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A Study of Cryptarithmetic problem-solving in elementary school

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Abstract. This research is motivated by the low score of the mathematics of Indonesian elementary school students at the international level. This study aims to determine the effect of "funtastic" battle math learning models on the cryptarithmetic problem-solving skill of elementary school students'. This study is an effort to increase the level of students' mathematical skill, especially in problem-solving. The research design used is pre-experiment with one-group pre-test-post-test design. The subject of research is the fourth-grade students in a public elementary school in Jatiluhur subdistrict, Purwakarta west java Indonesia. Based on Wilcoxon test, N-Gain test, and effect size test, the results show that the application of "funtastic" battle math learning model has a high influence on the cryptarithmetic problem-solving skill of elementary school students. It can be concluded that cryptarithmetic problem-solving abilities of students can be improved using the "funtastic" battle math learning model. The result of this study become one of the solutions to increase the level of mathematical ability of elementary school students in Indonesia.

1. Introduction

Mathematics is one of the compulsory subject on the curriculum of elementary and secondary education, in accordance with the National Education System Law number 20 of 2003. Mathematics education should develop the creativity of learners in the learning process [1]. Mathematics learning must develop logic, reasoning, and argument [2]. The above requirement contradicts the current reality in Indonesia. Wahyu and Mahfudy explain that there is still much math class that focuses on numeracy skills without building problem-solving skills, critical thinking skills, mathematical reasoning abilities, or other abilities [3]. Meanwhile, those abilities are very important, because mathematics learning in Indonesia still emphasizes on formulas and calculations, which caused the Indonesian Students' Mathematics score ranks 45th out of 50 countries [2,4]. With the belief that all children are born equally, this means that what is taught in Indonesia is different from international standard subject matter [5].

Several studies and effort that have been conducted to improvie students problem-solving skill in mathematics [5-7]. Problem-solving is chosen because it is very important, the most characteristic self-justifying activity in mathematics is problem-solving in its various aspects-first, searching for patterns and secondly applying to practical problems and situations [8]. This study is an effort to improve problem-solving skills students' with cryptarithmetic problem solving. Cryptarithmetic is one special

type of problem-solving, a puzzle that consist of an arithmetic problem which the digits have been replaced by letters of the alphabet. The goal is to decipher the letters (i.e., map them back onto the digits) using the constraint that no two letters can have the same numerical value [9,10]. This type is still very rarely used in the learning process in Indonesia, but commonly used in a tournament event such as the national olympics of mathematics [11]. Cryptarithmetic used to bridge with the Bruner theory, that to develops the children's mental ability gradually ranging from simple to complex, from easy to difficult, and ranging from the abstract to the concrete [12]. This study implements simple problem-solving to develop students' problem solving-skill using cryptarithmetic type.

Due to the fact that cryptarithmetic is still rarely taught in Indonesia, therefore, to teach it need necessary adjustment. Based on the meaningful learning theory of David Ausubel in Lestari and Yudhanegara that the learning will be more easily understood if the material is perceived meaningful for students [13] and according to Carl Rogers theory meaningful learning occurs if the learning process involves aspects of students' mind (cognitive) and emotion (affection) students [13], this study applied the "funtastic battle math" model which is considered to be appropriate to teach cryptarithmetic. "Funtastic" battle math is an alternative fun learning and designed to reduce the assumption that mathematics is a difficult subject and creepy subject [14]. "Funtastic" battle math is a learning game model which make every child loved to play, and through play, children can adjust to the environment [12].

Figure 1. Students activity in a "funtastic" battle math.

Figure 1 show the students' activity using number card to answer the cryptarithmetic problem during the game of "funtastic" battle math.

2. Cryptarithmetic problem-solving

types of problems outside the training material (drill exercise) is often used in the form of mathematical problem solving assignments. Those five types are: 1) simple translation problem; 2) complex translation problem; 3) the process problem; 4) the implementation problem; 5) puzzle problem [12]. One type of puzzle problem is cryptarithmetic. Cryptarithmetic is a class of constraint satisfaction problems which includes making mathematical relations between meaningful words using simple arithmetic operators like 'plus' in a way that the result is conceptually true and assigning digits to the letters of these words and generating numbers in order to make correct arithmetic operations as well [9]. A cryptarithmetic puzzle is a simple mathematical operation in which letters or other symbols have replaced the digits and challenged to find the original number [10]. According Cooper in Shadiq cryptarithms is a mathematical puzzle where the letters of the alphabet stand for numbers [11]. Cryptarithmetic is a puzzle consisting of an arithmetic problem in which the digits have been replaced

by letters of the alphabet. The goal is to decipher the letters (ie. map them back onto the digits) using the constraint that no two letters can have the same numerical value [9].

Cryptarithmetic is classified as challenging mathematical problem solving. Cryptarithmetic problem solving requires students to have courage to try, a skill or strategy is needed in the process of problem-solving in which he worked later in life [11]. The activities of this problem-solving with cryptarithmetic is a good exercise to improve the students ability of reasoning, problem solving, creative and critical thinking [11].

An example of problem-solving cryptarithmetic.

