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A concept map-embedded educational computer game for improving students' learning performance in natural science courses

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A B S T R A C T

Many recent studies have reported the benefits of educational computer games in promoting students' learning motivations. On the other hand, however, the effect of digital game-based learning in improving students' learning performance has been questioned. Several previous studies have reported that without properly integrating learning strategies into gaming scenarios, the effectiveness of educational computer games could be limited, or may be even worse than that of the conventional technology-enhanced learning approach. In this study, a concept map-embedded gaming approach is proposed for developing educational computer games by integrating concept mapping as part of the gaming scenarios to help students organize what they have learned during the game-based learning process. Moreover, a role-playing game has been developed for an elementary school natural science course based on the proposed approach. From the experimental results, it is found that the concept map-embedded gaming approach can significantly improve the students' learning achievement and decrease their cognitive load. Moreover, the students who learned with the proposed approach revealed a significantly higher degree of perceived usefulness than those who learned with the conventional game-based learning approach.

1. Introduction

Digital game-based learning has been regarded as a highly potential issue among various technology-enhanced learning approaches (van Eck, 2006). Researchers have indicated that, owing to their nature of providing challenging tasks, encouraging different levels of interaction, and providing enjoyable multimedia and instant feedback, computer games have the potential to provide students with deep and meaningful learning experiences (Aldrich, 2005; Federation of American Scientists, 2006; Shaffer, 2006) as well as engaging them in self-directed learning (Salen & Zimmerman, 2004). In the past ten years, researchers have tried to develop various computer games for educational purposes, and have reported the effectiveness of digital game-based learning in promoting the learning motivation of students (Bourgonjon, Valcke, Soetaert, & Schellens, 2010; Gee, 2003; Inal & Cagiltay, 2007; Malone & Lepper, 1987; Yun, Jiang, & Li, 2010). In the meantime, researchers have also indicated that students' learning performance might not be as good as expected if educational computer games are merely another way of presenting the learning materials (Hwang, Wu, & Chen, 2012; Wang & Chen, 2010); that is, to improve students' learning performance, it is important to provide or lead in to proper learning supports or instructional strategies in addition to integrating the learning materials into computer games (Charsky & Mims, 2008; Fisch, 2005).

On the other hand, researchers have further indicated that improper lead-in of learning strategies or tools might even decrease learning motivation and cause negative learning effects (Charsky & Ressler, 2011; Randel, Morris, Wetzel, & Whitehall, 1992). For example, the study of Charsky and Ressler (2011) showed that the students who were asked to use knowledge construction tools during the game-based learning process revealed significantly lower motivation than those who only learned with educational computer games. Accordingly, they have pointed out the importance and necessity of effectively integrating learning strategies or tools into the gaming scenarios or

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gaming objectives, instead of treating them as additional supports or objectives. That is, to assist students in improving their learning performance, it is important to integrate learning strategies or tools as part of the educational computer games.

Consequently, in this study, an educational role-playing game is developed by integrating concept maps as part of the gaming scenarios. Moreover, an experiment has been conducted on the "knowledge of the plants on the school campus" unit of an elementary school natural science course. During the game-based learning process, students are asked to collect information related to the target plants to complete the concept maps based on the need of the storyline, which helps them to organize what they have collected in the game as well as what they have learned from the textbook. To evaluate the effectiveness of the proposed approach, the following research questions are investigated:

(1) Do the students who learn with the concept map-embedded educational game show better learning achievements than those who learn with the conventional educational game?
(2) Do the students who learn with the concept map-embedded educational game show higher learning motivation than those who learn with the conventional educational game?
(3) Does the concept map-embedded educational game decrease the students' cognitive load in comparison with the conventional educational game?
(4) Do the students who learn with the concept map-embedded educational game show higher acceptance degree in terms of perceived ease of use and perceived usefulness than those who learn with the conventional educational game?

