Studying an Adaptive Evaluation Game using Ebbinghaus' Forgetting Theory and Leitner's Flashcard Mnemonic

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Abstract. It is important to memorize vocabulary in order to learn a language. Recently, learning games for smart appliances are emerging. If there is a learning game where the learner can actively engage in learning on mobile platform like smart appliances, an efficient learning can be achieved. This study seeks to create a game memorizing English vocabulary on a mobile platform. For efficient memorization, we examine how to apply Ebbinghaus' forgetting theory and Leitner's flashcard mnemonic to the learning game. In addition, we propose an adaptive evaluation game based on Bloom's mastery learning. We constructlearning models on smart appliances to conduct vocabulary memorization.

Keywords: Learning game**,** Learning model,smart appliances, Mastery learning,Forgetting theory, Flashcard mnemonic

1   Introduction

Functional games are emerging one by one. Functional games, which have various purposes, show highly educational effect, since it escapes from tedious textbook learning and uses a new method of learning that attempts to combine with edutainment. In addition, as the smart devices havebecome popular recently, the usage rate of apps on smart devices has increased as well. As a result, using these advantages of applications, we seek to combine adaptive edutainment and mastery learning.

Here, edutainment is the term that combined education and entertainment. Mastery learning based on Bloom's theory, breaks down learning units from simple ones to more complex ones, and then makes individual students to learn the given materials in order. After completion of each learning unit, there is a test that assesses the magnitude of learning, and if the learner does not pass the test, he or she continues to repeat the learning until a certain amount of material is mastered.

Although many learning tools using edutainment are being utilized, the fact that mastery learning is not being done is problematic. We will inject gaming factors into education in order to provide mastery learning. This study uses Ebbinghaus' forgetting theory and Sebastian Leitner's flashcard mnemonicto create an effective model for

vocabulary memorization in order to enable an efficient memorization learning based on the theory.

2   Literature review

Bloom posited that mastery learning will be achieved by controlling the time needed for learning and the variables that determine the time used in learning. Mastery learning means that 95% of students, excluding approximately 5% of students who have flaws in intellectual and technical aspects, will perfectly learn 90% of the given material.

Based on Bloom's theory, it divides learning units from simple ones to complex ones, then makes each student to learn the given material in order. When a learning unit is completed, students take evaluation, a test, to evaluate how much they learned. When they do not pass the test, they have to repeat the learning until they pass.

The forgetting theory of the German psychologist Ebbinghaus [1] is a theory which, based on the fact that human memory is inversely proportional to time, emphasizes on appropriate repetition (4-time period) at appropriate point, according to the period of the forgetting curve in order to preserve the decreasing memories permanently as long-term memories.

Rate of forgetting (%) = (Time initially taken for learning - time taken for review) $\div$ Time initial taken for learning x 100.

According to Ebbinghaus, forgetting begins 10 minutes after the learning, and people forget 50% in one hour, 70% in one day, and 80% after one month.The most effective method to remember something from this forgetting is review. Ebbinhaus finds out that period is extremely important for reviews. Based on the finding that reviewing ten minutes after learning yields one day of remembering the material, review after one day yields one week of remembering, review after a week yields one month of remembering, and review after a month yields over six months (long-term memory) of remembering, it takes review after ten minutes, after one day, after a week, and after a month in order to permanently retain the materials learnt.

There is a learning flashcard that was introduced in "So lernt man lernen" by Sebastian Leitner [2]. The learner writes the definition and the word of the learned vocabulary on the front and back of the flashcard. After that, the learner divides a long box into five spaces (the bigger the number, the bigger the space) and numbers the space with 1, 2, 3, 4, 5. Then take a look at the word on the card and when the learner can remember its definition, he puts it on number two, and if he or she cannot, heputs it on number one. When he reviews the cards in space 2, if he cannot remember the word, he moves it to space 1 and if he can remember it, he moves it to space 3. Likewise, words that are not memorized are continued to be repeated in space 1, and as the word moves to spaces 1, 2, 3, 4, 5, it is repeated at least four times during the learning.

The first advantage of this learning method is that it can reduce unneeded repetition. The second is that the word that cannot be remembered right away can be repeated until the learner can remember the word.

As some of its related studies, Jeong, Yeong-Hee analyzes and predicts learning achievement based on previous and current phased performance evaluation score in order to evaluate individual level, and pre-selects those who need additional learning [3]. Selected students are provided with optimal additional learning resources based on their levels. Additional learning resources on individual learning is conducted to students with decreased performance in order to induce re-learning, reducing the time of attainment of mastery learning to predetermined time period. Positive feedbacks are given to students with increasing performance in order to expect more development. In addition, Cho, Byung-Houses object-oriented analysis/design method UML to develop a functional game called "Playing hard and answering English vocabulary" and presented effective analysis and design method of functional game by using design method using storyboard [4]. Finally, Kim, Ji-Yeonutilizes advantages of efficient e-learning and presented an evaluative learning system for mastery learning that is conducted through mutual interaction between learners who are provided with questions according to their performance as well as feedbacks and the system [5].

