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Development and Evaluation of a Computer Supported Collaborative Learning Tool for Teaching Activities Using Educational Board Games

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Abstract: Educational board games have been widely used in the teaching practice. However, when teachers use educational board games for collaborative learning in classrooms, they may have problems in monitoring students' learning process. Students may also experience high cognitive load due to complicated rules and need immediate scaffolding guidance. This study developed a computer supported collaborative learning tool for board games (CSCLBG), aiming to help teachers apply board games in teaching. We also preliminarily evaluated this tool with empirical research. The results showed that learners' learning effectiveness in the CSCLBG activities improved. Positives results were also found in learners' flow and their technology acceptance. Moreover, learners showed lower anxiety in the activities.

Keywords: educational board game, CSCL, scaffolding, flow, anxiety

1. Introduction

Educational board games are useful tools to promote interpersonal interaction, encourage students' learning motivation (LeBlanc & Bearison, 2014), and increase their flow experience and learning achievement (Hou & Lin, 2015; Li et al., 2017). Teachers can apply different scaffolds to support students' learning by using educational board games. The board games may also provide peer scaffolding to promote peer interaction and learning achievement (Poole, Clarke-Midura, Sun, & Lam, 2019). Moreover, learners' flow experience in educational game may affect their learning performances and behaviors (Hsieh, Lin, & Hou, 2016). Considering the game design that could increase student' flow experience, Killi and Lainema (2008) suggested that the cognitive process was an important element which may influence flow experience. Cognitive load was an impact factor in cognitive process (Sweller, 2010).

Therefore, when using educational board games in classrooms, teachers need to increase learners' flow experience, provide scaffolding, and reduce their cognitive load. On the other hand, using digital applications as the guiding tool may effectively assist teachers to conduct educational board game activities in the classroom. The combination of digital applications and educational board games could help reduce repetitive actions and mechanism quickly (Park, 2017).

Moreover, computer supported collaborative learning (CSCL) is a strategy that students constructed knowledge, interacted with group members, and solved learning task collaboratively with computer applications (Bayir, 2014; Cress, Stahl, Ludvigsen, & Law, 2015). A web-based application could guide the students to collaborate with peers, help teachers collect the students' behavioral data immediately, and reduce the students' cognitive load (Wu, Chen, & Wu, 2018).

When the teacher guided the students for group-based educational board game learning in the classroom, the teacher may face the following problems. For example, the teacher may be interrupted and asked to repeat the rules because the students forgot about them. The teacher may also have problems in monitoring the learning progress of each group and in analyzing students' learning process.

For students, they may lack complementary information as the scaffolding in problem-solving activities. Moreover, students in collaborative learning groups may not be able to collaborate and complete game tasks due to complex rules and insufficient scaffolding.

Therefore, this study developed a tool to help teachers apply educational board games for CSCL teaching. This tool included many functions for teachers to solve various problems when implementing group-based CSCL educational board game activities in the classroom. For example, teachers could monitor the progress of real-time playing behaviors and the learning process of each group. The tool provided a step-by-step guide for the students to understand game rules, thus reducing their external cognitive load. The tool also provided cognitive scaffolding for the students when they played board games (e.g., supplementary learning resources and the real-time diagnosis).

The purposes of this study are as follows.

(1) The study aims to develop a computer supported collaborative learning tool for educational board games, which could guide the students to play games and help the teacher monitor students' learning immediately.
(2) Teachers could apply functions of the proposed tool and a history educational board game in their teaching activities.
(3) The study preliminarily evaluates students' learning effectiveness, flow state, anxiety, and their acceptance of the tool in the learning activity.

2. Methods

2.1 Participants

Participant of this study included 48 undergraduate students from a college located in northern Taiwan, and they were 18-20 years old. All of them had information management background. They all attended the same history course for one year. In this study, participants needed to play a history educational board game which included the knowledge they had learned. They were also guided by the computer supported collaborative learning tool developed by the study.

2.2 Research Procedures and Tools

This study was a quasi-experimental design and only included a single group. The research procedures were as follows. First, participants were asked to do a pre-test about history knowledge. The contents of the pre-test were chronology of historical events in Taiwan, designed based on history textbooks. Second, the participants were divided into groups and asked to play a board game with the computer supported collaborative learning tool. Each group used one device and spent 30 minutes on game. Third, to the study explored the participants' flow experience, anxiety, and technology acceptance. For example, the participants' flow experience was measured with the flow scale developed by Kiili's (2006) and translated by Hou and Chou (2012), and the scale was of high reliability (Cronbach's α=0.967) and validity (KMO=0.832) for flow. The participants' anxiety was measured with the questionnaire adapted by Krashen (Krashen, 1981; 1982), and the scale was of high reliability (Cronbach's α=0.833) and validity (KMO=0.793) for anxiety. The participants' technology acceptance was measured with our revised questionnaire of Davis (1989), including of the three dimensions of perceived usefulness, perceived ease of use, and game elements. The scale was of high reliability (Cronbach's α=0.951) and validity (KMO=0.867) for technology acceptance. All these questionnaires used the five-point Likert scale. Fourth, the participants were asked to do the post-test about history knowledge. The questions in the pre-test and the post-test were identical in order to know whether the students acquired more knowledge after they played the game.

