology acceptance and flow state of a chamber escape game-Escape The Lab© for learning electromagnet concept. *ICCE 2012*, 38.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340.

Hou, H. T. (2013). Analyzing the behavioral differences between students of different genders, prior knowledge and learning performance with an educational MMORPG: A longitudinal case study in an elementary school. *British Journal of Educational Technology*, *44*(3), E85-E89.

Contact email: hthou@mail.ntust.edu.tw