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Effects of a Progressive Prompting-based Educational Game on Second Graders' Mathematics Learning Performance and Behavioral Patterns

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ABSTRACT

Game-based learning (GBL) has been proven to be an attractive learning model by many studies; however, scholars have pointed out that the effectiveness of game-based learning could be limited if proper learning strategies are not incorporated. Prompting is a strategy that plays the important role of providing hints and guidance in interactive learning environments. Therefore, this study proposes a game-based learning approach with a progressive prompting strategy, using different levels of hints to guide students to complete tasks and achieve learning goals. Quasi-experimental research was employed in this study using two groups of students. The experimental group learned with the proposed approach, while the control group was allocated a conventional game-based learning strategy. The findings of the study show that the proposed approach significantly improved the second graders' mathematics learning achievement. From the analysis of the experimental students' learning behaviors, it was reported that the experimental group students could generate the answer after two progressive prompts. Thus, we could see that the proposed approach could enhance the learning achievement of the experimental group students by correctly guiding them to answer questions, step up their thinking, and understand the learning content in the learning process.

Keywords

Progressive prompting, Game-based learning, Learning behavior, Mathematics course

Introduction

With the advancements in information technology, the conventional teaching model has changed. In recent years, the combination of games and learning has gradually become a popular research topic of game-learning; many studies have indicated that game-based learning could enhance learners' interest and motivation in learning (Gee, 2003; Ebner & Holzinger, 2007; Dickey, 2011; Moreno, 2012). Based on the game fantasy, curiosity, and sense of control for learners, their learning motivation could be stimulated, and thus their learning performance could be enhanced (van Eck, 2006). Game-based learning has been recognized as a potential learning model; however, previous studies have indicated that it may not be beneficial for learners without appropriate learning strategies in the process (Charsky & Ressler, 2011; Hwang, Sung, Hung, Huang, & Tsai, 2012; Wouters & van Oostendorp, 2013). The research findings of Mitchell and Savill-Smith in 2004, for instance, indicated that the learners' attention to learning may be distracted if the purposes of the game and the learning are not identical in the game-based learning context. Thus, it has become very important to provide immediate guidance and hints to learners when game-based learning is conducted.

A well-designed game-based learning context could stimulate learners to challenge themselves by performing game tasks and solving learning problems repeatedly through immediate prompts before gaining subject knowledge. Moreover, learners may learn relevant knowledge and concepts that they were previously unfamiliar with in the problem-solving process (Kirriemuir, 2002). The progressive prompting strategy could help learners to solve problems based on various levels of hints. On the contrary, if learners could lose their learning motivation without the help of instant hints or guidance, it would eventually affect their learning achievement (Gibbs & Habeshaw, 1989). Miller and Mercer (1993) proposed a concrete-semiconcrete-abstract (CSA) approach as a progressive prompting strategy for nine students with mathematics disabilities. Their research findings showed that the CSA is not only beneficial for students in terms of learning mathematics, but also helps with the learning retention.

Recently, many researchers have tried to design and implement feedback or guiding mechanisms, and most of the mechanisms have been confirmed as being effective in educational settings. For example, Chu et al. (2010) adopted a two-tier test to diagnose misconceptions, and provided adaptive feedback according to the diagnostic results to replace the misconceptions. Wang (2014) developed a graduated prompting online test system for providing the assessment feedback with three-step text prompts to assist learners' learning. Chen, Hwang, and Tsai (2014) proposed a progressive prompt-based context-aware learning approach and effectively improved the students' learning performance. They also found that the proposed approach encouraged the students to put more effort into examining the contextual information and interpreting the learning content. Therefore, it is important to provide adequate prompts to assist students' learning in the personal learning process.

Among various applications of technology-enhanced learning, Mathematics is an important subject due to its high correlation with our daily life. Imaging math situations will help learners concretize the content, and then they should be able to learn math more easily. However, as far as we know, there are few studies on feedback content presented in an image-based format. Accordingly, in this study, we developed an educational game with a progressive prompting mechanism, by providing two prompts which progressively moved from abstract (text description) to concrete (image description) for learners to construct the correct concepts, comfortably learn in the game-based learning environment, and finally consolidate their mathematical knowledge foundation.
To evaluate its effectiveness, the following research questions were investigated to evaluate the performance of the proposed approach from various aspects:

- Did the students who used the game-based learning approach with the progressive prompting strategy show better learning achievements than those who used the conventional game-based learning approach?
- Are there differences between the learning achievements of students with different levels of mathematics self-efficacy in the experimental group?
- Are there differences between the flow experiences of the students who learned with the different learning modes (the game-based learning approach with the progressive prompting strategy and the conventional game-based learning approach)?
- Did the students who learned with the game-based learning approach with and without the progressive prompting mechanism show different learning behaviors?

