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Effect of Paper Folding (Origami) Instruction in Teaching Geometry

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ABSTRACT: Considering the poor performance in mathematics of the Philippines in international examinations like PISA and TIMSS, this paper investigated the effect of paper folding (origami) instruction in teaching geometry. The participants were eighty-six (86) Grade 8 learners which randomly assigned to two groups – the control group and experimental group. This study used the quasi-experimental pre-test/post-test design. The experimental group was exposed to paper folding instruction and the control group learned through non-paper folding instruction. Results revealed the both groups achieved better performance through paper folding and non-paper folding instruction. However, the experimental group recorded higher mathematics performance compared to the control group. Thus, paper folding instruction promoted more effective learning in geometry. The information and insights from this study may be helpful to enhance the learners' performance in geometry, the teacher's strategies in teaching mathematics and to future researchers who would like to undertake similar studies.

KEYWORDS: Origami Paper Folding, Mathematics Instruction, Teaching Geometry, Mathematics Performance

I. INTRODUCTION

Geometry has received limited attention in the mathematics curriculum across the grades, which has been a long-standing problem in the field of mathematics education (Clements and Sarama, 2011). Ligett (2017) presented that the use of manipulative is one way to foster students' understanding in mathematics. Manipulative may play an instrumental role in enhancing geometric reasoning skills of students by creating a suitable context that allows transition from empirical thinking to more abstract thinking (Arici & Aslan-Tutak, 2013).

Paper folding or origami is the Japanese art of paper folding. It uses geometry to create artistic forms (Yuzawa et al., 1999). The use of paper folding in mathematics can help students to achieve many of the desired learning outcomes. Many studies justify these benefits. Just like the findings of Wares (2011) that origami helps students engage in spatial visualization, communicate better, and see that mathematics emanates from various cultural activities, and that mathematics is not just comprised of formulas and calculations. Origami allows many to create their own manipulative, make learning more of a tactile experience, and help teachers excite students who are more artistically inclined about mathematics. Origami based instruction developed students' spatial ability in mathematics (Cakmak et al., 2015).

The Department of Education (DepEd) has pushed for curricular revisions and the adoption of different teaching methodologies to produce a better curriculum and improve the educational system as part of the government's attempts to respond to perceived needs in the education sector (Capate, 2015). Looking on this view, these serious problems in mathematics and mathematics Curriculum Instruction and Evaluation performance must be addressed systematically. It is in this light that the researchers who are mathematics teachers, prompted to undertake the study and determine the effect of paper folding instruction in teaching geometry that could enhance learners' mathematics achievement. Thus, this study determine the effect of using paper folding in instruction to enhance the mathematics performance of Grade 8 learners.

II. METHODOLOGY

A. Research Design

This study employed a quasi-experimental design to determine the effectivity of paper folding instruction in teaching geometry. Quasi-experiments are study designs in which the researcher has only partial (or no) control over randomly allocating participants to categories of a manipulated variable of interest (Cresswell, 2018). The two groups were given a pre-test (control group and experimental group) in order to determine the differences between the groups at the beginning of the experiment and to serve as basis in determining the achievement of both groups at the later part of the experiment. Then the intervention or treatment was introduced to the experimental group. The control group did not receive any treatment. After the intervention, a post-test was made.

B. Participants of the Study

The participants of this study were eighty-six (86) Grade 8 learners in mathematics, which was comprised of two sections, each with fourty-three (43). The two sections of Grade 8 learners were assigned as experimental group and control group. To ensure that the participants have the same level of knowledge in geometry, testing for the significant difference in pre-test was made.

C. Data Gathering Instrument

To measure the learners' mathematics performance in geometry, a 40-item multiple choice test taken from the teacher's manual released by the Department of Education in Mathematics 8 was utilized. The instrument primarily focused on the topics about concepts of geometry, triangle congruence, triangle inequalities, parallel lines and perpendicular lines. The researchers prepared lesson plans prior to the conduct the study. Paper folding instruction and non-paper folding instruction group had the same lesson plan but varied on some parts of the lesson plan such as motivation, evaluation and agreement. Interpretation was based on the following scale: very low (0.00-8.00), low (8.01-16.00), average (16.01-24.00), high (24.01-32.00), and very high (32.01-40.00)

D. Data Gathering Procedure

The data collection procedure was conducted in three stages: pre-experimental stage, experimental stage and post-experimental stage.

