ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Teaching Geometry through Paper Folding

Sheila Mae Manlangit, M. Ed.
University of the Philippines Cebu
Corresponding Author Email: *sheilamanlangit@gmail.com*

Received: 19 January 2024 **Revised**: 24 February 2024 **Accepted**: 26 February 2024

Available Online: 26 February 2024

Volume III (2024), Issue 1, P-ISSN – 2984-7567; E-ISSN - 2945-3577

Abstract
Aim: The study aimed to determine the effectiveness of manipulatives in the form of paper folding in teaching Geometry to the Grade 9 students of Lawaan National High School, Third Quarter of the School Year 2017–2018.
Methodology: This study is a quasi-experimental method of research which made use of the pretest–posttest nonequivalent control group design.
Results: The findings of the study are the following: (1) the pretest performance in Geometry of the control and experimental groups were both Below Average; the two groups had Above Average posttest performance in Geometry, (2) both the control and experimental groups had significant mean gains from the pretest to posttest, (3) there was no significant mean gain difference between the two groups, (4) the experimental group exhibited a Positive attitude towards Paper Folding Approach in Geometry, and (5) there was no significant correlation between the attitude of the students towards Geometry taught through Paper Folding and their performance in the subject.
Conclusion: Both approaches were proven effective in enhancing student's performance in Geometry. Engelmann's Direct Instruction which highlights the use of straightforward approach in teaching where the teacher feeds the information to the students was affirmed in this study. Likewise, Paper Folding Approach was supported by Kolb's Experiential Learning Theory which emphasizes that concrete objects can stimulate better learning was affirmed as well.

Keywords: Manipulative, Paper Folding, Geometry

Introduction

A statement by an English philosopher, scholar, and scientist, Roger Bacon, as cited by Hackett (2013) "Neglect of Mathematics works injury to all knowledge, since he who is ignorant of it cannot know the other sciences or the things in the world," tells about how essential Mathematics is.

The Philippine educational system has been modified from time to time in order to elevate the countries status being one of the developing countries as adhered by the International Statistical Institute. Since, mathematics education is one of the subjects acknowledged as a major factor in development; authorities have been focusing their attention into it. However, mathematics achievement of the country is evidently low based on the local, national, and international test results.

Based on the reports from the Department of Education, the National Achievement Test (NAT) average mean percentage score (MPS) for high school in school year 2012 – 2013 was only 51.41% with an MPS of 46.83% in mathematics. This performance fails to reach the standard mastery level of 75%. Furthermore, as cited by Dingal (2016), according to Trends in International Mathematics and Science Study (TIMSS), among the 46 countries, Philippines ranked 42nd having an average scale score of 378, failing to achieve the international average of 467.

Sherman (2017) categorized the factors on why students struggle with Mathematics. Some of the factors identified were the gap between the learner and the subject matter and individual factors such as locus of control, memory ability, attention span, and understanding the language of Mathematics. Most of the students' have difficulty liking and learning the subject because they find the subject too abstract.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Teaching in a public secondary school for more than three years, the researcher observed the passive attitude and low performance of the students towards the subject. The usual reasons are that it is too abstract to imagine, and formulas, theorems, and mathematical concepts are difficult to memorize.

Two theories were used as anchors in this study, namely, Direct Instruction by Siegfried Engelmann and Experiential Learning by David Kolb.

Direct Instruction by Engelmann which is the conventional method of teaching, highlights a face-to-face instruction by a teacher using a structured daily lesson (Engelmann & Becker, 1975). As it is straightforward using clear and direct language, direct instruction is suited in teaching skills, which is why most teachers use this method in teaching Mathematics. In the traditional classroom environment, teacher standing in front of the classroom presenting information was considered as a productive approach to learning because a large amount of information could be provided in a short period of time (Smith, 2009 as cited by Pableo, 2016). In fact, Direct Instruction (explicit instruction) is cited as one of the three evidence – based mathematics instructional strategies in an article published by The IRIS Center of the Vanderbilt University. "The IRIS Cener of Vanderbilt University" (n.d.) further specify the steps in using Direct Instruction: (1) orientation of the lesson, (2) initial instruction, (3) teacher-guided practice, (4) independent practice, (5) check, and (6) reteach. This theory served as the basis of the conventional lecture method used in the control group.

