The Effect of a Mobile Mathematical Game on the Mathematic Learning of the Student with Intellectual Disability

Chun-Ping WU[a*]& Yu-Chen LIU[b]
[a]*Department of Educational Technology, TamKang University, Taiwan*
[b]*Department of Educational Technology, TamKang University, Taiwan*
*cpwu303@gmail.com

Abstract: Taking into account of students with intellectual deficits and special needs in concept learning, this research designed a digital game for a fourth grade elementary student with mild intellectual disability to learn the concept of triangle. The participant's experience of learning from the game and the impact of the game on his learning gains on the introduced concepts of triangle were explored. This study adopted the A-B-A' research design of the single-subject model. One 4th grade elementary student with intellectual disability was recruited as the research participant. The experiment included three stages: the baseline, the intervention, and the retention. The participant's level of satisfaction towards the game was collected via observation and interview using the game satisfaction questionnaire. Moreover, the participant's performance on the tests embedded in the game was collected throughout the experiment. Two major conclusions are obtained. The participant is satisfied with digital game-based learning process. The designed digital game is effective in helping elementary students with intellectual disabilities to learn the concepts of triangle.

Keywords: Mobile game, intellectual disabilities, mathematical game

1. Introduction

Students with intellectual problems usually suffer from inattentive, short-term memory deficit, low logical thinking, and feel difficult in concept generalization (Drew, Hardman, & Logan, 1996; Langone, 1990). While learning, they are easily distracted, not being able to concentrate on the important messages delivered by the instructor. They also have difficulty in processing and memorizing the declarative knowledge and procedural knowledge (Crane, 2002). Specifically, they are deficient in synthesis, reasoning and learning abstract concepts. Those physical limitations lead to their difficulty in understanding and applying the basic mathematical principles to solve complex mathematical problems, which further results in their failure and frustration in learning mathematics. Therefore, it is necessary to provide them with individualized learning support and guides to accommodate their special learning needs.

As suggested by the literature in the special education, organization and presentation of the learning content, workout examples and constant practice might help to facilitate the learning process (Katai & Toth, 2010; Ministry of Education, 2011). First, the short-memory deficit limit the amount of the content the students could process simultaneously; therefore, task-analysis is usually adopted to break the content into even smaller meaningful pieces to avoid the cognitive overload. Then the contents are re-chucked based on students' cognitive structure. Second, more concrete worked examples are essential to help them understand the meaning and generalization of complex concepts. Multimedia presentation of contents might attract their attention and help them to visualize the concepts such as geometric figure and solid figure. However, since the students are easily distracted, message irrelevant with the learning content should be avoided. Third, constant and deliberate practice with timely feedback becomes essential to their mastery of the learning content.

A well-designed mobile game, such as breaking-through-the-barricade game, in which the idea of drill-and-practice is embedded, could serve as a learning tutor for the students with intellectual disabilities. The content to be learned in the game could be reorganized into smaller pieces and

re-chunked according to the structure of the concepts to be learned and students' cognitive structure. Besides, the learners are allowed to observe and interact the multimedia presentation of the content. Moreover, the test-items presented in each barricade could be sequenced based on the item-difficulty. The game could offer the students with constant practice and instant feedback to help clarify any misconception about the content.

Taking into account of these students' problems, this research aim to design a mobile game for a 4th grade elementary student with intellectual disabilities to learn the concept of triangle. The impact of the designed game on the participant's learning gains and his experience of learning from the game were explored.

2. Method

2.1 Research Participant

One 4th grade elementary student with mild intellectual disability is recruited as the research participant. His performance in the Wechsler Intelligence Test is 67. In math learning, she reports difficulty in understanding the concepts of geometry. Specifically, despite the facts that she can describe the definitions of several types of geometry graphs, when given several geometry graphics, she are not able to identify the correct graphics of a specific type of geometry. Moreover, she has difficulty in reasoning through a complex problem.

2.2 Research Design

The A-B-A' design of the single-subject model was adopted. The instructional goal of the designed mobile mathematics game (intervention) is to develop the subject's knowledge in regard to triangle. The experiment included three stages: the baseline, the intervention, and the retention. (1) The baseline stage: The subject received traditional instruction on the topic of triangle in class for two weeks. Her performance on the test of triangle is collected 5 times after instruction. The data is used as the baseline data. (2) The intervention stage: The subject received individualized instruction with the designed mobile mathematic game implemented after class for five weeks. Her performance on the test of triangle was collected 15 times during this period. (3) The retention stage: After the intervention, the subject's performance data of the same topic was collected again. Additionally, the participant's level of satisfaction towards the game was collected via observation and interview using the game satisfaction questionnaire as well. The implementation procedures are described as follow:

2.2.1 Intervention: the Mobile Mathematical Game

The game is designed to facilitate the player's understanding of three units: types of triangle, the features of triangle, and congruent graphics, including congruent triangles, square, parallelogram etc.). In corresponding to the special needs of the participant, the texts and explanation delivered in the game is written by a teacher with expertise in special education and mathematics. Besides, the participant is deficiency in catching the abstract concept, such as "rotation of the graphic"; therefore, animations are used to visualize the rotation of different introduced graphics. Furthermore, the practice with instant feedback was designed in the game.

