Limited trial on origami construction as mathematics learning strategy for early childhood on kindergarten teachers

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Abstract. The aim of this study is to do a limited trial on the hypothetical learning strategy for early childhood mathematics concepts using origami construction. Using the training devices designed for the limited trial, 17 early childhood education teachers in Bandung and its surrounding areas were trained on the learning strategy. The trial pre-test and post-test scores and it shows an improvement in the knowledge of participating teachers of early childhood mathematics learning using origami. The significance of the improvement had been proven using t-paired test. The improvement might be caused by the fact that most of the participants only have high school diploma as education background with lack of training on early childhood mathematics learning, and also with the fact that origami is mainly used for fine motor skills improvement in early childhood education. Thus, the origami construction can be used as an alternative strategy to learn mathematics concept in early childhood.

1. Introduction

Mistakes in teaching mathematical concepts of early childhood, in contents or methods, may lead to various mistakes in future mathematical learning. Mathematics may be considered as a hard subject, horrifying, and unpleasant to learn. Hence, the teachers must be creative and innovative to motivate and stimulate the children so they can develop the ability of mathematical concept since early childhood.

From the data collected from 12 kindergartens in Bandung in 2017 [1], there are 4 kindergartens (34%) which showed the mathematical learning that is not oriented to early childhood development principal. It can be observed from these tendencies: 1) Some children are passive when asked to join the counting activities; 2) Some children are still confused when asked to associate number symbols with a number of things; 3) Some children are not able to add or subtract numbers. Apparently, these 4 kindergartens are the Early Childhood Learning Posts (known as *Pos PAUD* in Indonesia) which are managed by the local community, with local housewives as the teachers. The housewives have never been trained or educated as a teacher, so that they teach in accord with the three R's (reading-writing-arithmetic) worksheets material. Thus, it is necessary to provide them with the appropriate mathematics learning strategy.

The use of origami for mathematics learning has often been done in elementary school level [2-5] and middle school level [6-8], but it has not been developed for teaching mathematical concept in early childhood. However, origami often used for developing fine motor skills in early childhood [9,10].

The material for origami is paper, which is considered cheap and easy to obtain. It also can be made into various models to interest the children. On the other hand, teaching origami using demonstration method is often considered complicated. From the teacher's point of view, it is hard to raise the children's interest in folding paper, and from the child's point of view, origami is considered not fun and hard to do. Origami construction as a hypothetical learning strategy on the mathematical concept for early childhood has been developed by Respatiwulan [1]. It gave an alternative method to use origami for teaching. Thus, it is important to do a trial on the hypothetical learning strategy. The aim of this article is to show the result of the limited trial on hypothetical learning strategy using origami construction.

2. Theoretical basis

2.1. Huzita-Justin origami construction using crease pattern

One of the techniques to construct origami is by using the crease pattern. Huzita & Justin present 7 crease pattern operations which can be used to construct origami. It has been stated in Alperin that these 7 operations gave the 'complete' operations for origami construction; in the meaning of there are no other operation that can be made except as a variation of these operations [11]. The second operation (O2) of Huzita-Justin stated that if there are two points p_1 and p_2 , then there will be a crease line that made the points p_1 and p_2 coincide. While the third operation (O3) of Huzita-Justin stated that if there are two lines l_1 and l_2, then there will be a crease line that made the lines l_1 and l_2 coincide. The operations O2 and O3 are considered sufficient and simple to be done by kindergarteners.

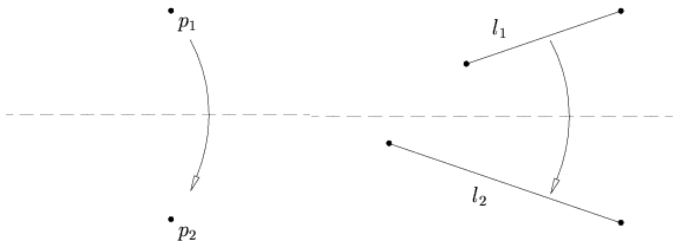

Figure 1. Second and third operation of Huzita-Justin origami construction.

The existence of these two operations is guaranteed since O2 is the line perpendicular to the line passing through p_1 and p_2, and the O3 can be obtained by bisecting the angle between the two known lines.

2.2. Mathematics for early childhood

According Bruner, there are three steps of a child learning process. The steps are: (1) Enactive, during this step, the child will be directly involved in manipulating concrete object; (2) Iconic, during this step, the child will have a connection with the mental as he picturing the manipulated object; and (3) Symbolic, in this final step, the child will manipulate the symbols of the certain objects. The sequence can help the child to follow the lesson in accordance with the child age. This theory is linked with the mental development; that is the child's mental ability to develop gradually, from simple to complicated, from easy to difficult, from realistic to abstract. Bruner also stated the child should be given the material which can be manipulated [12].