Literature review

Game-based learning

Game-based learning (GBL) refers to a computer game environment in which learning and interactive entertainment are combined to create students' learning fun and learning achievement based on learning theories (Prensky, 2007). In recent years, many studies have focused on GBL because games could make students become immersed in the game situations characterized by challenge and fun, thus improving the students' motivation and helping them acquire subject knowledge. For example, Hwang, Chiu, and Chen (2015) designed a game-based learning context with "Saving Island" and "Investment Island" to help sixth graders learn financial concepts in a social studies course. Chu, Yang, and Chen (2015) developed an educational computer game for the unit of "Siege of Fort Zeelandia by Zheng Cheng-Gong" in an elementary school history course. They found that the approach improved the students' learning achievement. Wang and Chen (2010) indicated that challengeable game tasks would bring high flow experience and high interest for learners participating in the games so that their learning achievement could be enhanced. Chang, Wu, Weng and Sung (2012) also reported that GBL could promote learners' high learning motivation, more flow experience, and better learning outcomes in comparison with conventional approaches. Barzilai and Blau (2014) indicated that learning and enjoyment would lead learners to complete tasks successfully; moreover, both learning and gaming experience show high interaction and correlation in GBL.

To sum up, learners can gain enjoyment, self-confidence, and satisfaction from educational games if they are given challenging tasks that are equal to their skills and knowledge in GBL. Learning attitude and learning achievement can be improved when learners' flow experience occurs in GBL. However, several studies have reported that although students' learning motivation could be raised in GBL, no significant improvement was found in their learning achievement without incorporating proper learning strategies into the gaming process (Hwang & Chang, 2016; Charsky & Ressler, 2011). Thus, many studies have emphasized that it is important to embed teaching strategies or learning theories into GBL (Charsky & Ressler; Hwang, Yang, & Wang, 2013; Hsiao, Chang, Lin, & Hu, 2014). Hwang and Wang (2016) investigated students' performance of learning English vocabulary with different guiding strategies in a game to serve as guidance for learners. The experimental results showed that the students using the game with the cloze guiding strategy had significantly better learning achievement than those learning with the multiple-choice guiding strategy. Thus, the current study proposes a game-based learning approach with different types of progressive prompting strategies. We hope the proposed approach could help learners complete game tasks in GBL.

Progressive prompting strategy

Progressive prompting is assistance progressively provided to a learner by teachers in order to increase the probability of correct responses. Teachers guiding students with scaffolding to solve problems and tasks is the most important principle of prompting. That is, prompting aims to allow learners to think how to solve problems and to challenge themselves to exceed their current ability. Wang, Huang, and Hwang (2016) indicated that if students cannot understand their own learning weaknesses and blindness, it is difficult for them to improve their learning situation. The role of the teacher is to guide students to solve learning tasks when they lack the necessary knowledge. As long as the learning tasks are completed, their performance could be improved (Mayer, 2004). With the advancements in information technology, learners are able to be given appropriate prompts by learning systems as soon as they encounter problems in learning activities. Therefore, subject course designers or teachers have to consider when and how to provide immediate and appropriate hints to help students think about and improve their problem-solving ability in the learning process (Chen & Choi, 2010). Chu and Chang (2014) developed an educational computer game system with a two-tier test mechanism to guide fifth graders to learn the bird identification unit of a natural science course. The experimental results showed that the proposed approach not only significantly promoted the students' learning motivation, but that they were also able to correctly identify the learned knowledge of birds. In the researchers' opinion, the advantage of the two-tier test is that it helps the learners revise their misconceptions or alternative conceptions. On the other hand, the progressive prompting strategy's advantage is that is strengthens internalization of the concepts.

Many studies related to prompting strategies have been performed. For example, Gerber, Semmel, and Semmel (1994) developed a computer-based dynamic assessment of multi-digit multiplication with progressive prompting functions for secondary students. They found that most of the test takers who were able to solve the mathematics questions successfully needed more prompts as the difficulty of the test items increased. Chen, Hwang, and Tsai (2014) developed a progressive prompt-based context-aware learning approach with three-stage prompts. Their results showed that the proposed approach could effectively enhance the learning achievement of the students in comparison with the conventional context-aware learning system with single-stage prompts. Their study also indicated that more challenging tasks encouraged the students to put more effort into examining the contextual information and interpreting the learning content.

Therefore, in the teaching sequence of the progressive prompting strategy, each prompt will offer more information to learners than the previous one. That is, at the beginning, learners are given more abstract or simpler prompts to solve the questions. If they cannot solve the question, increasingly concrete prompts will be offered. In the meantime, the number of prompts depends on the ability of the student. The final prompt will be inclined to be a more detailed explanation of the question. Thus, it is important to offer proper prompts at the prime time to learners based on the learning activity.

The game-based learning approach with the progressive prompting strategy

In this study, we developed a computer game-based learning approach with a progressive prompting strategy in which students were given corresponding prompts progressively to help them figure out mathematics questions. At the beginning, the students were given more abstract or simpler prompts to solve the questions. If they could not solve the question, increasingly concrete prompts were offered. The final prompt was a detailed explanation of the question.