2. Literature review

Digital game-based learning is a student-centered educational model that incorporates learning content into computer games or employs computer games to achieve educational objectives (Hwang, Sung, Hung, & Huang, 2012; Prensky, 2007). In an educational computer game, learners are situated in gaming scenarios to complete a series of learning tasks individually, collaboratively, or even competitively (Nelson, Erlandson, & Denham, 2011; Paraskeva, Mysirlaki, & Papagianni, 2010; Squire & Steinkuehler, 2005). The gaming missions need to be challenging enough to encourage learners to improve their knowledge and problem-solving skills (Gentile & Gentile, 2005; Kinzie & Joseph, 2008); moreover, meaningful feedback is necessary to help the learners make progress in the interactive process of probing, reacting, hypothesizing and planning (Oblinger, 2004). Learners need to follow the gaming rules to complete their game missions, which usually comply with the learning objectives. It is expected that learners can engage in the learning activities in an enjoyable and effective manner (Cagiltay, 2007). Furthermore, they can think, analyze and make meaningful decisions when trying to complete the gaming missions, and win prizes via looking for possible solutions that meet the gaming rules (Coller & Scott, 2009; Prensky, 2007). Consequently, several researchers have indicated that the digital game-based learning approach has great potential to be an effective method of knowledge acquisition and construction (Pivec, 2007; Tüzün, Yılmaz-Soylu, Karakus, Inal, & Kızılkaya, 2009).

In the past decade, various studies have been conducted and have reported that digital game-based learning is able to promote students' learning interest and learning motivations (Ebner & Holzinger, 2007; van Eck, 2006; Gee, 2003; Huang, Huang, & Tschopp, 2010; Papastergiou, 2009). For example, Chang, Peng, and Chao (2010) reported the positive effect of simulation games on students' learning motivation in three decision-science courses in industrial engineering. Rosas et al. (2003) reviewed and investigated the effect of several studies that employed computer games in teaching settings, and indicated that the nature of games could benefit students in several aspects, including learning achievement, cognitive performance, learning motivation and concentration.

In the meantime, many digital games have been implemented and applied to various educational applications. such as software engineering courses (Connolly, Stansfield, & Hainey, 2007), civil engineering courses (Ebner & Holzinger, 2007), meta-cognitive strategy training (Kim, Park, & Baek, 2009), geography courses (Tüzün et al., 2009), Chinese language learning (Hao et al., 2010), English listening (Liu & Chu, 2010), programming skills training (Wang & Chen, 2010), mathematics (Hung, Hwang, Lee, & Su, 2012; Liao, Chen, Cheng, Chen, & Chan, 2011), and natural science courses (Hwang, Sung, et al., 2012; Sung & Hwang, 2013). In addition, researchers have investigated the impacts of digital game-based learning from various aspects, including the acceptance and efficacy of teachers (Ketelhut & Schifter, 2011), the self-efficacy of the students (Meluso, Zheng, Spires, & Lester, 2012), gender issues (Carbonaro, Szafron, Cutumisu, & Schaeffer, 2010; Hou, 2012), learning style issues (Hwang, Sung, et al., 2012), collaboration or interaction between peers (Charles, Charles, McNeill, Bustard, & Black, 2011; Paraskeva et al., 2010; Sánche & Olivares, 2011), critical thinking (Gerber & Scott, 2011), and assessment issues (Nelson et al., 2011).

On the other hand, researchers have also indicated the importance and necessity of embedding proper teaching strategies or learning designs in digital games (Chang, Wu, Weng, & Sung, 2012; Charsky & Ressler, 2011; Hoffman & Nadelson, 2010). For example, Ke (2008) indicated that digital game-based learning might be superior in terms of motivating students than the traditional instructional approach; however, without effective learning supports, the effect of game-based learning on students' learning performance could be limited. Hence, it is important to consider the lead-in of effective learning strategies or tools while developing digital games for educational purposes.

Concept mapping has been recognized as an effective visualized learning tool that helps learners memorize and organize their knowledge (Novak & Gowin, 1984; Pankratius, 1990). Researchers have further indicated that concept mapping is able to engage learners in higher order thinking and help them clarify misconceptions (Chiou, 2008; Novak, Gowin, & Johansen, 1983). In the past decades, concept mapping has been applied to a variety of educational applications by playing the roles of knowledge construction tools (Hwang, Shi, &Chu, 2011; Wu, Hwang, Milrad, Ke, & Huang, 2012), assessment tools (Chang, Sung, Chang, & Lin, 2005; Hwang, Wu, & Ke, 2011) and instructional tools (Price, 2008; Roth & Roychoudhury, 1994).