Pre-experimental stage. Before conducting the study, the researchers secured a permit of consent to the selected learners who were given the pre-test and post-test in both groups. Likewise, a letter of permission was sent to the principal's office to allow the researchers to conduct the study to the Grade 8 learners. Letters asking permission from parents to allow their children to become participants of the study was also distributed to the parents of the learners who were selected as the participants. At the same time, the researchers secured learners' consent. The instrument was prepared before the session started. There were two teaching methods of instruction used: paper folding instruction for experimental group and non-paper folding instruction for control group. The researchers gave an instruction to the participants of the flow of the sessions; learners were informed of the schedule and duration of the experimentation.

Experimental Stage. The learners were informed, an orientation was done by the researchers to the participants about the materials and procedure used during the discussion. The validated lesson plan for each group was used during the 6-week intervention stage (schedule of activities is attached at the appendices). The lead researcher as Grade 8 mathematics teacher handled both classes within the intervention period. Both groups with the total of eighty-six (86) participants were given the pre-test on the first day of intervention. They were allotted one hour to finish the test, which is equivalent to the actual class of the intervention. The control group, which was exposed to non-paper folding instruction, was given a problem, solving activity, questions or situations and they work as individual or by group. Then a short assessment test in the form of exercise was given to the group which was also the same assessment given to the other group. In the session of experimental group, which was exposed to paper folding instruction, the teacher presented and demonstrated the topic using paper folding which are manipulative and they were given either a group or an individual activity to apply paper folding. Then, at the end of each lesson, they were given an opportunity to solve the given problem using the paper folding. The progress of each group was monitored through quizzes, recitation, responses, and performance tasks based from the lesson plan. The tests which were given as assessment after the class are exactly the same for both groups, to ensure that all other factors like topics, evaluation, and length of contact time is uniform except for the teaching strategies to be used. To make sure that the study was conducted accordingly, class visitations and observations were done by the researchers. One of the mathematics teachers was also requested to conduct regular class observation for the entire duration of the study.

Post-experimental stage. At the end of the six-week period, the 40 items multiple-choice test in mathematics was administered as post-test. The test was given after the period of intervention.

III. RESULTS AND DISCUSSIONS

A. Pre-test achievement in geometry between learners exposed to paper folding instruction and non-paper folding instruction

The pre-test achievement in geometry of learners exposed to paper folding and non-paper folding instruction was determined through mean. Results in pre-test revealed that learners for paper folding instruction (M= 12.43, SD= 4.00) and non-paper folding instruction (M= 11.30, SD= 2.50) had low level of achievement. This indicates that the learners have a narrowed interpretation and limited ideas of the concepts based on their prior knowledge on the selected topics in the third and fourth quarters in mathematics before the intervention. The standard deviation showed that scores in the control group were more homogeneous than that of the experimental group.

An independent-samples t-test was used to compare the pre-test scores between the control and experimental group. Result revealed no significance difference in the pre-test achievement in geometry between paper folding instruction (*M* = 12.23, *SD* = 4.00) and non-paper folding instruction (*M* = 11.30, *SD* = 2.50, *t*(84)= 1.29, *p*= 0.20). The magnitude of mean difference in the pre-test achievement of both learners (*95% CI:* 0.50 to 2.36) was very small (*eta-squared* = 0.02). It implied that the difference of pre-test achievement between two groups is too small. Results showed that the level of achievement in geometry in two treatments was statistically similar and therefore their performances were comparable indicating both groups had similar prior knowledge on geometry before the intervention was given.

Table 1: Pre-Test Achievement in Geometry of Learners Exposed to Paper Folding Instruction and Non-Paper Folding Instruction

Group	Iean	SD	95% CI		df	t	p	Eta-squared
			Lower	Upper				
Pre-test of Experimental Group (Paper folding Instructions)	12.23	4.00	0.50	2.36	84	1.29	0.20	0.02
Pre-test of Control Group (Non-paper folding instructions)	11.30	2.50						

B. Pre-test and Post-test achievement in geometry of learners exposed to paper folding instruction and those exposed to non-paper folding instruction

The difference in the pre-test and post-test scores achievement in geometry of the experimental and control group was determined using paired sample t-test. There was a significant difference between the pre-test (*M* = 12.23, *SD* = 4.00) and post-test (*M* = 21.40, *SD* = 4.81) achievement in geometry of learners exposed to paper folding instruction, *t(42)*= -12.49, *p*=0.001. The magnitude of the means difference in the pre-test and post-test of paper folding instruction group was very large (eta-squared = 0.79). Thus, paper folding instruction can greatly improve learners' achievement in geometry.