The mathematical game-based learning system adopted by the experimental group and control group was designed with the same learning content, using the digital game software, RPG Maker. The control group used the conventional math game, while the experimental group learned with the conventional math game and the extra two-tier progressive prompts. The learning content of the mathematical game-based learning system is divided into four maps, in the order of a forest, village, maze, and room. A total of 30 questions were answered by the learners involving two-step addition, two-step subtraction, and two-step addition and subtraction.

The mathematical game is named "Kingdom of Addition and Subtraction." The protagonist is a warrior. In this kingdom, the king and queen gave birth to a beautiful and clever princess. Then one day, a terrible witch appeared and put the kingdom under a horrible curse. The curse put the people of the whole kingdom to sleep, with only the princess left awake. A fairy told the warrior of a rescue plan to save the kingdom. With the plot, the map, and the NPC (non-player character), the warrior must learn the concept of two-step addition and subtraction and answer the questions step by step. To complete the assigned task based on different levels, the warrior must answer and get the antidote as well as bring enough money before they can be handed over to the princess. If the task is completed successfully, then the kingdom will be totally saved.

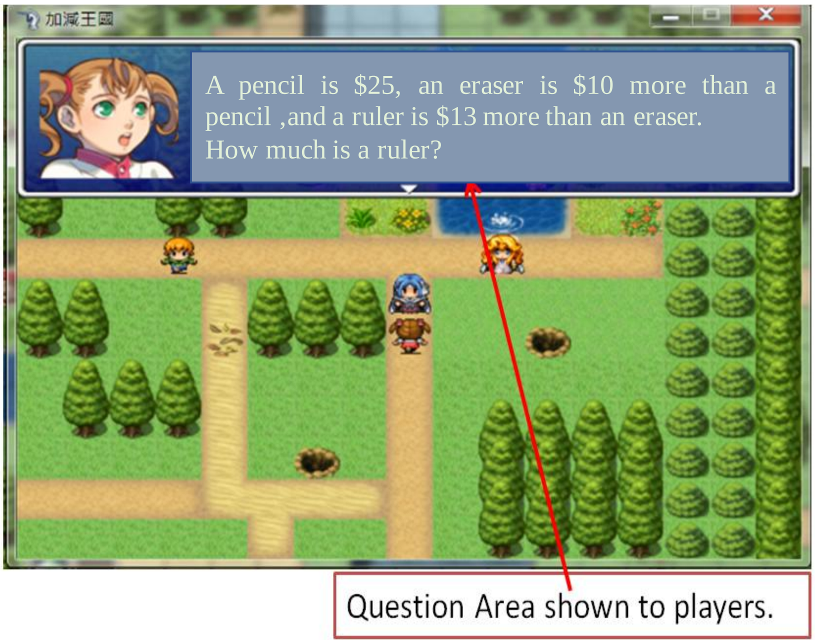

Figure 1. Screenshot of two-step addition in the experimental group with progressive prompting

Figure 2. Screenshot of first-tier text description prompt

In addition, an immediate feedback mechanism was set up in our system, so that when the learner chooses the wrong answer, the system will provide a prompt with the correct concept for relearning. In the experimental group, the progressive prompting mechanism was implemented. Figure 1 shows a math question delivered to the students on the screen: "A pencil costs 25 NT dollars, and correction fluid is more expensive than the pencil. A stapler is more expensive than the correction fluid by 13 NT dollars; please tell us how much the stapler cost." If the students responded with the wrong answer, the learning system would give prompts with text description in the first-tier progressive prompting, as shown in Figure 2, then would give the learner the chance to answer the same question again. If the learner responded with the wrong answer again, the system would prompt with an image description in the second-tier progressive prompting, as shown in Figure 3. The learner is then given more chances to answer the same question until he/she has responded with the correct answer. Only in that case can the student learn the next concept. The framework of the progressive prompting educational game is shown in Figure 4. On the other hand, the feedback mechanism in the control group is the same as the first-tier prompting mechanism in the experimental group. Moreover, both groups were given exactly the same learning material, content, and assessments.