In recent years, some researchers have tried to employ concept maps in digital game-based learning activities. From the experimental results, they found that concept mapping has the potential for improving the learning performance of students (Coller & Scott, 2009; Price, 2008). In the meantime, they also pointed out the difficulty of applying it. For example, Charsky and Ressler (2011) presented a failure experience of using concept mapping in an educational computer game. They found that the students who were asked to organize what

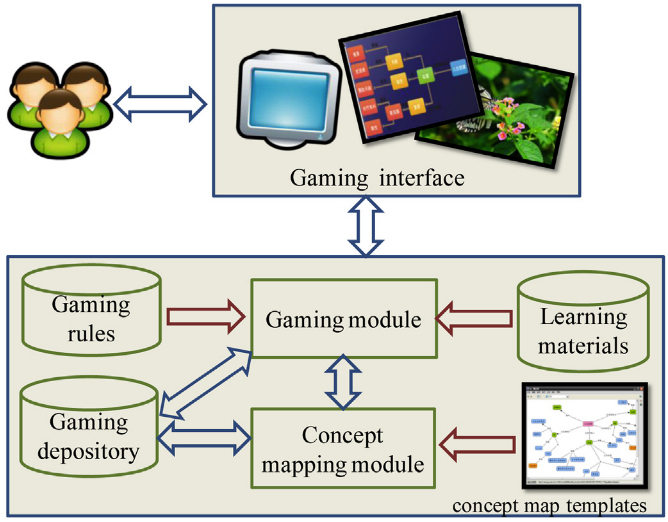

Fig. 1. Structure of the concept map-embedded digital game.

they had learned from the game revealed significantly lower motivation and worse learning performance in comparison with those who played the game without concept maps. Furthermore, they concluded that using concept mapping in game-based learning activities could cause negative results unless the concept mapping strategy can be well integrated into the games. That is, it is important to consider the role of concept mapping in designing gaming scenarios.

3. Development of a concept map-embedded digital game

In this study, we tried to develop a role-playing game by embedding concept mapping strategies as part of the gaming scenarios to assist students in improving their learning performance. The game was implemented with the RPG Maker developed by Enterbrain Incorporation. Fig. 1 shows the structure of the game, which consists of a gaming module, a concept mapping module, a gaming rule database, a gaming depository database, a learning materials database, and a set of pre-defined concept maps.

The gaming module is in charge of executing the role-playing game based on the scripts stored in the gaming rule database and the materials (text, graphics, images and videos) stored in the learning materials database. The learning portfolios of the students, including the completed learning missions, the uncompleted learning missions, the collected data, and the health status of the main character, are recorded in the gaming depository database. The concept mapping module assists the students in organizing the collected data following the storyline based on the concept map templates provided by the teachers.

The learning unit is about the growth of butterflies, including their living environment, characteristics, natural enemies, and food in each growth stage (i.e., egg, larva, pupa, and imago). The storyline is related to a mysterious magical world, in which magicians raise insects to get powers from nature. The main character of the game is a young man who needs to learn to raise butterflies to obtain the power to rescue his people. Therefore, he starts a journey to collect data about butterflies and to learn to get the power via passing various kinds of testing and training. Fig. 2 shows the gaming scenario of collecting information about the food plants of butterflies. In this illustrative example, the main character (i.e., the young magician) finds one of the learning targets, that is, the food plant of the imago of the "Idea leuconoe clara," and hence his power is increased by 1. The collected information is recorded in the repository database for further review.

In addition to collecting data to complete the gaming missions, there are a fighting game and a puzzle game to help the players identify the natural enemies and the appearances of the butterflies. Fig. 3 shows the interface of the fighting game. When using their magic power to fight the natural enemy of the target butterfly, from whom they derive the power, the players will find that the fighting is very difficult and dangerous; in the meantime, the system will warn the players "This could be the natural enemy of the butterfly" and remind them to identify and keep away from it. After collecting the required data, the players need to take a test in order to pass each gaming stage. The test aims to help them review what they have learned so far. The players can look for relevant information from the repository database, which presents the collected data in a categorized list, to answer the questions of the test.

Fig. 4 shows a concept map template embedded in one of the gaming missions. Instead of presenting the items and their relationships as a task list, the concept map template guides the players to collect and present data in a well-organized manner. In this illustrative example, the young magician has found an egg of "Idea leuconoe clara" and has observed that the color of the egg is "white or light yellow." The finding is then added to the concept map as a feature of the egg of "Idea leuconoe clara."

