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A Tetris Game to Support Students' Mental Computation: Design and Evaluation

Charles Y. C. YEH, Hercy N.H. CHENG, Zhi-Hong CHEN, Calvin C.Y. LIAO & Tak-Wai CHAN

Graduate Institute of Network Learning Technology, National Central University, Jhongli City, Taiwan
Charles@cl.ncu.edu.tw

Abstract: The objective of this paper is to develop a PDA-based learning game for mental computation, entitled EduTetris. As mental computation skills are used in everyday life, many researchers have indicated that mental computation skills facilitate students' arithmetic computation. It is important to teach students about the skills and strategies of mental computation in their mathematics learning. In this study, we implemented a game on PDA and designed a unique material for learning digits which sum to 10. The game was used to help students practice mathematics addition and mental computation. In addition, an evaluation of the system was also conducted.

Keywords: Game-based learning, digital games, Tetris, primary school education

1. Introduction

People use mental arithmetic skills in everyday life (Bell, 1974; Kulak, 1993). For example, when doing shopping in a supermarket, we tend to choose the cheaper one between two similar merchandises. The ability to compare two numbers is a kind of mental calculation. "Mental computation (arithmetic) is defined as procedure being performed mentally, without using external devices such as pencil and paper. (Rey, 1984)"

Arithmetic operations involve procedure understanding and undertaking. American and England mathematics education experts have indicated that procedural fluency is one of the essentials of successful mathematics learning: a group of American mathematics educators and researchers have list procedural fluency as one of the five strands of mathematical proficiency (National Research Council, 2001), and the experts in England raised the issue that lack of essential technical fluency—the ability to carry out numerical and algebraic operations with fluency and accuracy—is one of the three problems highlighted as an examination of their national mathematics education (London Mathematical Society et al., 1995).

2. Materials design: mental arithmetic skills of addition

For the training of the basic mental arithmetic with elementary school students there have three main points as follows: (1) Mental arithmetic for mathematics teaching requires a certain degree of understanding about the addition such as recognizing numbers, understand the basic mathematical symbols and have ability of add three numbers. For example: first grade student learning mental arithmetic with million-digit addition will be difficult. (2) Proficient in calculation without the use of external force likes pen or calculating machine. This study was using PDA to avoid student calculus in the paper and judging answer immediately. (3) Have ability of judgment in question. System will give students a variety of additions questions which the answer may be right or wrong.

This study was designed some mental arithmetic paper materials which referenced by mathematic books, textbooks, mental arithmetic researches and other related books. The purpose of this category is to observe accuracy of the Two-digital addition questions. If students use ten complement skills we expect the speed and accuracy will increasing.

Material structure as shown in Table 1:

Table1: Material structure with mental arithmetic

Category	Example
One-digital add One-digital	9+1=10
	9+3=9+(1+2)=(9+1)+2=10+2=12
Add three numbers	5+4+1=10
	5+4+2=5+4+(1+1)=(5+4+1)+1=11
Add five numbers	5+8+5+2+3=(5+5)+(8+2)+3=10+10+3=23
	4+5+8+1+3=(4+5+1)+8+3=10+(8+2)+1=21
Two-digital add Two-digital	45+25=70
	45+27=45+(25+2)=(45+25)+2=70+2=72

3. PDA Game Design: EduTetris

Game challenge and the gameplay are very important element of game (Crawford 1980). The design part of the game follows the following principles:

- Game must have a difficulty of speed. Speed will changed with the circumstances of students.
- Use the highest score to create a challenging target for students and enhance their game motivation.
- Using the box which embedded a one-digital number can enhance student's number sense and make then more proficiency with ten complement.
- Design a math game that based on a typical Tetris game to improve students' acceptance.

The gameplay with EduTetris is match two blocks add up to ten. When such a blocks is created, it disappears, and any block above the deleted block will fall. The scoring formula for the majority of EduTetris products is built on the idea that more block clears should be awarded more points. Figure 1 is a basic game skill for removed the two blocks. Figure 2 is an advanced way to remove blocks. When students control the "block 5" stacked in another "block 5" on the left or right then the two blocks will be removed. The top of the "block 2" will drop down a grid and the "block 2" will be also removed with the "block 8". Students can determine better path of every block and pre-calculated results of successive terms in order to achieve the maximum benefit of the game to enable students to skilled number add up to 10 in various combinations.

In addition to the two stacked blocks can be removed, the three blocks add up to ten as another way also can removed blocks. Students can control the "block 5" stacked in the left of the "block 3".Due to the three blocks add up to ten so the three blocks will be removed(Figure 3). Figure 4 is another example of the vertical removed. Students practice by EduTetris with the increasing speed can make students more quickly determine the strategic and proficient of the ten's complement that students can be used in mathematical computation.