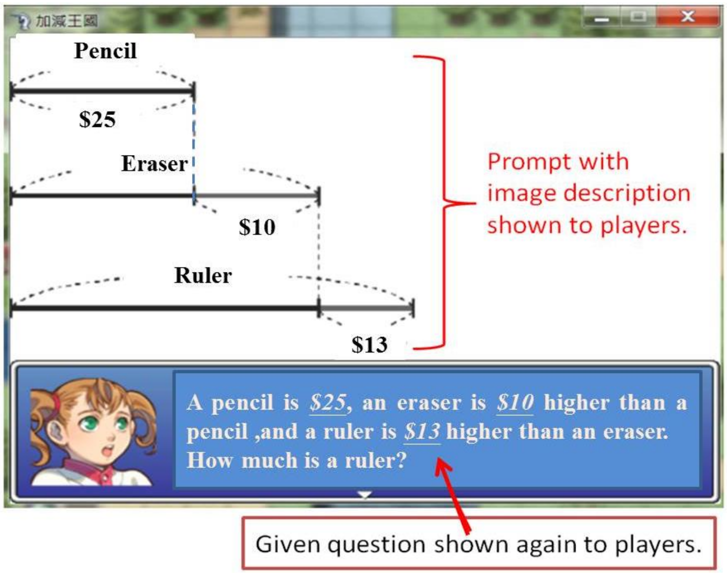

Figure 3. Screenshot of second-tier image description prompt

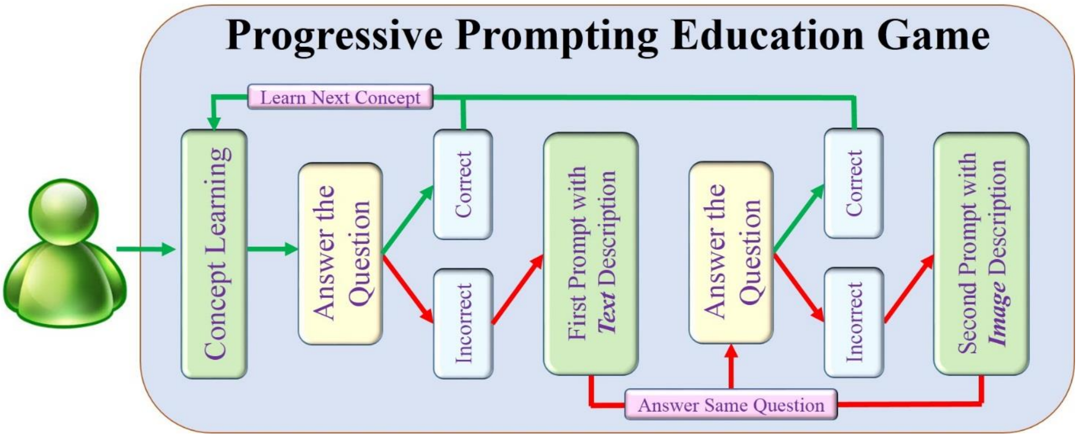

Figure 4. Framework of the progressive prompting educational game

Experiment design

To investigate the effect of game-based learning with the progressive prompting strategy, the second graders were invited to participate in the experiment. Their learning achievement, self-efficacy, and flow experience were examined.

Participants

There was a total of 58 second graders from two classes of an elementary school in northern Taiwan. Thirty students in the experimental group learned with the conventional math game with the extra two-tier progressive prompt, while 28 students in the control group learned with the conventional math game only. The two groups were taught by the same instructor for the experiment.

Experimental process

The purpose of this study was to guide the students to learn and enhance their learning outcomes by combining the characteristics of game-based learning and the progressive prompting strategy. The second graders participated in the experiment of the “Two-step Addition and Subtraction unit” of the mathematics course in elementary school, as shown in Figure 5. Before conducting the experiment, students from both groups first spent 30 minutes filling in the questionnaires, including mathematics self-efficacy and math learning achievement as the pre-test scores. Then, the students were taught the two-stage concept in addition and subtraction for three classes (120 minutes). After the instruction, the experimental group engaged in game-based math learning with the progressive prompting strategy, while the control group learned with the conventional game-based math learning for 90 minutes. After the end of the learning activities, the two groups spent 30 minutes filling in questionnaires, including mathematics self-efficacy, flow experience, and mathematics learning achievement as the post-test scores to investigate whether the proposed approach affected the students’ learning achievement, self-efficacy, and flow experience.

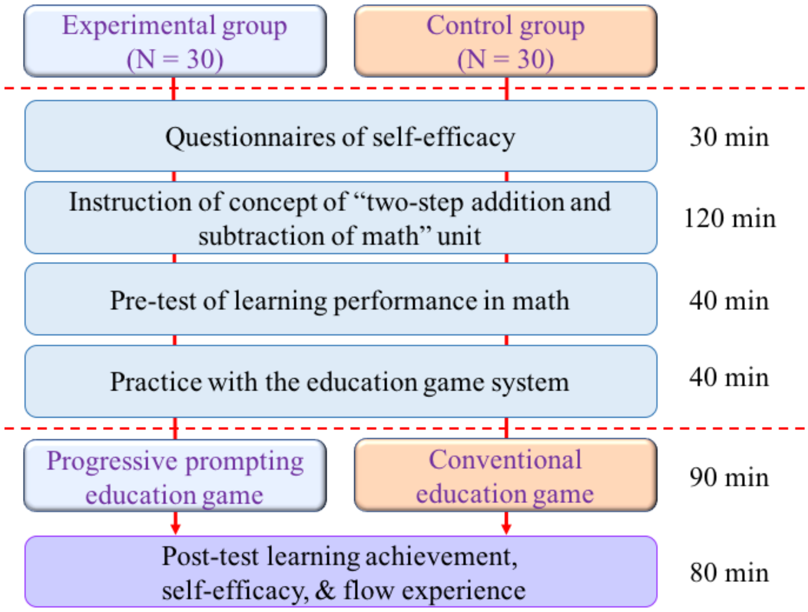

Figure 5. Experimental design of the study

Measuring tools

The measuring tools employed in the study include questionnaires of flow experience, mathematics self-efficacy, and the pre-test and post-test of two-step addition and subtraction. Finally, the learners’ learning behavior patterns were recorded in the system.