Contrary to Direct Instruction, the use of manipulatives as classroom instruction is anchored on Kolb's Experiential Learning Theory. Experiential learning involves a, "direct encounter with the phenomena being studied rather than merely thinking about the encounter, or only considering the possibility of doing something about it." (Borzak, 1981 as quoted by Smith, 2011).

Kolb's model on Experiential Learning shows that the process of learning is a continuous cycle with four stages. As illustrated in Figure 1, concrete experiences are the basis of reflections. These reflections are integrated into abstract concepts from which new conclusions can be drawn. These conclusions can be actively tested and serve as guides in creating new experiences.

John Dewey basically refers the theory as "learning–by–doing". He emphasizes that students will learn best if they are personally involved in the learning process such as in an activity. Therefore, in order to promote meaningful learning, the teacher should make careful plan on the activities to be experienced by the students.

The theories of David Kolb and John Dewey were the bases for the Paper Folding Approach which was applied to the experimental group.

In article posted in Education Week by Loewus (2014), entitled "*Study: Struggling Math Students Need Direct Instruction, Not "Fun" Activities"*, a university researcher, Paul Morgan, compared Direct Instruction to the use of manipulatives. He claimed that Direct Instruction is more effective to those students who are learning basic math concepts for the first time and to those who have been identified to have math learning disabilities.

Upon multiple meta-analyses, Luke (2013) in his paper, On Explicit and Direct Instruction, concluded that direct instruction is a necessary part of an effective school-level response however it cannot be considered as a universal or total curriculum solution.

There are a number of benefits that a teacher can get when using manipulatives in teaching Mathematics. Jarvin and McNeil (2011), provided an overview on the three theories supporting the use of manipulatives in Mathematics instruction. First, manipulatives offer students further method to learning mathematical concepts. Second, manipulatives provide students with the opportunity to bring about real-life knowledge. Third, the integration of manipulatives may boost physical activity.

In Geometry, one of the challenges that a teacher has to face is to inculcate the different properties and formulas for various types of polygons. In fact, according to the National Center for Education Statistics in 2003, Geometry was recognized as one of the area of weakness among students. However, paper folding, specifically origami has been found to reinforce an understanding of geometric concepts (Ramirez, 2012). One of the reasons is that paper folding can represent geometric concepts like lines and angles through its folds and creases.

In the present, several personalities have encouraged the use of paper folding as a form of classroom instruction. Some of the famous names in the field are Robert J. Lang and Patsy Wang – Iverson who have authored a number of books regarding Paper Folding in Mathematics and Engineering. Liu (2017) in his article The Magic and Mathematics of Paper-Folding discussed the incredible connection of paper folding to Mathematics specifically Algebra and Geometry. Similarly, a professor of University of Alberta, Alton T. Olson, provided detailed instructions in illustrating various mathematical concepts in his paper, Mathematics Through Paper Folding.

Kay (2013) evaluated the impact of direct instruction and constructive-based instruction on the secondary and middle school student attitude and learning performance. In his study, he found out that students performed

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

better in the understanding and application knowledge categories when direct instruction was applied. He further speculated that a direct-instruction design may be better suited to younger students who are learning basic level concepts.

The study conducted by Mansyur (2015) aimed in obtaining an established instructional design to support mental-modeling ability discovered that the use of external representation into direct instruction can support students' mental-modeling ability.

In Zhang's (2017) study, "*Effects of Visual Working Memory Training and Direct Instruction on Geometry Problem Solving in Students with Geometry Difficulties*", it was found out that the students remarkably improved their working memory and enhanced their performance on the spatial rotation and general geometric problem-solving. However, their performance on specific tasks related to triangle-congruence did not improve until direct instruction with concrete-representational-abstract was introduced.

On the other hand the use of manipulatives in teaching Mathematics is not foreign in the field of education. They are generally used as teaching tools in order to engage students in hand-on learning and visualization of the abstract mathematical concepts. Indeed, various studies and researches were conducted to evaluate the effectiveness of manipulatives, concrete and visual, as part of the different teaching methods used in teaching Mathematics.