The creative proses involved in making origami also considered important to train out-of-the-box thinking, which is useful for solving mathematical problems with open-ended solution. According to Syaodih, children aged 4-6 year-old have a high curiosity about their environment [13]. They gain meaningful learning experience through plays, experiments, findings, and social interactions. Hence, the indicators of problem-solving skills on kindergarteners are: 1) observation skill; 2) information and data collecting skill; 3) information processing skill; and 4) information communicating skill.

Based on these indicators, Syaodih stated that the problem-solving skill indicators that need stimuli from the teachers are the information collecting and communicating skill, also the motivation and encouragement to ask and to answer questions [13]. Therefore, the teachers must be more creative and innovative to motivate and stimulate the children to develop their problem-solving skill.

2.3. Mathematics learning strategy for early childhood using origami

According to Respatiwulan, below are the learning objectives targeted by learning strategy using origami [1].

Table 1. Aspects and indicators for learning objectives.

Aspect	Indicator
Logical thinking	1. Classify objects based on color, shape, and size (3 variations); 2. Classify larger number of objects to the same or similar group, or pairing from more than 2 variations; 3. Recognize ABCD-ABCD pattern; and 4. Sorting object based on their size, from smallest to biggest and vice versa.
Symbolic thinking	1. Naming number symbol 1-10; 2. Using number symbol to count; and 3. Matching number with its symbol.

The teaching methods to use are demonstration, simulation, problem solving, and playing games. For the teaching technique, the teacher must understand the characteristics of 5-6-year-old children, which are active, love to explore, and highly curious. So, a fun teaching technique using songs, games, and attractive voice intonation must be applied. The learning steps can be divided into 3 parts: Pre-instructional, Instructional, and Assessment and Follow-up.

Pre-instructional step includes: The teacher prepares the children by singing, marching, and rhythmic exercise; invites the children to come inside the class and do morning habituation (checking dates, weather, and presence); doing circle time and converse about the children's activities, linking them with the previous and current session.

Instructional step includes: The teacher prepares children by doing various claps and song; explains the activities that will be done today; and giving an example of the activities:

- (Indicator: color, shape, and size classification) The teacher prepares folding paper which had been formed into fish, boat, house, etc. with various colors, shape, and size. Teacher then makes game activity through a race of putting certain color into baskets or 'fishing' certain shape or size.
- (Indicator: classification of larger number of objects into same or similar group or pairing from more than 2 variations) The teacher prepares the activity using lap book; the children will classify the object asked into available bags alternately.
- (Indicator: naming number symbol) The teacher demonstrates folding activity while asks the children to mention and point the numbers.

Assessment and Follow-up step includes: The teacher evaluates the activities by doing observation and performance assessment of the children's work. The teacher asks the children to paste their work on the worksheet. Observation is done when the children are following the learning process.

3. Research methods

The research was done on selected *Pos PAUD* teachers in Bandung and its surrounding area. The teacher followed limited trial of learning strategy using origami construction. The trial was done at the

Laboratory of Microteaching, Early Childhood Education Program, Faculty of Tarbiyah & Education Bandung Islamic University on June 2018.

The data of the trial were gained from pre-test & post-test, observation, and documentation study. In-depth interview was done to gain deeper information. While the documentation study was done to gain secondary data related to the mathematics learning method for early childhood.

The quantitative data analysis process was done using paired T-test analysis to see the effectiveness of the trial. The calculation was done using T.TEST function on spreadsheet software.

4. Results and discussion

The training devices used for the limited trial are: 1) origami construction module which had been validated by experts; 2) kit for early mathematics learning using origami construction which had been adjusted with early childhood characteristics; 3) trial media of early mathematics learning using origami construction which was given to the teachers; 4) pre-test questions; and 5) post-test questions.

The trial kit consists of plain and patterned origami folding paper in various colors, special made origami construction paper for assorted model, and module of mathematics learning strategy for early childhood using origami construction. The example of origami construction paper can be seen in Figure 2.

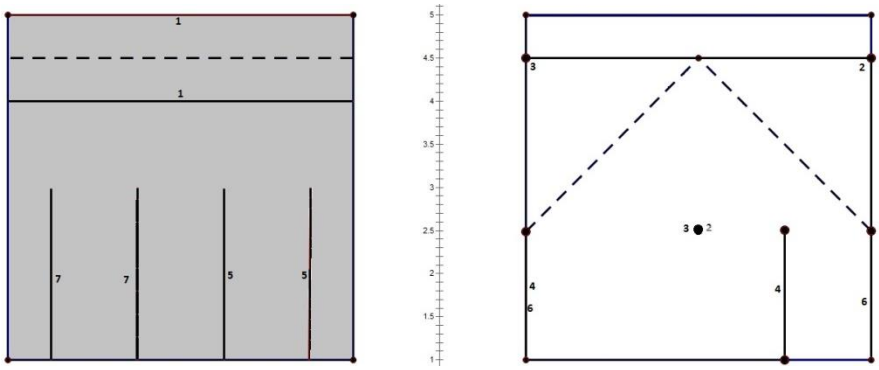

Figure 2 Origami construction paper for rocket model.