4. Experiment design

To evaluate the performance of the proposed game-based learning approach, an experiment was conducted for the "butterfly ecology" unit of an elementary school natural science course. The course unit has been included in the formal curriculum of the selected school for more than 10 years, and has been recognized as part of its school-based curriculum. We aimed to investigate the effects of the proposed approach on the students' learning achievement, learning motivation, cognitive load, and their degree of technology acceptance.

Fig. 2. Gaming scenario of collecting information about the food plants of butterflies.

4.1. Participants

The subjects of this study included two classes of sixth graders of an elementary school in northern Taiwan. Each class consisted of 28 students. This number of classes in each grade and the number of students in each class can be found in most of the medium to small sized schools in Taiwan. That is, the selected subjects reflect the teaching reality in Taiwan. A quasi-experiment was designed by assigning the students in one class to the experimental group, and those in the other class to the control group. The experimental group learned with the concept map-embedded digital game, while the control group learned with the digital game without concept maps. All of the students were taught by the same instructor who had more than eight years' experience of teaching natural science courses.

4.2. Research tools

The research tools in this study included a pre-test, a post-test, and the questionnaire for measuring the students' learning motivation, cognitive load and technology acceptance.

The pre-test and post-test were developed by two experienced teachers. The pre-test aimed to evaluate the students' prior knowledge of learning the course unit. It consisted of ten yes-or-no items and ten multiple-choice items, with a perfect score of 100. The post-test consisted of ten multiple-choice items, four matching items and five question-and-answer items for assessing the students' butterfly ecology general knowledge. The perfect score of the post-test was 100.

The questionnaire of learning motivation was modified from the measure developed by Hwang and Chang (2011). It consisted of seven items (e.g., "I think learning natural science is interesting and valuable" and "I would like to learn more and observe more in the natural science course") with a six-point rating scheme. The Cronbach's alpha value of the questionnaire was 0.79.

The cognitive load questionnaire was developed based on the measures of Paas (1992) and Sweller, van Merriënboer, and Paas (1998). It consists of 8 items with a six-point Likert rating scheme, including 5 items for "mental load" and 3 for "mental effort." The Cronbach's alpha values of the two dimensions are 0.86 and 0.85, respectively.

Fig. 3. Gaming scenario of fighting the natural enemy.

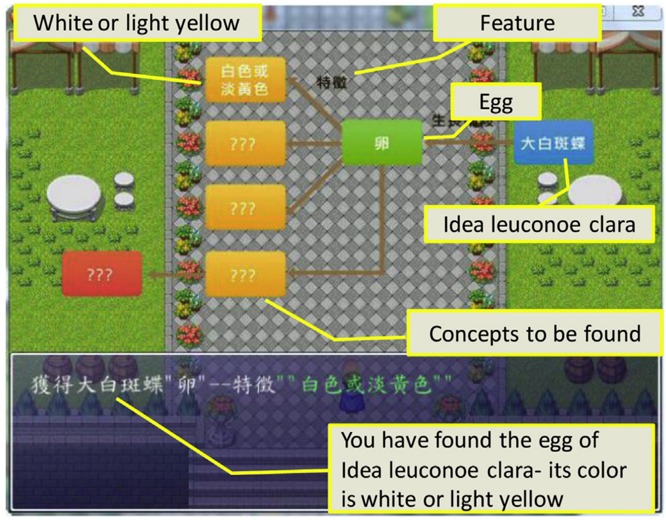

Fig. 4. Illustrative example of a concept map template embedded in a gaming mission.

The technology acceptance questionnaire originates from the questionnaire developed by Chu, Hwang, Tsai, and Tseng (2010). It consists of 13 items with a six-point Likert rating scheme, including 7 items for "Perceived ease of use" and 6 for "Perceived usefulness." The Cronbach's alpha values of the two dimensions are 0.94 and 0.95, respectively.

4.3. Experiment procedures

Fig. 5 shows the procedure of the experiment. Before the learning activity, the two groups of students took a two-week course about the basic knowledge of butterflies, which is a part of the natural science curriculum of the selected school.