Conditions:

- Replace each letter on the following problems with the numbers 0,1,2,3,4,5,6,7,8, or 9!
- One letter represents only one number.
- If there is the same letter on the question, then the replacement is also the same for the same letter.
- Obey the rules to obtain the proper summation!
- If $A + C + E = 10$; $B + C + D = 10$; while the letter C is replaced with the number 6, specify the appropriate numbers to replace letters A, B, D, and E!

3. Research method

The method used in this research is a quantitative and qualitative methods (mix methods). The methods are used because the research questions have two types of questions [15]. The quantitative research design used is pre-experimental with the kind of one-group pre-test-post-test design as shown in figure 2.

$$O_1 \; X \; O_2$$

Figure 2. Pre-Experimental research design.

Description:

$O1$ = Pre-test (tests before being given treatment);

X = given treatment;

$O2$ = Post-test (tests after being given treatment).

The quantitative data instruments used is a form of a written test questions which are made based on simplified Indonesian mathematical Olympiad questions for elementary school students. The instrument is directed and judged by one of the Deputy Director of SEAMEO QITEP in Mathematics (The Southeast Asian Ministers of Education Organization Regional Center for the Quality Improvement of Teacher Education Personnel in Mathematics) Mr. Fajar Shadiq. Before being tested to students in the experimental class, the questions were tested for validity and reliability, differentiation tests and the level of difficulty of the questions. The sample in this study are 27 of a 4th grade students in one public school in the district of Jatiluhur Purwakarta, West Java Indonesia.

The qualitative data is gather by an interview. The interviewee are 6 students, includes of two students with the highest post-test scores, two students with mid post-test score, and the two students with the lowest acquisition of post-test score. The questions asked are about their feeling during mathematics learning with "funtastic" battle math models; how they worked on cryptarithmetic use "funtastic" battle math models; and about the media card that was provided for the "funtastic" battle math in solving the cryptarithmetic problem.

There are four steps in this study, includes: 1) planning; 2) the implementation stage and data gathering; 3) data analysis stage; 4) the conclusion stage [13]. All phases of the research has been carried out from November 2017 until July 2018. This study determines the information of the effect of "funtastic" battle math learning model against cryptarithmetic problem-solving skills of elementary school students. The hypothesis tested in this research are as follows:

$H0$: The average cryptarithmetic problem-solving skill of students after using the "Funtastic" Battle Math learning model is no better than the cryptarithmetic problem solving-ability of students before using the "funtastic" battle math learning model.

Ha: The average cryptarithmetic problem solving ability of students after using the "funtastic" battle math learning model is better than the cryptarithmetic problem-solving ability of students before using the "funtastic" battle math learning model. The effect of the model that implemented in this research was analysed with Wilcoxon test, n-gain and effect size. The three tests were carried out in this report to get more convincing results.

4. Result and discussion

The experiment was conducted in accordance with the study design has been described previously, namely one-group pre-test-post-test design. The treatment given to the students is applying the "funtastic" battle math learning model with the subject matter in natural number cryptarithmetic addition.

The data used for the data analysis stage are pre-test and post-test score. Pre-test is conducted a week before the experiment was conducted. The treatment was held in 3 meetings with details: 1) The first meeting learning material was cryptarithms types 1 and 2; 2) The second meeting learning material was type 3 and 4 cryptarithms; 3) The third meeting learning material was type 5 cryptarithms. During the experiment, students engaged actively and enjoy the learning activities. In accordance with the objectives of the "funtastic" battle math learning model, the attitude of confidence, discipline, and cooperation of students also began to be trained.

The last stage of post-test was carried out after the experiment. This post-test was attended by 28 students. The existence of students who did not fully participate in learning activities in this study is deleted, so that there were 27 data obtained to be tested. The score of pre-pest and post-test is illustrated in figure 3, with the minimum score is 0 and maximum score is 100.
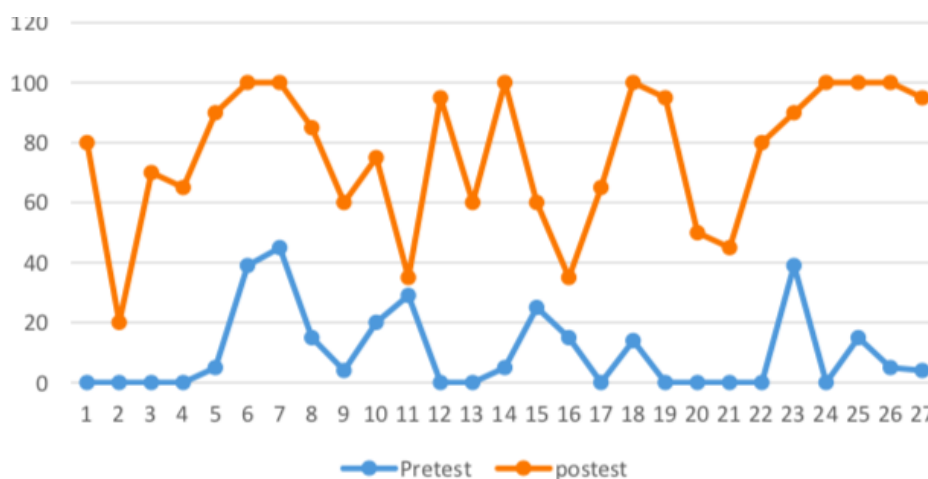
Figure 3. Pre-test and post-test score of student' cryptarithmetic problem-solving.