Based on literature and empirical study, the user profiles for this learning strategy—in this case, the early childhood teacher/educator—should consist of: 1) Understand the science of early childhood development, especially cognitive aspect of the child; 2) Oriented to the child's needs, such as the child physical needs, safety—the paper used for origami should be odorless and not with flashy colors—using papers with interesting patterns, show love and affection to the child during activities. In this case, the child should be the learning center. The teacher must develop the child's activeness in early mathematics learning activity; 3) The learning must in accordance with the child development stage; 4) Mathematics learning activity is packed using origami play; and 5) Teacher must be able to stimulate the child's creativity and innovation.

The training activity for users, who are early childhood education teachers, has been done on 8 June 2018, followed by 17 participants from various kindergartens in Bandung and its surrounding areas. The participants' knowledge of early childhood mathematics learning was assessed using pre-test which consist of 15 questions. After the training, the participants were given a post-test with the same questions to observe if the participants' knowledge had improved. Participants' scores—before and after the training—are available in; the maximum score is 20.

Table 2. Pre-test and post-test score of the limited trial.

Participant	School	Sex	Test Score		Difference
			Pre	Post	
A	TC Kindergarten	F	15	19	4
B	TC Kindergarten	F	14	17	3
C	PAUD AM	F	11	16	5
D	MI Playgroup	F	9	15	6
E	PAUD AS	F	11	18	7
F	PAUD AS	F	8	16	8
G	IM Childcare	F	12	16	4
H	PAUD AS	F	6	15	9
I	IM Kindergarten	F	13	17	4
J	PAUD AM	F	7	17	10
K	G Playgroup	F	8	15	7
L	PAUD AM	F	6	14	8
M	IH Kindergarten	F	10	17	7
N	AK Islamic Kindergarten	F	14	18	4
O	*Raudhatul Athfal* AM	F	12	18	6
P	PAUD NS	F	5	15	10
Q	PAUD NS	F	7	14	7
	Average score		**9.88**	**16.29**	**6.41**

From Table 2, it is obvious that after training, all participants have improved their score. The average score for pre-test is 9.88, while the average score for post-test is 16.29. Thus, each participant had improved their score as much as 6.41 points in average. However, we want to ensure that the improvement is significant, so the score will be observed using t-paired test.

The first step is to check the normality of the pre-test and post-test difference using Kolmogorov-Smirnov Test. Here the amount of the sample is the same with population number which is 17. Using 95% of confidence interval, the calculated Kolmogorov-Smirnov (KS) is 0.136, which is less than 0.329 (KS table on DF 17—degree of freedom with 17 samples). Therefore, the data of pre-test and post-test difference has normal distribution.

Table 3. Kolmogorov-Smirnov & t-paired test result for participant's pre-test and post-test score.

Statistics	Var I
N sample	17
Mean	6.411764706
Standard Deviation	2.1811357
KS	0.135713235
KS Table	0.32984845
p-value	1.78001E-09

Since the data has normal distribution, the next step is to test the data using t-paired test. The test was done using T.TEST function available on spreadsheet software. The calculation gave the p-value of $1.78001 \times 10^{-9} \approx 0$. With 95% of confidence interval, the p-value is less than 100-95% = 5% = 0.05, which means there is a significant difference between the pre-test and post-test score. Thus, the participant's knowledge of early childhood mathematics learning has improved significantly after the training.

The knowledge improvement of the participant might be caused by the lack of training and education background of the participants. As we can see, most of the participants were teaching at *Pos PAUD*; their education background is mostly high school diploma and their knowledge of early childhood

education came mostly from free trainings and seminars. This is in accordance with the result from [1] which stated that most of the *Pos PAUD* teachers are housewives volunteering to teach at the community's early childhood education. One of the participants was came from *Raudhatul Athfal* which is an Islamic based kindergarten administered under the Ministry of Religion.

The participant also never thought that origami can be used for early childhood learning of mathematics concept. Most of them teach origami to the children to improve creativity, art, and fine motor skills. They also only teach the children how to make the origami models and by using demonstration methods. This is also showed by the lack of study on the use of origami for teaching mathematics concept for early childhood.

5. Conclusion

From the limited trial, we conclude that the user profiles for early mathematics learning strategy are: 1) Understand the science of early childhood development, especially the cognitive aspect of the child; 2) Orientated to the child's needs, safety, shows love and affection to the child during activities; 3) The learning must in accordance with the child development stage; 4) Mathematics learning activity is packed using origami play; and 5) Teacher must be able to stimulate the child's creativity and innovation. The empirical validation of the limited trial showed a significant improvement of the teachers' knowledge of early childhood mathematics learning before and after the training with average score improvement of 6.41 points. The conclusion is supported by the paired T-test on the scores, which showed p-value $1.78001 \times 10^{-9} \approx 0$. Thus, the confidence interval of 95% has been met since the p-value is less than 0.05.

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