At the beginning of the learning activity, the students took the pre-test and the learning motivation questionnaire. During the learning activity, the students in the experimental group learned with the concept map computer game; on the other hand, those in the control group learned with the educational computer game that did not have a concept map. Both versions of the game included the same background story, learning missions and learning content. The students in both groups were scheduled to learn by playing the educational computer games and to complete a learning sheet in 120 min to control the "learning time" factor. Moreover, they were allowed to review the learning contents and modify their learning sheets by playing the games repeatedly if they completed the gaming missions before the time was up.

After the learning activity, the students took the post-test and the learning motivation questionnaire for comparing the learning achievements and the improvements in learning motivations of the two groups.

5. Results

5.1. Analysis of learning achievement

The aim of this study was to examine the effectiveness of the educational computer game with concept maps in terms of improving the learning achievement of the students. The mean values and standard deviations of the pre-test scores were 75.36 and 11.30 for the control

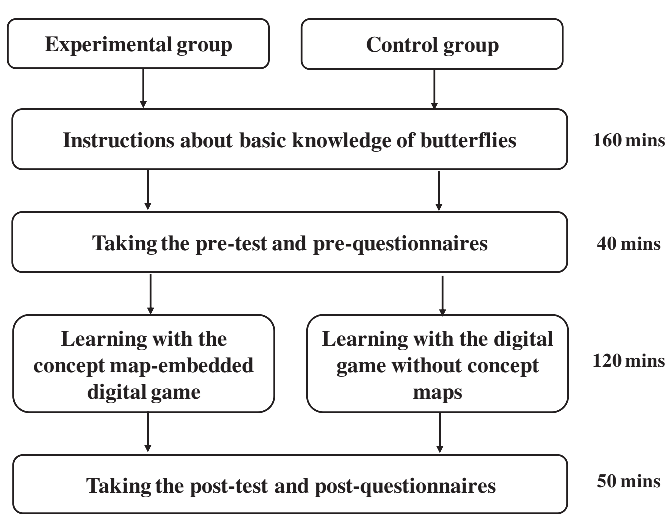

Fig. 5. Diagram of the experiment design.

Table 1
t-Test result of the pre-test scores.

		N	Mean	S.D.	t
Pre-test	Experimental group	28	78.93	6.72	−1.44
	Control group	28	75.36	11.30	

Table 2
Descriptive data and ANCOVA of the post-test results.

Group	N	Mean	S.D.	Adjusted mean	Std. error	F
Experimental group	28	74.86	10.16	74.34	2.15	5.89*
Control group	28	66.39	12.63	66.91	2.15	

*$p < .05$.

group, and 78.93 and 6.72 for the experimental group. The *t*-test result ($t = -1.44$, $p > .05$) shows that there was no significant difference between the two groups; consequently, it is evident that the two groups of students had equivalent prior knowledge before the learning activity, as shown in Table 1.

After the learning activity, the analysis of covariance (ANCOVA) was used to test the difference between the two groups by using the pre-test scores as the covariate and the post-test scores as dependent variables, as shown in Table 2. The adjusted mean value and standard error of the post-test scores were 66.91 and 10.16 for the control group, and 74.34 and 12.63 for the experimental group. According to the results ($F = 5.89$, $p < .05$), there was a significant difference between the two groups; that is, the students who learned with the concept map-embedded educational game showed significantly better learning achievements than those who learned with the game without concept maps.

5.2. Analysis of learning motivation

Table 3 shows the *t*-test result of the learning motivation pre-questionnaire ratings of the two groups. The means and standard deviations of the pre-questionnaire ratings were 4.64 and 0.78 for the control group, and 4.75 and 0.72 for the experimental group. The *t*-test result showed no significant difference between the pre-questionnaire ratings of the two groups ($t = -0.51$, $p > .05$), showing that the two groups of students had equivalent learning motivation before participating in the learning activity.

After the learning activity, the two groups of students took the learning motivation post-questionnaire. Table 4 shows the ANCOVA result of the post-questionnaire ratings of the two groups. The adjusted means and standard deviations of the ratings were 4.85 and 0.65 for the control group, and 4.93 and 0.63 for the experimental group. It is found that the post-questionnaire ratings of the two groups were not significantly different ($F = 0.71$, $p > .05$). This result is reasonable since the students in both groups learned with digital games, and hence their learning motivations improved, no matter whether concept maps were embedded in the games or not. This finding conforms to those reported by previous studies that digital game-based learning is able to promote the learning motivations of students owing to the enjoyable and challenging nature of the games (Ebner & Holzinger, 2007; van Eck, 2006; Gee, 2003; Huang et al., 2010; Papastergiou, 2009). On the other hand, it is inferred that integrating the concept mapping strategy in the computer game did not have a significant impact on the students' learning motivation.