3　Learning model

Fig. 1 shows that the learning should be repeated until the learning achievement degree is reached to the threshold value, based on the mastery learning theory.
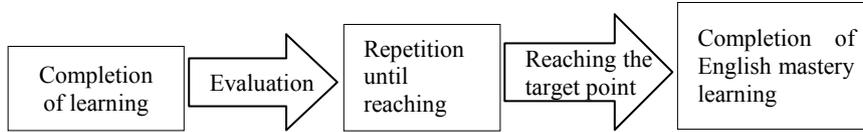

Fig. 1. Learning model applying the mastery learning

Table 1. Threshold of English word learning game

English vocabulary game learning	
Number of words	Approximtately 50
Criterion for passing the game	Over 90% are correct
Pass	Next unit can be learned
In case of failure	Re-game using incorrect words
re-game	(Incorrect words + Correct words x 0.3)

According to the theory of mastery learning, the passing criterion of the game was set as over 90%, as shown in Table 1.

3.1 Forgetting theory-based learning model

English vocabulary game learning is done with four repetitions with the application of Ebbinhaus' forgetting theory.Based on the finding that review after ten minute yields one day of remembering, after one day one week of remembering, after a week a month of remembering, after a month six months (long-term memory) of remembering, it takes 10 mintues, a day, a week, and a month of review after learning in order to make a memory permanent. Based on this Ebbinhaus' forgetting theory, we made review of English word game learning possible up to four-level review.Fig. 2 shows that there is 4 times repetition period based on the forgetting theory.Long-term memory learning is possible through four times of English vocabulary game learning.

After completion of learning		
1-level review	After 10 minutes	English vocabulary game learning
2-level review	After a day	English vocabulary game learning
3-level review	After a week	English vocabulary game learning
4-level review	After a month	English vocabulary game learning
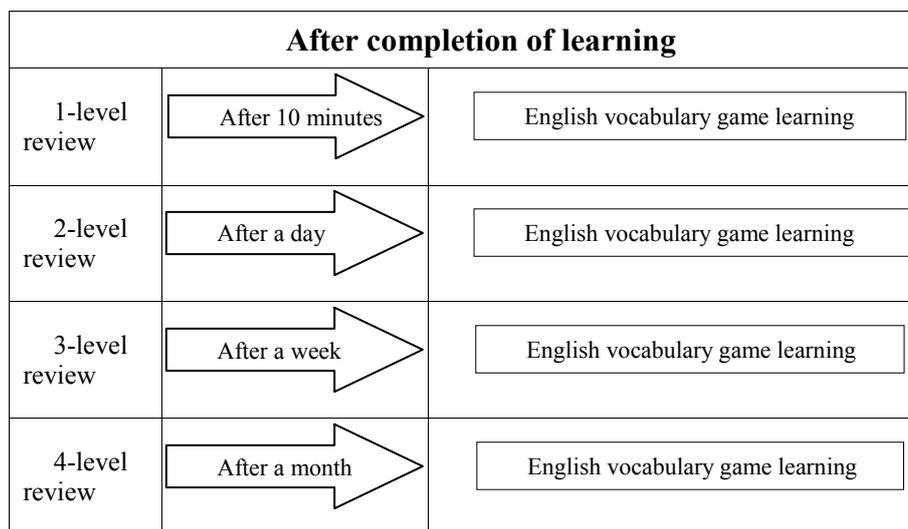
Fig. 2. Forgetting theory-based repetition time

3.2 Flashcard mnemonics-based learning model

Sebastian Leitner's flashcard learning method divides words into memorized and unmemorized word and then conducts repetitive learning by dividing them again into memorized and unmemorized words after rememorization. It reduces unnecessary repetition and enables repetition of necessary parts.

From here we devised the concept of trashcan in real life. Trashcans have to be emptied when it is full. Likewise, we created unmemorized-can, and after the evaluation game of unit (after 10 minutes, one hour, one week, and one month), words that are missed in the first game are moved to unmemorized-can (repeated words are not marked as repeated).