The pre-test aimed to evaluate whether the two groups of students had an equivalent prior knowledge for learning the mathematics course. It consisted of three parts: four “simple addition” items (20 points), four “addition first and then subtraction” items (40 points), and five “subtraction” items (40 points) for evaluating the students’ prior knowledge. The post-test included four types of operation methods, two additions (20 points), addition first and then subtraction (30 points), subtraction first and then addition (30 points), and two subtractions (20 points). Moreover, in order to avoid resistance to the text reading comprehension by the second graders, the researchers designed multi-topic types including multiple choice questions, fill-in-the-blank questions, right and wrong, as well as column formulas. After the test questions were done, the mentor and two senior teachers with over 15 years of teaching experience were invited to review the learning achievement test. Therefore, the two-step addition and subtraction test had expert validity.

The self-efficacy scale is used to evaluate the level of self-efficacy when an individual performs a task. The scale was adapted on the basis of the Motivated Strategies Learning Questionnaire (MSLQ) developed by Pintrich et al. (1991). In line with the needs of the study, only the self-efficacy with seven questions from the Motivation questionnaire was involved and measured with a 5-point Likert scale. The reliability of the scale was tested by internal consistency with a Cronbach’s alpha of .87.

The flow experience scale mainly evaluates the state of learners who are fully engaged in the game-based learning, including both dimensions of pre-flow experience and flow experience, where the pre-flow experience dimension means the learners’ opinion based on the game-play experience, and the flow experience dimension means the learners' feeling during game-play. The study adopted the flow experience questionnaire from Wang and Chen (2010), including 22 items for pre-flow experience, and 12 for flow experience. A 5-point Likert scale was adopted in the study, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The reliability of the scale was tested by internal consistency with pre-flow experience (Cronbach's $\alpha = .92$), flow experience (Cronbach's $\alpha = .87$), and the whole scale (Cronbach's $\alpha = .94$). The internal consistency coefficient is acceptable.

Coding scheme for lag-sequential analysis

One aim of the study was to investigate and trace the students' learning behaviors in the game-based learning process through a code book related to learning behaviors, as seen in Table 1. This code book collected some codes in relation to two main classifications, namely irrelevant to the learning tasks and relevant to the learning tasks. This will help researchers understand the continuous relationship among the different behaviors and to look into the correlation among specific behaviors. All of the learning behaviors were automatically recorded and encoded in the database of the game-based learning system, and finally analyzed by lag-sequential analysis. In this study, the coding scheme for lag-sequential analysis was designed by three elementary school teachers who have rich teaching experience, and was examined by two professors of information education. Therefore, our coding scheme had expert validity.

Table 1. Coding scheme designed for learning behaviors of students in the experimental group

	Code	Behavior	Definition
Irrelevant to learning tasks	E	Exploration	Dialogue with NPC or search for objects
	F	Fighting	Just fighting
	V	Victory	Win the fight
	W	Withdraw	Retreat from the fight
	L	Losing	Lost the fight
	T	Transition	Move to another scene
Relevant to learning tasks	A	Answering	Answer questions from NPC
	H1	1st step	Get point from text description
	H2	2nd step	Get point from image description
	O	Task completed	Correct answer to question asked
	X	Task failed	Wrong answer to question asked

Experimental results

This study investigated the effect of the proposed approach, game-based learning with a progressive prompting strategy, on the second graders' learning achievement and self-efficacy, using one-way ANCOVA. If the test result reached a significant level ($p < .05$), then it represents a significant change. Finally, the Independent sample *t* test was used to explore whether the two groups of students had a change in the status of their flow experience. As for the students' learning behaviors of the two groups, GSEQ can be used to present learners' behavior patterns in the learning process.

Learning achievement

The Independent sample *t* test was employed to analyze the students' learning achievement for the two groups before the experiment. The statistical result showed no significant difference ($t = 0.143$, $p = .887 > .05$) between the two groups for mathematics in the pre-test. Furthermore, one-way ANCOVA was used to analyze the effect on the students' learning achievement for the experimental group and the control group after the experiment. The result showed that there was a significant difference ($F = 10.392$, $p = .002 < .01$) between the two groups, implying that students who learned with the game-based learning with progressive prompting strategy had superior learning performance compared with those who learned with the conventional game-based learning model without the progressive prompting strategy.

Table 2. One-way ANCOVA results of the post-test scores for the experimental and control groups

	N	Mean	*SD*	Adjusted mean	*F*
Progressive prompting game-based learning	30	87.70	12.74	87.44	10.39^{**}
Conventional game-based learning	28	79.10	15.18	79.40	28

Note. $^{**}p < .01$.