A study by Bouck, et al. (2015) which aimed to investigate the use of virtual manipulative known as polynominoes as a tool in presenting area and perimeter found out that the said manipulative, helped in improving the understanding of area and perimeter by the middle school students with disabilities.

Another study was conducted by Carbonneau, et al. (2015) on preschool children. The study revealed that learning is improved when the instruction is conducted with high levels of guidance and is impacted by the perceptual qualities of manipulatives. It further indicated that the said manipulatives decreased the performance of the learners on outcomes that deal with conceptual knowledge and improved the performance of the learners in terms of transfer of learning. Moreover, the said transfer of learning is positively affected by the manipulatives when there is low level of instructional guidance.

Kablan (2016) examined the influence of manipulatives when combined with traditional approaches in Mathematics and how the duration of time spent in using the manipulative influence the achievement of the students through the various learning styles. The result of the study revealed that abstract learners showed a higher performance when the traditional methods were used. Concrete learners demonstrated higher performance when the manipulatives were used as compared to their performance when only abstract instructions were given. Nevertheless, the increase in the duration of manipulative use did not show a clear advantage to concrete learners.

Lee, et al. (2014) investigated the impacts of virtual and physical manipulatives and Prior Knowledge in Grade 8 Geometry. The study revealed that students with high prior knowledge and engaged in virtual manipulatives had better performance and displayed greater enjoyment in the subject.

Pableo (2016) studied the effectiveness of the use of algebra tiles in teaching polynomial factoring and found out that the students exposed to the said manipulative had better academic performance than those who were not. Likewise, Templa (2017) in her study on virtual manipulatives as an intervention in teaching polynomial operations presented a positive result. She emphasized that the use of virtual algebra tiles was proven better than the conventional method.

However in another study conducted by Boakes (2011) which focused on the impact of the use of Origami, the art of paper folding, as a teaching tool in middle grade Mathematics, she found out that mathematics instruction with Origami are as beneficial as the traditional instruction in teaching geometrical terms and concepts.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Conceptual Framework

The theoretical background which shows the conceptual framework of the study in schematic diagram is shown in below.