2.3 Educational Board Game: Voyage with Taiwan

Voyage of Taiwan is an educational board game for history learning (Lin & Hou, 2015) (Figure 1). This game included 89 *event cards*. On the front side of each card, the players could see a title of one historical event in Taiwan history, an example picture, and three keywords related to this event. On the back side of each card, the player could see the year period of the event and a brief description. Within limited time, the players needed to take as many cards as possible and read the information on the front side of the cards to decide the time sequence of events and get points. The students were assigned to groups for the activity and each group participated in the history learning activity with the help of Voyage with Taiwan and the CSCL tool developed by this research.

Figure 1. Voyage of Taiwan

2.4 The CSCL tool for educational board game

The proposed computer supported collaborative learning tool for board game ($CSCLBG_{beta}$) provided multi-modules for teaching activities. Figure 2 shows the instructions of each module and the interface of $CSCLBG_{beta}$. These functions were beneficial for players in educational board games. With the assistance from the system, the students could be guided step by step to play the game. Therefore, the students' cognitive load could be reduced since the students did not have to memorize rules or calculate points by themselves. On the other hand, the teacher could provide complementary information as scaffolding for the students to help them solve problems in board game activities. The teacher could also monitor the students' game progress from the data. Functions of each module are shown in Table 1. During the process of supporting Voyage of Taiwan, $CSCLBG_{beta}$ guided student the game progress, provided history information as scaffolding for the students, and helped countdown. During student playing game, $CSCLBG_{beta}$ send the data about duration of each actives, scores, and times of scaffolding using.