Effect on the learning achievement for high and low self-efficacy students in the experimental group

To investigate whether there was any difference for students with high and low self-efficacy in the experimental group in terms of learning achievement, according to the score of the self-efficacy pre-test, the first 50% of students in the experimental group based on the math self-efficacy survey was classified as the high mathematics self-efficacy group (HMS), while the rest were classified as the low mathematics self-efficacy group (LMS). The Independent sample *t* test was employed to analyze the students' learning achievement for the HMS and LMS of the experimental group before the experiment. The statistical result showed that there was significant difference (t = 2.09, p = .04 > .05) between the HMS and LMS before the learning activity. However, there was no significant difference (t = 0.96, p = .45 > .05) between the HMS and LMS after the two-step addition and subtraction unit, implying that the proposed approach could gradually scaffold LMS students in math learning process so that shorten the difference between HMS and LMS students in mathematical learning achievement, as shown in Table 3.

Table 3. Independent sample *t* test of learning performance for students with high and low mathematics self-efficacy in the experimental group.

Items	Group	*N*	Mean	*SD*	*t*	*p*
Pre-test	HMS	16	88.56	9.18	2.09*	.04
	LMS	14	75.63	11.03		
Post-test	HMS	16	88.98	17.02	0.96	.45
	LMS	14	86.24	11.74		

Note. $^{*}p$ < .05. High math self-efficacy group (HMS), Low math self-efficacy group (LMS).

Results of flow experience

To investigate the effect of the proposed approach on the students' flow experience for the two groups, the students in the experimental group and control group filled in the questionnaire of Flow experience after the learning activity. As shown in Table 4, there were no significant differences in either dimension of pre-flow experience or flow experience for the two groups through analysis of the Independent *t* test (p > .05). This result implies that the students of the experimental group and the control group had the same flow experience whether or not they were using the progressive prompting strategy. That is, the students in the experimental group did not change their flow experience when the progressive prompting strategy was added to the math game-based learning activity.

Table 4. Statistical results of the Independent *t* test of flow experience for the two groups

Items	Experimental group (*n* = 30)		Control group (*n* = 28)		*t*	*p*
	Mean	*SD*	Mean	*SD*		
Pre-flow experience	4.26	0.60	4.16	0.52	0.63	.53
Flow experience	4.13	0.64	4.06	0.55	0.37	.71

Analysis of students' learning behaviors

To further investigate the effect of the proposed approach on the students' learning achievement, lag-sequential analysis was employed to explore the students' learning behaviors for the experimental group and the control group. The lag-sequential analysis method aims to find the significant learning patterns of the coded behaviors. To ensure the quality of the coding process, the consistency of the two researchers' coding was examined. It was found that the inter-rater Kappa reliability of the two researchers' coding was .82 for the experimental group and .80 for the conventional game-based learning group, demonstrating high reliability. After performing the lag-sequential analysis, a Z-score was obtained to represent significance between each pair of the coded behaviors (Chiang, Yang, & Hwang, 2014; Hou et al., 2009). If the Z-score was greater than 1.96, it was concluded that the two behaviors had a significant sequential relationship in the learning context (Bakeman & Gottman, 1997).

Tables 5 and 6 show the Z-score values of the learning behaviors of the experimental group and control group. The behavioral codes listed in the left-most column were the starting behaviors, while those listed in the top-most row were the resulting behaviors. The value in each entry of the tables was the Z-score. The significant relationship was marked with a "*" if the Z-score was greater than 1.96. For example, the sequential relationship

"H2(stage 2 progressive prompting)"→"O(Answer correct)" was significant since the corresponding Z-score was 2.87.

Table 5. Z-scores for the behaviors of the students who learned with the progressive prompting game-based learning

Given code	A	H1	H2	O	X	E	F	V	W	L	T
A	-22.73	32.03*	-10.79	32.45*	-4.47	-11.73	-9.28	-2.11	-1.49	-8.93	-9.74
H1	-11.77	-6.23	44.03*	2.09	-2.34	-6.14	-4.94	-1.11	-0.78	-4.68	-5.18
H2	-10.79	-5.65	-5.12	21.76*	25.35*	-5.57	-4.48	-1.00	-0.71	-4.24	-4.69
O	35.84*	-11.89	-10.63	-22.67	-4.46	-3.36	4.83*	-2.11	-1.49	-8.92	11.95*
X	-4.47	-2.34	25.35*	-4.46	-0.88	-2.31	-1.85	-0.42	-0.29	-1.76	-1.94
E	18.72	-6.14	-5.57	-11.71	-2.31	-0.87	-4.15	-1.09	-0.77	-4.61	11.26*
F	-9.43	-4.94	-4.48	-9.42	-1.85	-4.39	-3.91	13.72*	9.69	57.93*	-3.55
V	-0.16	-1.11	-1.00	-2.11	-0.42	-1.09	10.07*	-0.20	-0.14	-0.83	-0.92
W	1.26	-0.78	-0.71	-1.49	-0.29	-0.77	2.82	-0.14	-0.10	-0.59	1.00
L	0.98	-4.68	-4.24	-8.92	-1.76	-4.61	32.12*	-0.83	-0.59	-3.51	3.10*
T	-9.59	-5.18	-4.69	-9.88	-1.94	51.13*	-4.10	-0.92	-0.65	-3.89	-4.30

Note. *Z > 1.96.