5.3. Analysis of cognitive load

As it is a new experience of the students to learn with the educational game with concept maps, it is interesting to know the cognitive load of the students during the learning process. As shown in Table 5, the means and standard deviations of the cognitive load ratings were 2.76 and 1.24 for the experimental group, and 3.60 and 1.13 for the control group. The *t*-test result shows a significant difference between the cognitive load ratings of the two groups ($t = 2.67$, $p < .05$), showing that the concept map-embedded approach is able to reduce the cognitive load of students in learning with educational computer games.

The study further compares the two aspects of cognitive load: mental load and mental effort, as shown in Table 6. For the mental load dimension, the means and standard deviations were 2.44 and 1.32 for the experimental group, and 3.38 and 1.31 for the control group. The *t*-test result shows that the mental effort of the control group is significantly higher than that of the experimental group ($t = 2.66$, $p < .05$). On the other hand, for mental load, the means and standard deviations were 3.09 and 1.66 for the experimental group, and 3.81 and 1.35 for the control group. The *t*-test result shows no significant difference between the mental load ratings of the two groups ($t = 1.80$, $p > .05$).

As mental load refers to the interaction between task and subject characteristics, it can be determined based on students' knowledge of the task and subject characteristics (Paas & van Merriënboer, 1994). On the other hand, mental effort represents the cognitive capacity allocated to accommodate the demands imposed by the task; that is, it reflects the aspect of cognitive load related to the way of structuring and presenting the learning content or the strategy adopted for guiding the students to learn (Pass, Tuovinen, Tabbers, & van Gerven, 2003).

Table 3
t-Test result of the learning motivation pre-questionnaire ratings of the two groups.

Group	N	Mean	S.D.	t
Experimental group	28	4.75	0.72	−0.51
Control group	28	4.64	0.78	

Table 4
ANCOVA result of the learning motivation post-questionnaire ratings of the two groups.

Group	*N*	Mean	S.D.	Adjusted mean	Std error	*F*
Experimental group	28	4.81	0.65	4.85	0.07	0.71
Control group	28	4.96	0.63	4.93	0.07	

Table 5
t-Test result of the cognitive load on the post-questionnaire scores of the two groups.

Group	*N*	Mean	S.D.	*t*
Experimental group	28	2.76	1.24	2.67*
Control group	28	3.60	1.13	

*$p < .05$.

Table 6
t-Test result of the cognitive load dimensions on the post-questionnaire scores of the two groups.

	Group	*N*	Mean	S.D.	*t*
Mental Load	Experimental group	28	3.09	1.66	1.80
	Control group	28	3.81	1.35	
Mental Effort	Experimental group	28	2.44	1.32	2.66*
	Control group	28	3.38	1.31	

*$p < .05$.

It is reasonable to find that the mental loads of the two groups are not significantly different since the learning materials in the two versions of the game are identical; in the meantime, the difference in mental effort reflects the effect of integrating the concept mapping strategy in the educational computer game on reducing the cognitive capacity allocated for completing the learning tasks by providing a visualized way of helping students organize their knowledge.

5.4. Analysis of perceived ease of use and usefulness

To better understand the students' perceptions of the use of the educational computer game, this study collected the students' feedback regarding "perceived usefulness" and "perceived ease of use," as shown in Table 7. It is found that most students gave positive feedback concerning the two dimensions of the educational computer game. The average ratings for "perceived usefulness" are 3.41 and 3.07 for the experimental group and the control group, respectively; moreover, their average ratings for "perceived ease of use" are 3.45 and 3.24. In comparison with the ratings given by the control group, it should be noted that the students in the experimental group gave significantly higher ratings for "perceived usefulness" ($t = 2.67$, $p < .5$), implying that those students who learned with the concept map-based educational game felt the benefits of the lead-in of concept mapping in improving their learning achievements.