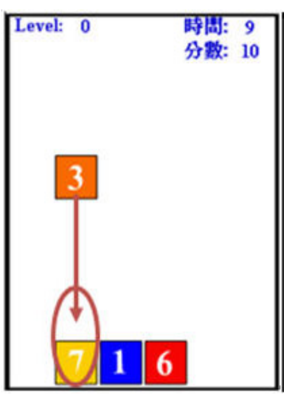

Figure1: basic skill

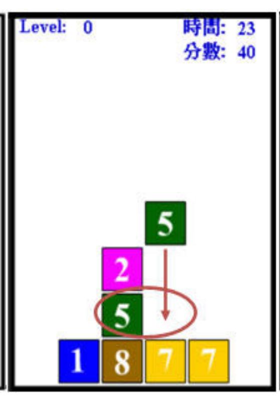

Figure2: advanced skill

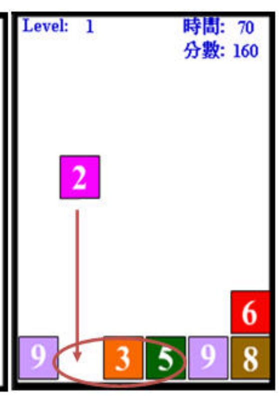

Figure3: horizontal removed

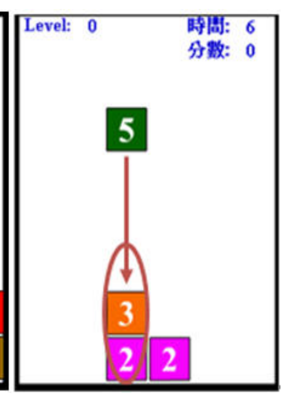

Figure4: vertical removed

4. Methods

In order to evaluation the effects of EduTetris, especially in learning effect, motivation, and self-efficacy. This paper proposed two research questions: (1)EduTetris is able to enhance the students on the computing of mental arithmetic addition. (2)EduTetris could enhance the students learning motivation of mental arithmetic.

4.1 Participants and Context

Participants were 15 nine year-old third-grade students from elementary school in Taiwan. Every student has a computing device with wireless capability. The main objective of this experiment was to evaluate the motivation and effectiveness influences of game. The procedure is shown as Figure 5. There has two phases, phase 1 used to measure student motivation. Students have completed the pre-test and post-test and fill out a motivation scale after playing EduTetris (in order to compare with phase 2). Phase 2 mainly measure learning effect. Students were doing mental arithmetic skill teaching materials for ten minutes and three achievement test whit EduTetris (Figure 5).

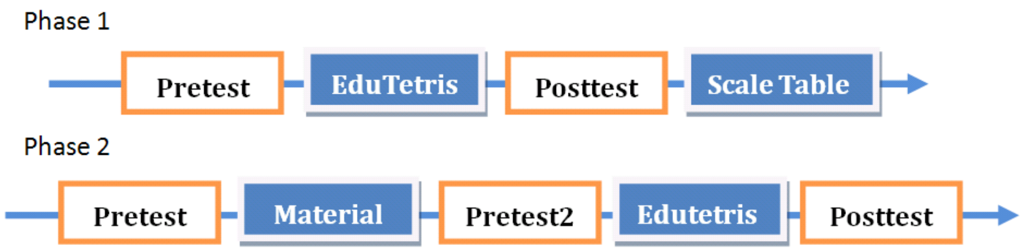

Figure5: Two phase of procedure

4.2 Data collection and measurement

In order to measure learning effect each test has thirty questions which has the same difficult and question types but different content. Test Includes: two One-digit addition (10 questions, such as: 2 +9 = 11), three One-digit addition (8 questions, such as: 2 +9 +8 = 18), five One-digit addition (8 questions, such as: 9 +3 +6 +7 +4 = 27) and two Two-digit addition (4 questions, for example: 45 +25 = 70). In the data collection and analysis, we based on the ARCS motivation theory (Keller, 1987; Keller & Suzuki, 1988) to design a motivation scale (Dempsey, Rasmussen, Haynes, & Casey, 1997). In ARCS**,** there are four major categories of motivational strategies: Attention, Relevance, Confidence, and Satisfaction. Learning motivation can be judged by the scale-score. Motivation scale adopted the five-point items that one-point means strongly disagree and five-point means strongly agree. Every three questions have and reverse question to judge students' careless answer and to improve reliability.