Table 6. Z-scores for the behaviors of the students who learned with the conventional game-based learning

Given code	A	O	X	E	F	V	W	L	T
A	-27.84	29.88*	27.55*	-9.04	-9.66	-3.11	-1.90	-9.19	-8.14
O	15.89*	-11.55	-10.65	0.56	2.82*	-2.00	-1.22	-5.02	7.28*
X	26.73*	-10.67	-9.83	-5.25	-5.29	-1.85	-1.13	-5.46	-3.79
E	9.08*	-5.95	-5.48	-2.69	-1.06	-1.03	-0.63	-3.05	8.51*
F	-9.66	-6.23	-5.74	-3.20	-3.36	14.92*	9.12*	40.85*	-2.83
V	-1.04	-2.01	-1.85	-1.03	5.92*	-0.35	-0.21	1.11	1.42
W	-1.06	-1.23	-1.13	-0.63	4.23*	-0.21	-0.13	1.07	1.34
L	-4.55	-5.92	-5.46	-3.05	27.25*	-1.03	-0.63	-2.66	6.06
T	-7.15	-5.28	-4.86	39.03*	-2.84	-0.91	-0.56	-2.70	-2.39

Note. *Z > 1.96.

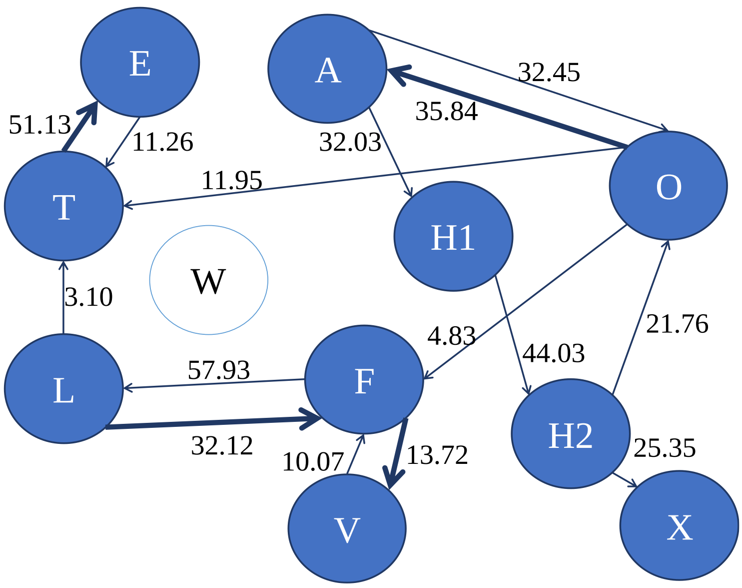

Figure 6. Students' behavioral sequences for the experimental group

A total of 3,743 learning patterns were recorded for the experimental group (*N* = 30), while 2,148 for the control group (*N* = 28) were collected. Figure 6 shows the behavioral sequence for the students in the experimental group, A→H1(Answering→1st step), H1→H2 (1st step→2^{nd} step), H2→O (2^{nd} step→ Task completed), H2→X (2^{nd} step→ Task failed), sequentially, indicating that it is significant to provide prompts to the students in the experimental group, but the students could give right answers or wrong answers after the second prompt was provided. Figure 7 shows the behavioral sequence for the students in the control group, A→X (Answering→Task failed), X→A (Task failed→Answering), sequentially, indicating that even if the answer was wrong, the students would try to continually answer. As we can see from Figure 6 and Figure 7, the students from the two groups could go all out to complete the learning tasks. It is particularly noteworthy that the students in the experimental group who presented a significant behavioral pattern from prompting to the answering process through the progressive prompts were able to complete the questions and gain better learning achievement.