The mobile mathematic game is developed using the App Inventor 2 and the game could be used in the Android-based mobiles. The starting page of the game includes four icons:

(1) the "story" icon directs the player to read the story and the mission of the player; (2) the "help" icon directs the player to access the instruction of playing the game; (3) the "game-start" icon directs the player to start the game journey and (4) the "game-record" icon allows the player/instructor to retrieve her performance in the game.

Three barricades corresponding to the three units were embedded in the game. In each barricade, the player starts learning the concepts with the instruction and explanation which are presented by animated graphics and texts (see figure 1). Then the player proceeds to take a practice, containing 5-10 question-items. She has to answer the item within time limit (ie., the time left is shown

in the right-upper corner of the figure 2). The "hint" button presented at the right allow the player to decide whether to read the hint before answering the question item. Once the player answer the question and click the submit button, she will be given 10 second to examine the mistake if her answer is wrong. Then, the detail explanations for the four options of the question are provided as the feedback. The score of the whole practice is updated with each question answered. After the practice, she has to take a test in order to break thought the barricade and proceed to the next one. The goal of game for the player is to break through the three barricades embedded in the game.

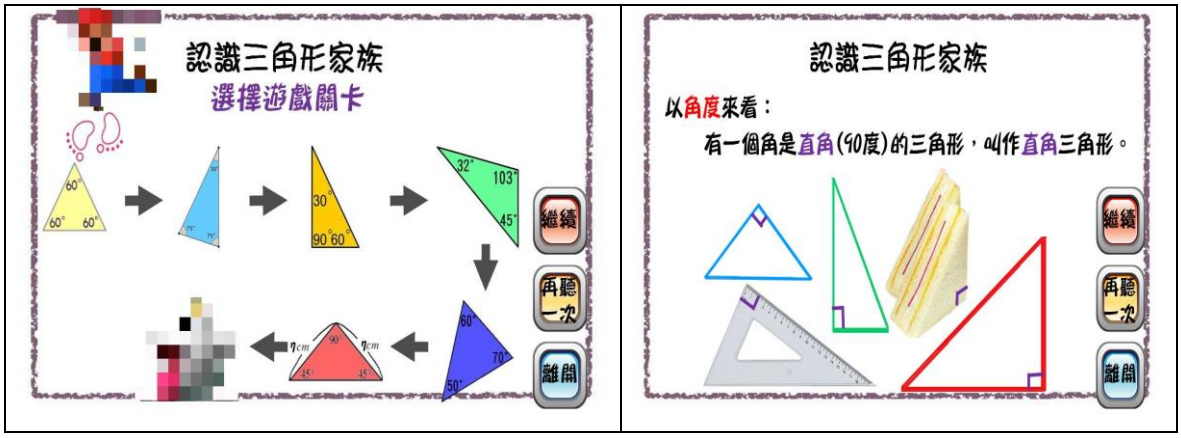

Figure 1. The Interface of Unit1: Triangle

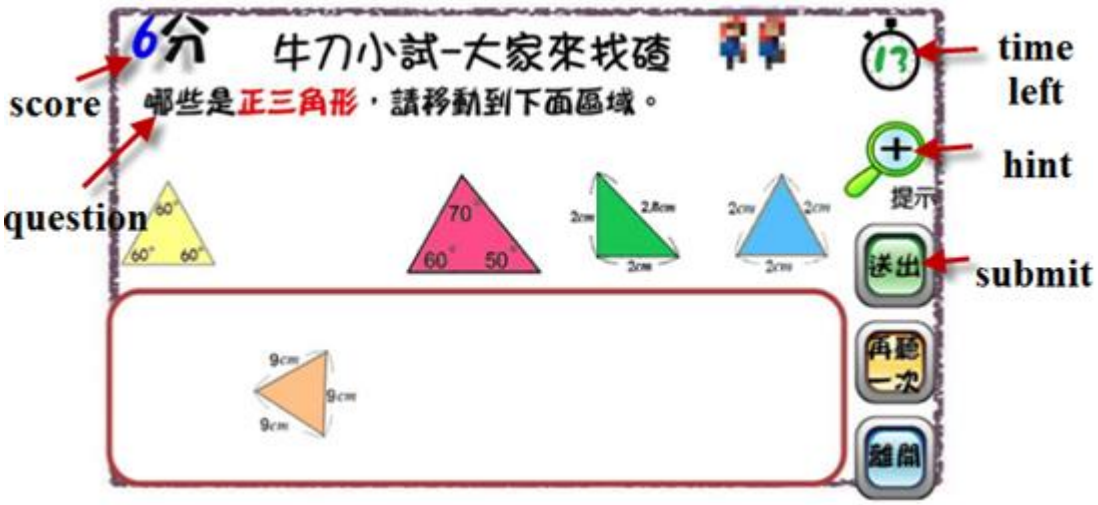

Figure 2. The Example of the Question-item Presented in the Practice

2.2.2 Dependent Variable