The highest score of the pre-test is 45 and the lowest score is 0, meanwhile the highest post-test score is 100 and the lowest is 20. The mean of the pre-test is 10,33 and the mean of the post-test is 75,93. In the pre-test score there is 12 students' got 0 score. By the interview, they couldn't answer the questions because they never had face a kind of problem like cryptarithm.

4.1. Wilcoxon test

Because the data obtained were not normally distributed, the Wilcoxon test was used to test the hypothesis. The Wilcoxon test results with the help of SPSS are shown in table 1.

Table 1. Wilcoxon test results of cryptarithmetic problem-solving skill.

			X2-X1
Z			-4,543[b]
Asymp. Sig. (2-tailed)			,000
Monte Carlo Sig. (2-tailed)	Sig.		,000
	95% Confidence Interval	Lower Bound	,000
		Upper Bound	,000
Monte Carlo Sig. (1-tailed)	Sig.		,000
	95% Confidence Interval	Lower Bound	,000
		Upper Bound	,000

From the table 1, it can be concluded that there are differences in the average of cryptarithmic problem-solving skill in learning mathematics after using the "funtastic" battle math learning model. The results that indicate the difference in average were possible because of the achievement of the learning objectives that have been made by the students' in the post-test score. The "Funtastic" battle math learning model is a model designed to make learning fun and train teamwork, and cryptarithmetic problem-solving is a challenging material to solve. The combination of both causes students to learn enthusiastically, therefore, the average result of mathematics learning before and after using the "funtastic" battle math learning model shows differences.

4.2. N-Gain test

N-Gain test is performed to determine the improvement score in students' cryptarithmetic problem-solving skill. The results obtained as in table 2. According to table 2, it shown that the average N-Gain students is at the high criteria. That means the cryptarithmetic problem-solving skills of students has high increased. The high increase assumed as the high influence of the "funtastic" battle math learning models to the cryptarithmetic problem-solving skills of elementary school students.

Table 2. The N-Gain Score of Student' Cryptarithmetic problem-solving skill.

Aspect	Score result
N-Gain cryptarithmetic Problem solving	0.73

4.3. Test of effect size

The test of the effect size values can provide information about the size of the experimental effect. The formula effect size of type Single-group pre-post used refers to Seidel, Miller and Chow [16].

Based on the Cohen formula and criteria, the following are the results obtained SD = ES = 3,358897. From the results obtained, the effect size value of 3.358897. According to the criteria, the value has a relatively large effect because it is located on the criteria ES> 0.8. It means that the application of "funtastic" battle math learning model has a great effect or influence on the cryptarithmetic problem-solving skills of elementary school students.

To find out the students' responses learning with "funtastic" battle maths, six students were selected, namely 2 students with the highest post-test scores, 2 students with medium post-test scores, and 2

students with the lowest post-test scores. In the first question "How do you feel when learning mathematics with the "funtastic" battle math model?", The six students said they were happy and interested. Moreover, the battle rules in the game make students more challenged to solve the cryptarithmetic problem given.

The second question is "How do you and your group friends work on cryptarithm problems using the "Funtastic" Battle Math model? Two students with low abilities revealed that they were working together with their respective teams. Friends in groups often teach them how to solve cryptarithms correctly. While 4 students with medium and high scores revealed that they divided the assignments into each group member, and afterwards they concluded together the correct answers.

In the third question "Is the card media provided provided for the Funtastic Battle Math game help you in solving cryptarithm problems?". The six students gave more or less the same answer. They revealed that at the beginning, the card was very helpful to try the right numbers. But after they understand the types of cryptarithms and the patterns, they prefer not to use cards because they feel that they can work faster. This means that the card that was originally functioned to help guess the right number, at the end of the learning only functioned to present in front of the class.

5. Conclusion

Based on the three tests above, the average difference test, the N-Gain test and effect size test, it shows that there is an effect of the implementation of the "funtastic" battle math learning model on cryptarithmetic problem solving skills. This can happen because the model applied to make joyful learning and train team collaboration [17]. Cryptarithmetic problem-solving material is a challenging material to solve [11]. The combination of the two causes students to enthusiastically participate in learning, causing a significant influence from the use of the "funtastic" battle math learning model on cryptarithm problem solving skills of elementary school students. This effect can be seen from the significantly increasing scores.

From the interviews that have been conducted, the researchers draw the conclusion that elementary school students provide a pleasant response to mathematics learning using the "funtastic" Battle Math model to solve cryptarithm problem solving problems. This is in line with Widodo that the "funtastic" battle math game makes students more challenged and help each other to solve cryptarithmic problems given, especially for students with low abilities [14].

Acknowledgment

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