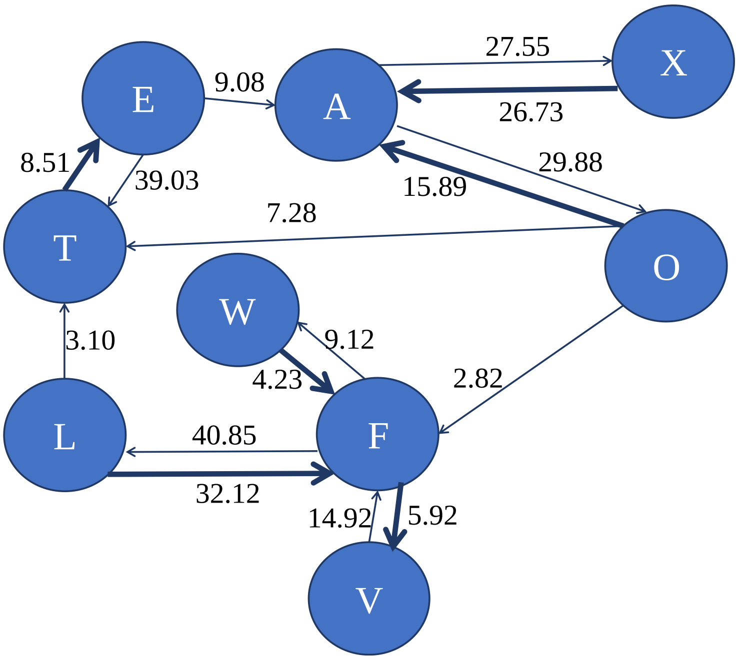

Figure 7. Students' behavioral sequences for the control group

Discussion and conclusions

This study investigated the effects of a game-based learning approach with a progressive prompting strategy on second graders' mathematics learning achievements related to "*two-step addition and subtraction,*" as well as mathematics self-efficacy and flow experience. A computer educational game has been developed accordingly. An experiment has been conducted on an elementary school mathematics course to evaluate the performance of the proposed approach. In addition, students' learning patterns were analyzed via using the GSEQ method to further understand their learning process. The research findings show that the proposed approach could enhance students' learning achievement more than the conventional game-based learning approach, showing that students can acquire the concept from the first prompt with text description; if they cannot understand the abstract text, they will receive the feedback with more concrete content from the second prompt with image description. After this stage, the learners are able to construct the integrated mathematical image. In other words, the progressive prompting mechanism brings a massive benefit for concept learning. Moreover, the proposed approach would not affect the students' flow experience in game playing. That is, a game-based learning approach with a progressive prompting strategy with learning activities has been shown to be beneficial to students' mathematics improvement. From these findings, the research questions are answered as follows:

- The students who used the game-based learning approach with the progressive prompting strategy showed significantly better learning achievements than those who used the conventional game-based learning approach.
- In the beginning, the learning achievements of the high mathematics self-efficacy group (HMS) were significantly better than those of the low mathematics self-efficacy group (LMS) in the experimental group. After the learning activity, there was no significant difference between the HMS and LMS groups. It can be inferenced that the proposed approach can effectively reduce the difference in the mathematical learning achievement of HMS and LMS students.
- The students who learned the game-based learning approach with the progressive prompting strategy and the conventional game-based learning approach showed equivalent flow experiences.
- According to the analytic results of the students' learning behaviors, those who learned with the proposed approach can figure out the questions successfully after they receiving the progressive prompts. On the other hand, those who learned with the conventional game-based learning approach revealed some difficulties in the learning process.

In recent years, analysis of learning behaviors has attracted the attention of researchers in the study of game-based learning (Hou, 2015; Hwang, Hsu, Lai & Hsueh, 2017). Behavioral analysis helps learners analyze their learning behaviors in the learning process and investigate the attribution of research results. The research findings show that the students in the experimental group presented a significant behavioral pattern from prompting to the answering process through the progressive prompts which could help guide them to complete the questions, improve their critical thinking, and finally gain better learning achievement. On the other hand, those in the control group needed to go through a trial and error process, whereby the students kept trying to answer the questions and failing. Once they correctly answered the question, they might not really understand the correct steps to solve questions.

As for their mathematics self-efficacy, the proposed approach could effectively reduce the difference in the mathematical learning achievement of the high mathematics self-efficacy group (HMS) and low mathematics self-efficacy group (LMS) students of the experimental group; that is, the proposed approach could help LMS students understand the learning content, and improve their learning achievement. This might be the reason why the LMS students could solve the questions based on correct prompts. As suggested by Vygotsky (1978), it is important to provide prompt supports to students when they face difficulties in the learning process. We inferred that it is more difficult for the LMS learners to imagine the situation during mathematics problem solving, so it causes lower self-efficacy; however, with the progressive prompting mechanism, it coulld assist students to imagine the concept, thus reducing the difference with the HMS learners. Although the proposed approach has been shown to enhance students' learning achievement, there are still some limitations to this study. First of all, only a 90-minute learning activity was designed in the experiment. If the learning design included more experimental learning activities, the researchers could further explore the relationship between meta-cognition and learning achievement in GBL.

The research findings also show that there was no significant difference between the experimental group and control group in terms of flow experience. Previous studies have indicated that the GBL approach could improve learners' flow experience (Chang et al., 2012; Hwang et al., 2015). In this study, two groups were given GBL to learn mathematics, so it is reasonable that there was no difference between the two groups, implying that the students were happy to get involved in the activity. It also indicates that the progressive prompting strategy designed for the experimental group is appropriate and will not affect students' learning. Hwang, Chu, Yin, and Ogata (2015) emphasized that an enjoyable and challenging game accompanied with appropriate learning strategies could help learners achieve effective learning achievement and learning goals. Therefore, the study incorporated the progressive prompting strategy into the second graders' mathematics game-based learning context.

In summary, this study validates four points. First, the educational game with the progressive prompting mechanism which provides learner multi-tier feedback from abstract to concrete hints could assist the learning of concepts, and increase learning achievement; second, with the concrete image description prompt, the proposed method could effectively assist low self-efficacy learners to construct the concrete image of mathematics, then decrease the difference with high self-efficacy students; third, based on the result of flow experience, we could say that combining the progressive prompting mechanism into game-based learning may not influence learners' feeling during game-playing; finally, the results of learning behavior analysis shows that the proposed method could help learners not only respond questions, but also to learn the math concepts, and gradually consolidate a stable foundation of mathematics.

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