Two dependent variables examined in study are level of satisfaction toward the game, and mathematics performance. First, the level of satisfaction is defined as the ease of the operation, usefulness of the game and perception toward this type of learning. The data was collected via interview and the interview protocol was modified from the game-satisfaction questionnaire developed in the study of Hwang, Sung, Hung, Yang & Huang (2012). Second, the mathematics performance is defined as the scores gained on the ten test-items of each unit (i.e. types of triangle, the features of triangle, and congruent triangles)

3. Results

3.1 Level of Satisfaction toward the Game

The interview results showed that the subject felt the ease of operating the game and learning the concept of triangle within the game interface. Besides, she reported that the animated graphics facilitated her understanding of the complex concepts of triangles. With the game mechanism such as time limit, hint and feedback, she concentrated on taking the practice and test in order to break through the barricades. Last, she felt that it was more interesting to learn mathematics in this way. She likes the game and would recommend this game to her classmates.

3.2 Mathematical Performance

As shown in figure 3 which presents the learning curve of unit1, in the baseline stage, the participant's performance is very low with the average score at 18. In the intervention stage with the game introduced, the performance scores are increasing to 82.67. In the retention stage, the average score (86) is higher than those in the baseline stage. The results supported the positive effect of the game on the participant's learning of unit 1.

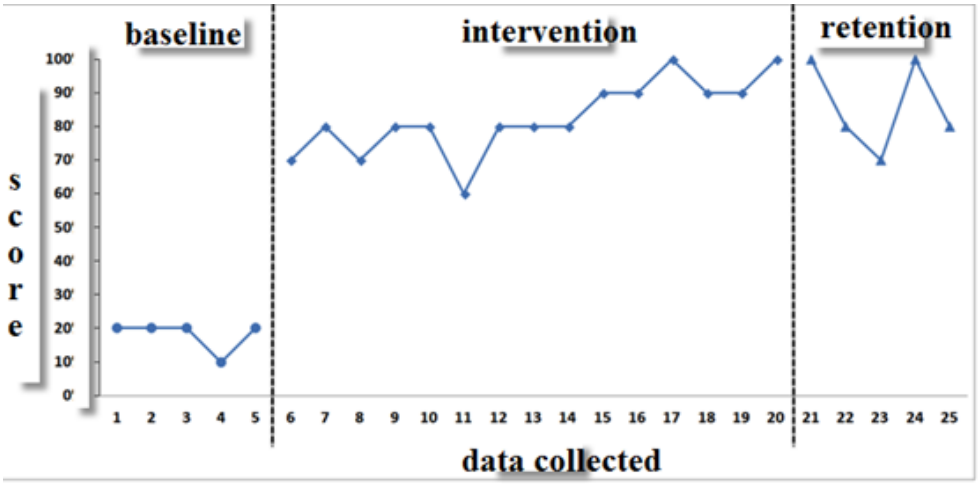

Figure 3. Performance Data Distribution at Unit 1

As shown in figure 4, which presents the learning curve of unit2, in the baseline stage, the participant's performance is low with the average score at 21. In the intervention stage, the performance scores are increasing to 85. In the retention stage, the average score (94) remains high. The results supported the positive effect of the game on the participant's learning of unit 2.