There was also a significant difference recorded between the pre-test (*M* = 11.30, *SD* = 2.50) and post-test (*M* = 14.42, *SD* = 3.24) achievement in geometry of learners exposed to non-paper folding instruction, *t(42)*= -6.31, *p*=0.001. The magnitude of the means difference in the pre-test and post-test of non-paper folding instruction group was large (eta-squared = 0.49). Thus, the non-paper folding instruction can also developed learner's mathematics achievement. It simply suggest that either paper folding or non paper folding instruction is used in teaching geometry has an improvement in learners geometry achievement.

Table 3: Pre-test and Post-test achievement in geometry of learners exposed to paper folding instruction and those exposed to non-paper folding instruction

Group	Iean	SD	95% CI		df	t	p	Eta-squared
			Lower	upper				
Pre-test of Experimental Group (Paper folding Instructions)	12.23	4.00	-10.64	-7.68	42	-12.49	0.001	0.79
Post-test of Experimental Group (Paper folding Instructions)	21.40	4.81						
Pre-test of Control Group (Non-paper folding instructions)	11.30	2.50	-4.11	-2.12	42	-6.31	0.001	0.49

Post-test of Control Group (Non-paper folding instructions)	14.42	3.24						

Note: Significant at $\alpha = 0.05$

Post-test achievement in geometry between learners exposed to paper folding instruction and non-paper folding instruction

The post-test results revealed that learners for paper folding instruction (*M*= 21.40, *SD*= 6.89) had an average level of mathematics achievement while non-paper folding instruction (*M*= 14.42, *SD*= 2.81) had low level of mathematics achievement. This indicates that learners exposed to paper folding instruction had greatly improved than those learners exposed to non-paper folding instruction and the standard deviation showed heterogeneity in the experimental group while homogeneity existed in the control group.

An independent-samples t-test shows that there is a significant difference in the post-test achievement scores of the learners exposed to paper folding instruction (*M* = 21.40, *SD* = 6.89) and non-paper folding instruction (*M* = 14.42, *SD* = 2.81), *t (84)* = 6.15, *p*= 0.001. The magnitude of mean difference in the post-test achievement scores (*MD* = 6.98, *95% CI*: 4.71 to 9.25) was large (*eta-squared* = 0.31). The result shows that learners exposed to paper folding instruction had acquired more knowledge in understanding the concepts on geometry, which indicates that learners can appropriately linked representations and insight pertaining in the topics. With this learning's became their edge in answering the mathematics test compared to the learners exposed in non-paper folding instruction. This implied that paper folding instruction is more effective than non-paper folding instruction in teaching geometry to address the mathematics achievement of the learners. The result is parallel with Obi et al. (2014) where students who are exposed to paper folding (origami) instruction gained higher mean score in remembering some geometric terms and concepts. It also helps students to retain the things they have learned and in turn improve their achievement in geometry. This finding is also supported by Gurbuz (2018) who discussed that the students were able to reach solutions more easily by concretizing the intangible questions through paper folding. Similarly, Cakmak, et al. (2014) also revealed that origami (paper folding) based instruction had positive effect on students' spatial ability. The integration of paper folding in teaching mathematics specifically in geometry can improve learners' mathematics achievement (Wares, 2013). The result is also validated by the findings of Arici and Aslan-Tutak (2013) in the effect of origami-based instruction on students' geometry achievement and geometry reasoning concerning triangles, which revealed that origami is a tool to empower in teaching geometry and make geometry learning more effective. Likewise, Yuzawa et al. (1999) revealed that children could acquire a meaningful understanding through paper works such as origami practice. However, Boakes (2009), did not find significant difference between origami instruction and traditional method, but found out that the approach affects the spatial ability of males and females differently.

Table 4: Difference in Post-test Achievement in Geometry between Learners Exposed to Paper Folding Instruction and Non-Paper Folding Instruction

Group	Iean	SD	95% CI		df	t	p	Eta-squared
			Lower	Upper				
Pre-test of Experimental Group (Paper folding Instructions)	12.23	21.40	4.41	9.25	84	6.15	0.001*	0.31
Pre-test of Control Group (Non-paper folding instructions)	14.42	3.24						

Note: Significant at $\alpha = 0.05$

IV. CONCLUSIONS

The use of paper folding (origami) instruction in teaching geometry has a positive effect on the learners' performance in mathematics. This study also shows that this type of teaching is a way better to the current mode of instruction in the Philippines. Augmenting paper folding activities in teaching geometry enabled the learners to understand and think comprehensively. It also provided the learners chance to explore positive and meaningful learning experience. Paper folding instruction provide meaningful learning experience to learners as they continue to develop positive attitudes towards geometry. Cakmak et al. (2014) explained that even though students having difficulty in paper folding, they developed positive opinions on the use of paper folding and its relation to mathematics.

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