5. Results

5.1 Learning effect

Student learning effect can view by answer time and accuracy. There have three region shown as Figure 6. Region I is students playing EduTetris practice without any intervention. It is the simplest game effects can be observed by EduTetris. Region II is through the learning task with materials regard for students' speed of answer. At this region is mainly to observe the skills that we teach students use ten's complement could be increasing students answer speed. Region III was used both learning skills material and EduTetris to observe it could be able to help students' answer speed. This region was shown in Table 2.

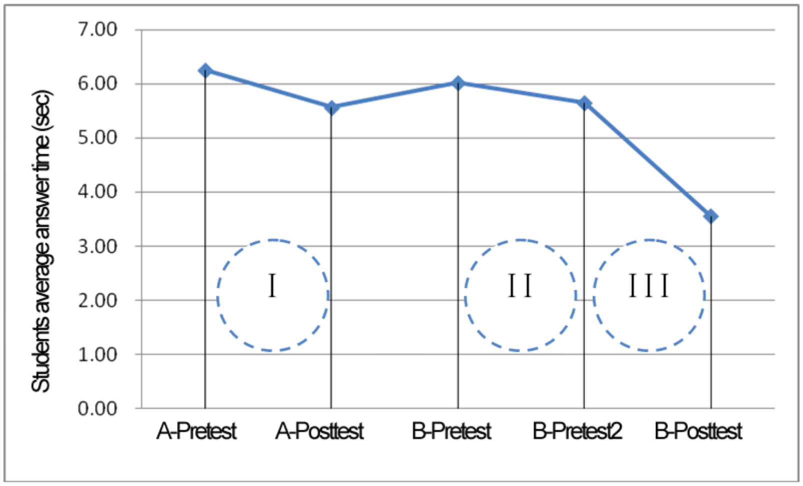

Figure6: the average answer time of various phases

Overall, in region I (did not use materials but playing EduTetris) and region II (after using materials), students' averaged answer speed were increasing but the difference was not significant. Region III can find the influence of both materials and EduTetris on students answer time. Average answer speed have significant improved in Region III. However, in addition to take care of speed we also need to take notice of accuracy. The table 2 was the results of students' average correct rate. There was no significant difference in accuracy before B-Posttest. But in the B-Posttest seems to have followed the decline in accuracy.

Table2: Students average correct rate

activities	A-Pretest	A-Posttest	B-Pretest	B-Pretest2	B-Posttest
accuracy	94%	96%	96%	94%	82%

5.2 Learning motivation

The results of measure learning motivation as shown in table 3. Four major categories of motivational seen from the standard deviation are not divergent. So it can be assumed that students have held a positive attitude with attention, relevance, confidence and satisfaction. In the part of attention students likes EduTetris with the sensory stimulation and variability. Students were interested in what was happened with this game and agree that EduTetris have attraction for them. In the association category, students also tend to agree that EduTetris have the game goal and training them practice ten's complement. For the self-confidence, students recognized that if they can success to breaking the highest record let they feel accomplished. We also find students are weakness of control and operate with game. In the satisfaction, students agreed that they can learn knowledge from the game and play this game will improve their performance. In the satisfaction, students agreed that they can learn knowledge from the game and play this game will improve their performance. In equity is tending to middle because some students consider that the other one with good math ability has more advantage of playing this game.

Table3: Four major categories of motivational scale (overall and sub-dimensions)

	Perceptual Arousal	Inquiry Arousal	Variability	Attention (overall)
M(SD)	4.1(0.6)	4.1(0.5)	4.3(0.6)	4.2(0.4)
	Goal Orientation	Motive Matching	Familiarity	Relevance (overall)
M(SD)	4.1(0.5)	4.1(0.6)	4.3(0.5)	4.1(0.4)
	Attribution Molding	Expectancy for Success	Challenge Setting	Self-confidence (total)
M(SD)	4.3(0.5)	4.0(0.6)	3.6(0.5)	4.0(0.4)
	Natural Consequences	Positive Consequences	Equity	Satisfaction (overall)
M(SD)	4.3(0.5)	4.2(0.7)	3.7(0.6)	4.1(0.4)

6. Conclusions and future work

This paper developed a mental arithmetic exercise game to support students practice in the mental arithmetic. The preliminary results of EduTetris can be divided into motivation and effect. According to the motivation scale can find students like EduTetris. Comparison of several achievement tests that EduTetris can increase computing speed is mental arithmetic but also followed the lower accuracy. For this result, there is no consensus conclusion. However, these studies are short-term experiments now. In the future we will plan more and more rigorous and long-term experimental design to evaluation of this system.

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