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An Augmented Reality Educational Board Game with Situated Learning and Scaffolding Teaching Strategy for Environmental Protection Issue

Cheng-Tai LI, Po-Yen WANG, Kuan-Ting CHEN, Chih-Chen KUO & Huei-Tse HOU*
Mini Educational Game Development Group,
Graduate Institute of Applied Science and Technology
National Taiwan University of Science and Technology, Taiwan
*hthou@mail.ntust.edu.tw

Abstract: The study developed an educational game on mobile device, *Saving the Earth*©, integrating the image recognition technique of augmented reality and board game, to facilitate learners acquiring the knowledge of energy efficiency and carbon reduction in science and technology curriculum, and explored learners' learning effectiveness, flow state and technology acceptance in the game through empirical research. The results showed that learners had high flow state and technology acceptance. Moreover, their learning effectiveness of energy efficiency and carbon reduction knowledge had significant improvement after the game.

Keywords: Augmented reality, board game, game-based learning, educational game, environmental protection

1. Introduction

With the advancement of multimedia and information technology, applying augmented reality in teaching is a prominent and important research issue (Lin et al., 2016). Cheng & Tsai (2013) indicated that augmented reality (AR) could bring a brand-new way of science learning and facilitate the enhancement of students' learning effectiveness. Learning with AR could foster student's learning attitude and reinforce their learning achievement. (Hwang, Wu, Chen and Tu, 2016) On the other hand, recently board game has been widely applied in teaching for promoting learners' F2F interaction. McLaren, Adams, Mayer, & Forlizzi (2017) suggested that board game is certainly an effective teaching tool. Therefore, the study aims to explore the application of integrating AR and board game in teaching, and assist learner learning through the immediate feedback from AR and board game cards.

Our research team (Mini Educational Game development group in e-Learning Research Center, National Taiwan University of Science and Technology) cooperative with Cathay Life Insurance Co., Ltd. developed an educational game App, *Saving the Earth*©, which was integrated the image recognition technique of AR and board game. In this game, players need to complete the mission to save the earth by answering the questions with the clues from the AR game app and tagging correct board game cards. The learning objective of this game is to obtain the knowledge of energy efficiency and carbon reduction through 15 stages. Questions are shown in the dialog box on the application, and players tag the correct board game cards with mobile device (see Fig. 1). The application will provide immediate feedback and related clues as scaffolding to allow players to have deeper understanding of the knowledge until the stage is cleared. The purpose of this study is not only to develop an educational game in energy efficiency and carbon reduction learning but also to evaluate the learners' flow, and technology acceptance and learning effectiveness in the game.

Figure1. Students discuss, select and tag the correct board game cards with mobile device.

2. Method

Participants in this study were 24 junior high school students in northern Taiwan (11 males, 13 females, their average age was 13.17). This paper referred to Davis's (1989) technology acceptance model (TAM) to make a preliminary evaluation of learner's attitudes toward perceived usefulness, perceived ease of use. The study adopted Killi's Flow Scale for Game (2006), which was later translated by Hou and Chou (2012), to evaluate the learners' flow state from the two dimensions including flow antecedent and flow experience. The questionnaire was scored on a 5-point Likert scale (5 = agree, 1 = disagree). In this study, the Cronbach's α values was 0.866 for the technology acceptance scale and 0.945 for the flow scale. This indicates that this scale is confirmed as reliable and suitable for the current study. The study also designed one semi-opened question to better understand learners' feedback and feeling toward this game. In the analysis of learning effectiveness, the contents of pretest and the posttest were the same. The test, including 15 questions, was designed by a senior teacher with abundant teaching experience of science and technology curriculum in junior high school. The participants firstly had the pretest (10 minutes), and played the game (30 minutes), which was followed by the posttest (10 minutes) and the technology acceptance questionnaire and the flow questionnaire (10 minutes).

3. Results and Discussion

In the analyses of the flow and acceptance of the game, across all dimensions, the average rating of flow state (M=4.288) and technology acceptance (M=4.779) were high. (The median in a five-point scale is 3). The results implied that learners were deeply involved in the game and perceived the game to be useful for learning. With respect to the learning effectiveness, there was a significant difference in the score for the pre-test and post-test ($t=-12.689$, $p<0.001$) (Table 1). The result suggested that learners′ knowledge of energy efficiency and carbon reduction improved through this game.

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

Variable	Posttest (N=24)		Pretest (N=24)			
	N	SD	M	SD	t	p
Posttest-Pretest	14.38	1.279	10.00	1.285	-12.689	0.000

***p<0.001

The study further explored learners' feedback and feeling towards the educational game with semi-open-end question. In particular, students considered that they are more familiar with the knowledge of energy efficiency and carbon reduction through the game and liked that game-based approach of leering; some of the students thought this is a very challenge and great game. Based on these feedbacks, students like the augmented reality educational game, enjoy learning in the game-based learning context, and surely acquire the target knowledge. On the other hand, some of the students claimed that there should be more stages than now and considered that the auxiliaries of the answer options are needed.

4. Conclusion and Suggestions

The study developed an educational game, *Saving the Earth*©, integrating AR and board game. The results showed that this game enhanced students' learning in the knowledge of energy efficiency and carbon reduction. The result of flow state and technology acceptance suggested that learners had high acceptance for this game in terms of the context and operation of the game. As for the feedback of the game, most students thought they can obtain the knowledge through this game, and some of them considered that this game is interesting and were in favor of this game-based learning. On the other hand, students suggested that more stages are expected to extend. Future study should explore the relation of learning process and learning effectiveness with behavioral pattern analysis (Hou, 2013) and it will help us better understand the influence of the game which integrates augmented reality and board game on learning.

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