When a certain amount of words go in, emptying game has to be done in order to empty the unmemorized-can. If it is not emptied, the learner cannot continue the evaluation game.At the time of unmemorized-can game, correct words are emptied and incorrect words stay in the unmemorized-can.

unmemorized－can		
unmemorized－can （ Not Full ）	unmemorized－can （ Full ）	
1－level evaluation game incorrect word unmemorized－can word / word / word word / word / word	1－level evaluation game incorrect word unmemorized－can word / word / word word / word / word word / word / word	
Wait	Game Start	At the time of unmemorized － can game, correct words are emptied and incorrect words stay in the unmemorized －can.
1－level evaluation game incorrect word unmemorized－can word / word / word word / word / word	1－level evaluation game incorrect word unmemorized－can word / word	

Fig. 3. The status change of unmemorized-can

Fig. 3 represents the status of unmemorized-can as mentioned above. The left side of the figure indicates that the game couldn't go further because the loading doesn't go up to the full. The right side of the figure indicates that the word is removed as the game goes on after the loading can is full.

The final learning method is shown in Fig. 4. Evaluation games are conducted when the basic learning of each unit is done. After ten minutes, learners do the first evaluation game. Before he or she passes the first evaluation game, he or she

continues to do the game. When the learner passes the test, he or she moves on to learning of next unit.

However, the number of evaluation game for learning unit is four, applied of Ebbinghaus' forgetting theory. It is done four times after ten minutes, one day, one week, and one month. For evaluations after one day, one week, and one month, they are done along with the learning of next unit.

In addition, missed words at the first stage of each evaluation game go to unmemorized-can. The reason that only words that are missed in the first game goes to the can is that words that are missed at each stage are passed only after re-games that reach a certain level. For re-game evaluation, all of incorrect words in the previous game and a part of correct words are presented. Therefore, incorrect words at the first game of each stage are the repeated ones of incorrect words at the next game, so only incorrect words at the first game go to the unmemorized-can.
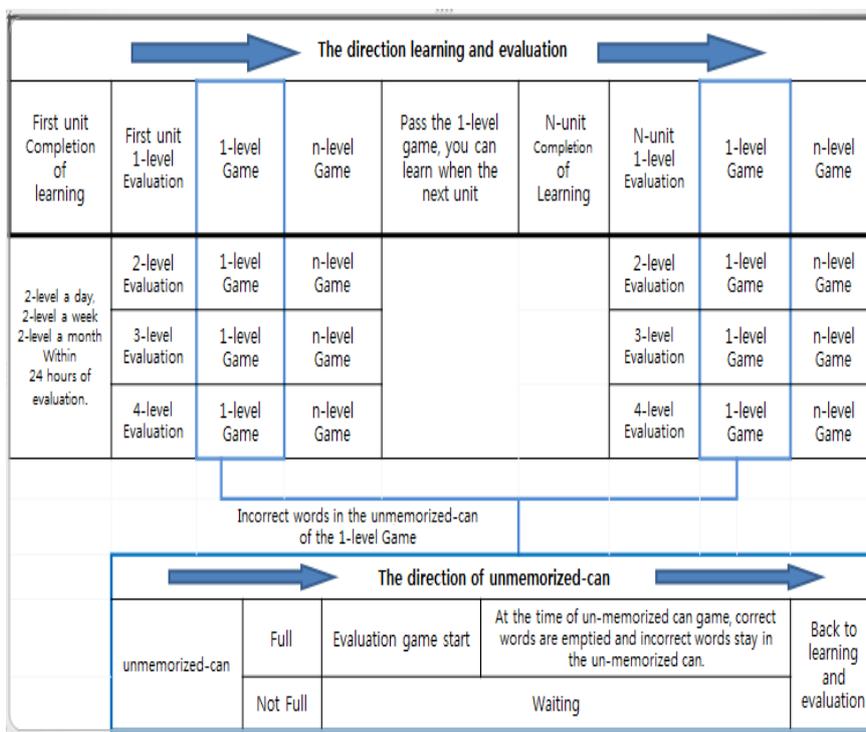

Fig. 4. The final learning model

Fig. 4 shows the final learning model through the fusion of Ebbinghaus' forgetting theory, Leithner's card learning, Bloom's mastery learning. The upper part of the figure shows the game flow after the overall learning and the lower part of the figure shows the flow of the unmemorized-can handling the incorrect words in the game.

4   Conclusion

In order to newly develop the learning model that becomes the foundation of learning, we used three theories - mastery learning theory, Ebbinghaus' forgetting   theory, and Sebastian Leitner's flashcard learning method. We added Ebbinghaus' forgetting theory on mastery learning so that learners will not forget the material by repeating four periods, and the memorization through these repetitions is facilitated by Sebastian Leitner's flashcard theory. In addition, we diversified the methods and types of the evaluation game. Therefore, we sought to increase the interest and concentration rates of learners on the evaluation test.

This study sought to escape the learning evaluation that is conducted in limited space and time. If we make the learning evaluation through smart devices possible, time and space will become freer. Therefore, we sought to create the learning evaluation environment that can be conducted using smart devices. We established evaluative learning models that enable solid evaluation even without limitation in time and space, and diversified types and methods of the evaluation. In the end, the improvement in interest and concentration rate of learners is expected.

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