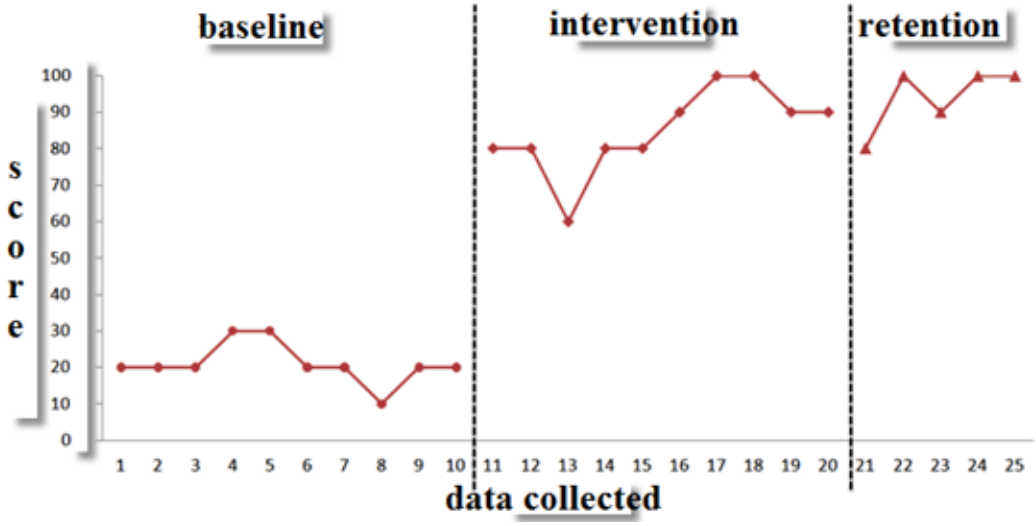

Figure 4. Performance Data Distribution at Unit 2

As shown in figure 5, which presents the learning curve of unit3, in the baseline stage, the participant's performance is low with the average score at 19.23. In the intervention stage, the performance scores are increasing to 84.29. In the retention stage, the average score (82) is remains high. The results supported the positive effect of the game on the participant's learning of unit 3.

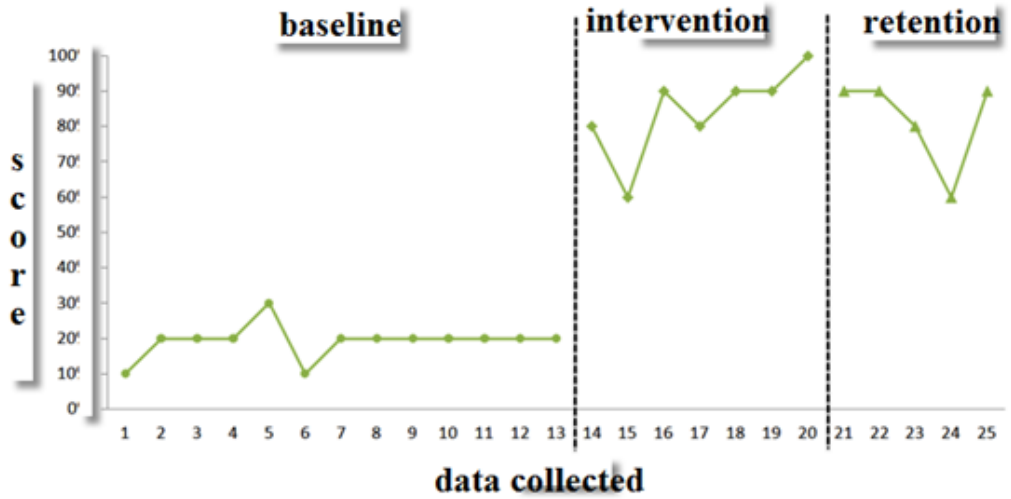

Figure 5. Performance Data Distribution at Unit 3

4. Conclusion

Two major conclusions are obtained. The participant is satisfied with the mobile game and the game-based learning process. As reported by the participant, it is easy to operate the game and interesting. The "barricades" design and the pace of the game could keep the participant concentrate on the gaming process, especially on answering questions. Her perception of the usefulness of the game also motivated her in learning the math with the game. Moreover, the designed mobile game is effective in helping the elementary student with intellectual disabilities to learn the concepts of triangle. The visual presentation of the abstract concept and principles helps the participant to understand the complex concept of triangle. Besides, the participant could observe diverse examples of triangle, which facilitates her in concept generalization. The design of barricades offers her the opportunity of constant practice with feedback, which helps her to process and memorize the concepts and clarify misconception.

References

Crane, L. (2002). *Mental Retardation: A Community Integration Approach*. Belmont, CA: Wadsworth/Thomas Learning Group.

Drew, C. J., Hardman, M. L., & Logan, D. R. (1996). *Mental retardation: A life cycle approach* (6th ed.) Englewood Cliffs, NJ: Prentice-Hall, Inc.

Hwang, G. J., Sung, H. Y., Hung, C. M., Yang, L. H. & Huang, I. (2012). A knowledge engineering approach to developing educational computer games for improving students' differentiating knowledge. *British Journal of Educational Technology*, 60(4), 623-638. doi : 10.1111/j.1467-8535.2012.01285.x

Langone, J. (1990). *Teaching students with mild and moderate learning problems*. Boston: Allyn & Bacon.

Katai, Z., & Toth, L. (2010). Technologically and artistically enhanced multi-sensory computer-programming education. *Teaching and Teacher Education, 26*(2), 244-251.

Ministry of Education（2011). The principle and curriculum for the special education at the stage of compulsory education. Retrieved June 28, 2015, from http://sencir.spc.ntnu.edu.tw/site/c_principle_001/index/process_t_key/212/mode_t_key/-1/data_t_key/-1/code/001/kind_code/001 (the reference is written in Mandarin)