6. Discussion and conclusions

In this paper, a concept map-embedded digital game is presented, along with the experimental results of the "butterfly ecology" unit of an elementary school natural science course. From the experimental results, it is found that embedding concept maps in gaming scenarios cannot only improve the students' learning achievement but can also decrease their cognitive load. The findings seem to conform to the effects of concept maps addressed by several researchers, such as Chiou (2008), Hwang, Shi, et al. (2011) and Jonassen, Carr, and Yueh (1998), who indicated the effectiveness of using concept maps in helping students link new learning experiences with their prior knowledge in an organized manner. However, such a result is in fact not obvious, in particular, for game-based learning. For example, the study of Charsky and Ressler (2011), who conducted a game-based learning activity and asked the participants to develop concept maps based on the gaming content, showed a completely different result. The students in Charsky and Ressler's (2011) study revealed apparently lower learning motivation and worse learning performance than that of those who learned with the conventional game-based learning approach, because they thought that the gaming process was interrupted; that is, developing the concept maps was an interference to the students instead of a learning support during the game playing process. Such negative experiences show that

Table 7
Questionnaire results about perceived ease of use and usefulness of using the concept map computer game.

	Group	*N*	Mean	S.D.	*t*
Perceived usefulness	Experimental group	28	3.41	0.50	2.28*
	Control group	28	3.07	0.62	
Perceived ease of use	Experimental group	28	3.45	0.41	1.63
	Control group	28	3.24	0.54	

*$p < .05$.

concept mapping is not always effective or can even cause negative impacts if researchers or instructors do not carefully consider when and how it can be applied to a learning process.

Therefore, the satisfactory performance of the proposed approach in this study could be due to the good integration of the concept maps in the gaming scenarios and missions. Such a concept map-embedded gaming approach made the students highly accepting of the appearance as well as the assistance of the concept maps during the gaming process. This finding provides a good reference for those who intend to develop educational computer games with learning support tools.

On the other hand, there are some limitations to the concept map-embedded gaming model. First, owing to the nature of concept mapping, the model is more suitable for instructing those courses with a set of highly related concepts or learning objectives, such as natural science courses or social science courses. Second, the teachers need to clearly address the relationships between the concepts or items to be learned in order to develop the concept map templates for guiding the students. Third, the development of such an educational computer game could be time consuming. To cope with these problems, we are planning to develop several different gaming models for courses with different features. For example, in most mathematics courses and some science courses, finding and comprehending the relationships between numeric variables are vital; therefore, it is important to develop a gaming model with a learning support tool for inferring numeric relationships such as spreadsheets. Moreover, we also plan to propose a meta-model for helping researchers and instructors select appropriate game development models to implement effective educational computer games.

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Appendix. Questionnaires.

Learning motivation

1. I think learning natural science is interesting and valuable.
2. I would like to learn more and observe more in the natural science course.
3. It is worth learning those things about natural science.
4. It is important for me to learn the natural science course well.
5. It is important to know the natural science knowledge related to our living environment.
6. I will actively search for more information and learn about natural science.
7. It is important for everyone to take the natural science course.

Cognitive load

Mental load

1. The learning content in this learning activity was difficult for me.
2. I had to put a lot of effort into answering the questions in this learning activity.
3. It was troublesome for me to answer the questions in this learning activity.
4. I felt frustrated answering the questions in this learning activity.
5. I did not have enough time to answer the questions in this learning activity.

Mental effort

1. During the learning activity, the way of instruction or learning content presentation caused me a lot of mental effort.
2. I need to put lots of effort into completing the learning tasks or achieving the learning objectives in this learning activity.
3. The instructional way in the learning activity was difficult to follow and understand.

Technology acceptance

Usefulness

1. The learning approach enriched the learning activity.
2. The learning system was helpful to me in acquiring new knowledge.
3. The learning mechanisms provided by the learning system smoothed the learning process.
4. The learning system helped me obtain useful information when needed.
5. The learning approach helped me learn better.
6. The learning approach is more useful than the conventional computer-assisted learning approaches.

Ease of use

1. It is not difficult for me to learn to operate the learning system.
2. It only took me a short time to fully know how to use the learning system.
3. The learning activity conducted in the learning system was easy to understand and follow.
4. I quickly learned to use the learning system.
5. It was not difficult for me to use the learning system during the learning activity.
6. I felt that the interface of the learning system was easy to use.
7. To sum up, the learning system adopted in this learning activity was easy to learn and use.

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