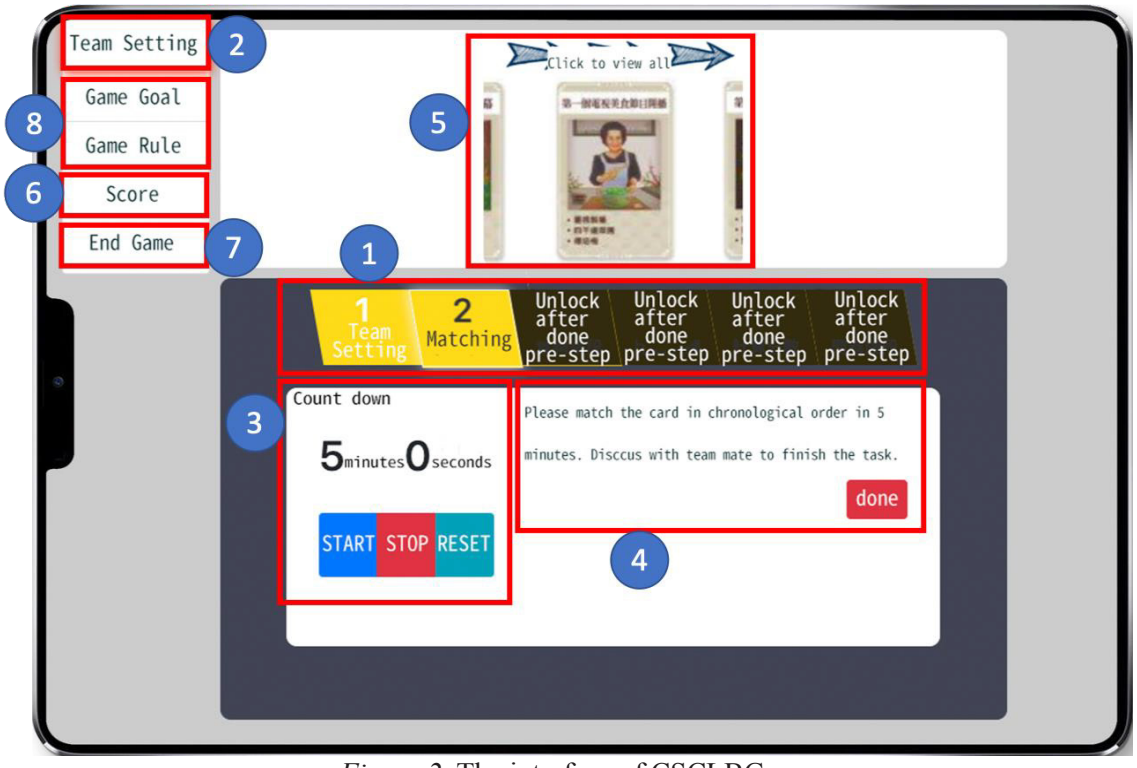

Figure 2. The interface of CSCLBG$_{beta}$

Table 1. The modules and functions of *CSCLBG*

Module	Function	Feature
1. The step-by-step guidance module	The players chose steps and they were guided step by step to complete the board game learning activities. The teacher could understand the learning progress of each group through this module.	The module provided guidance step by step and reduced players' cognitive load. The students could better understand the gaming progress and focus on collaboration and communication on game tasks. The teacher could also immediately monitor the students' learning process.
2. The group setting module	This module helped group setting and record learning information of each group.	The module assisted the teacher to monitor learning process.
3. The time setting module	This module helped set the countdown and set time limit for each step.	This module helped set time limit for each stage and assisted the teacher and group members to manage their time.
4. The task phase guidance module	The teacher could set game mission in each phase. The students could move based on the goal in each phase.	Since the mission and rules of each phase was given, the students did not need to memorize these rules and their external cognitive load was thus reduced.
5. The cognitive scaffolding module	The teacher could provide texts, pictures, and videos as the	The teacher could provide the texts or images as scaffolding

		complementary information.	to assist students' discussions and collaborative problem-solving tasks (e.g., problem-solving directions, multimedia clues, websites related to information for problem-solving tasks).
6.	The scoring module	The module provided students' records and calculated their scores in the game.	This module helped reduce complex score calculations, thus lowering cognitive load.
7.	The game completion module	The module reported to the teacher that the game was completed, and the data would be sent to the cloud.	This module helped the teacher monitor students' learning process and helped analyze their learning information.
8.	The game goal and rule module	The module showed the students completed rules and goals of the game.	This module reminded the students of the game goals so that they did not need to memorize the rules. The students could repeat reading the detailed rules and their external cognitive load could be reduced.

3. Results

As for learning performance, Table 2 shows that the students' learning performance improved after they had played the educational board game witch CSCLBG ($t=-4.703$, $p<.001$). This finding suggested that these students acquired history knowledge and had significantly better learning performance with the help of our educational board game and CSCLBG.

Table 2. The results of the *paired sample t-test*

	Mean	N	SD	t	p
Pre-test	32.81	48	27.95	-4.703	.000**
Post-test	72.88	48	54.70		

**$p< 0.01$

As for the student's experiences and their perceptions of the board game with CSCLBG, Table 3 shows the results of the flow scale, anxiety scale, and technology acceptance scale. As shown in table 3, the means of the students' overall flow (M=3.42) and acceptance (M=3.45) were above the median 3 in a five-point scale. The mean of the students' anxiety was below 3 (M=2.54). Based on these findings, students in the CSCLBG and board game learning activities showed positive views on system acceptance (including perceived usefulness and perceived ease of use) and on flow. Moreover, they also showed low learning anxiety in the activities.

Table 3. Means and standard deviations of flow scale, anxiety scale, and technology acceptance scale.

Dimension	Mean	S.D.
Flow	3.42	0.76
Flow antecedents	3.49	0.76
Flow experience	3.37	0.81
Anxiety	2.54	0.63

Technology acceptance	3.45	0.76
Perceived usefulness	3.45	0.84
Perceived ease of use	3.53	0.82
Game elements	3.40	0.79

4. Discussion and Conclusion

This study developed a tool that can be applied by teachers with educational board games in their group teaching. This tool had potential and could be applied into different fields. The study showed that learners' learning performance improved after the CSCLBG activities. Moreover, positive results were also found in learners' flow experience and technology acceptance. Learners did not show much anxiety in the game. These findings suggested that learners could apply this tool with the educational board game in learning activities. They concentrated on learning and they were deeply involved in learning without being affected by much anxiety. The prototype of this tool has been developed, and more modules would be added in the future. We will improve its visual interface and add teacher monitoring dashboard to make its functions more completed and promote its ease of use. Moreover, after this preliminary evaluation, future studies could include the experimental group (using CSCLBG only) and the control group (using board games only) for many other disciplines to analyze learners' learning process and performance.

In addition, we suggest researchers explore learners' cognitive load or learning behavioral patterns in the future (e.g., Hou, 2015; 2012). This helps us know whether learners could have better learning effectiveness and experience with the help of this tool.

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