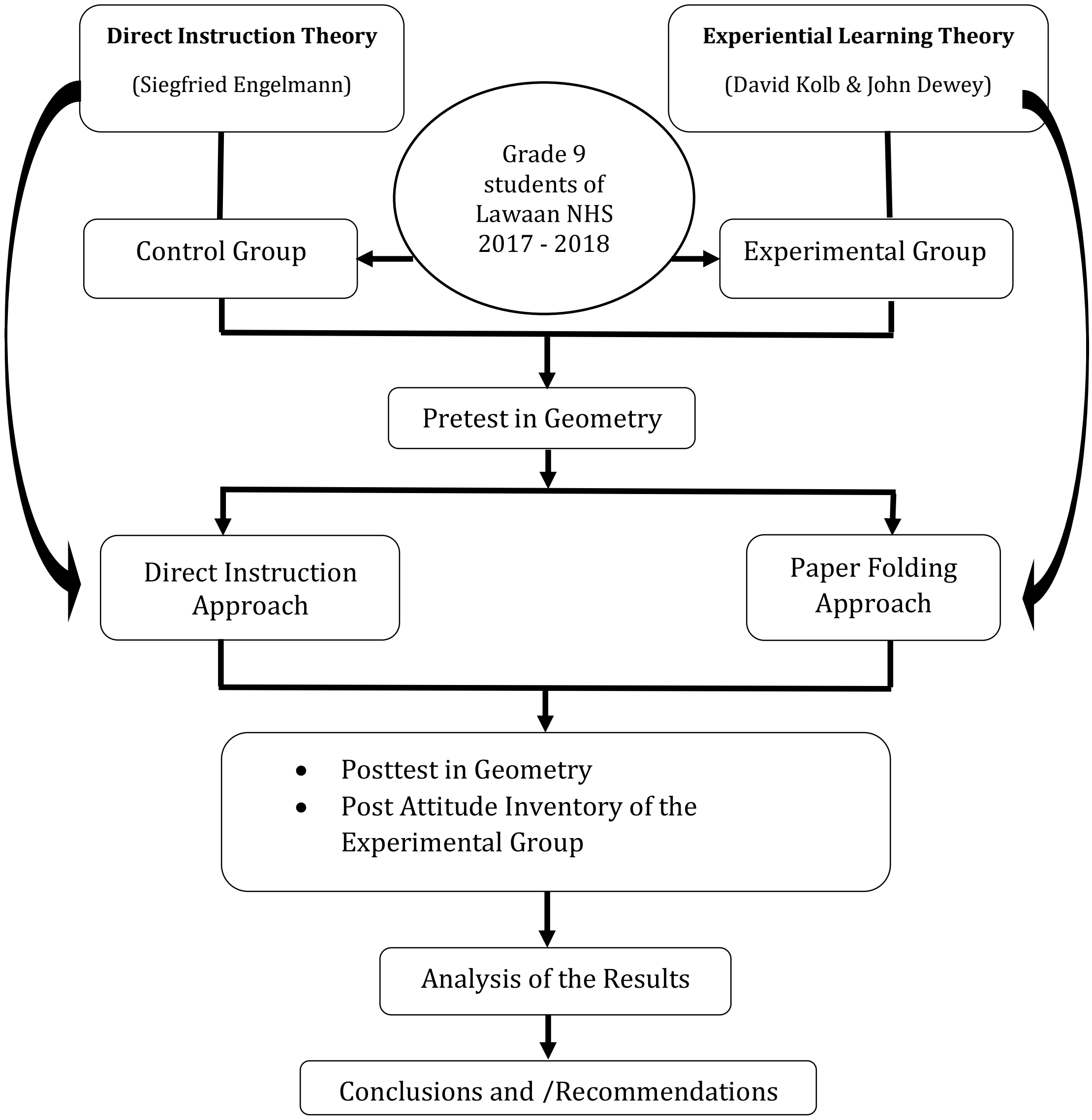

Figure 1. The Theoretical - Conceptual Framework of the Study in Schematic Diagram

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035
Thank you for embracing the culture of research with us!

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR P - ISSN 2984-7567 E - ISSN 2945-3577
The Exigency P - ISSN 2984-7842 E - ISSN 1908-3181

As shown in Figure 1, the study was anchored on Siegfried Engelmann's Direct Instruction Theory and Experiential Learning Theory by David Kolb and John Dewey.

The Grade 9 students of Lawaan National High School with two sections were randomly identified as the control and experimental groups. Both groups took the same pretests. The control group was taught the Properties of Quadrilaterals and Triangle Similarities using the Direct Instruction Approach, specifically the conventional lecture method, as supported by Direct Instruction Theory while the experimental group was taught the same topic using the Paper Folding Approach.

After the application, the two groups took the same posttests. The data that were gathered were analyzed and interpreted using the appropriate statistical treatments which served as the bases for the conclusions and recommendations.

Objectives

The main purpose of this study was to determine and compare the effectiveness of Direct Instruction and Paper Folding approaches in teaching Geometry to the Grade 9 students in Lawaan National High School.

Specifically, it aimed to answer the following questions:

1. What is the level of performance in the pretest and posttest in Geometry of the:
    1.1. control group (subjected to direct instruction approach), and
    1.2. experimental group (subjected to paper folding approach)?
2. Is there a significant mean gain in the performance of the students in the pretest to the posttest in Geometry of the:
    2.1. control group, and
    2.2. experimental group?
3. Is there a significant difference in the mean gains between the control group and the experimental group?
4. What is the attitude of the students in the experimental group towards Geometry after using the Paper Folding Approach?
5. Is there a significant correlation between the students' performance in Geometry and their attitude towards the subject?

Hypotheses

These are the hypotheses of the study.

Ho_1: There is no significant difference between the hypothetical mean and the actual mean of the students in the pretest and posttest in terms of their performance in Geometry of the:
2.1. control group, and
2.2. experimental group.

Ho_2: There is no significant mean gain in the performance of the students from the pretest to the posttest of the:
2.1. control group, and
2.2. experimental group.

Ho_3. There is no significant difference in the mean gain between the control and the experimental groups.

Ho_4. There is no significant correlation between the students' performance in Geometry and their attitude towards the subject.

Methods

Research Design

This study used a quasi-experimental method of research which utilized pretest – posttest nonequivalent control group design as shown in the following diagram:

G_1	O_1	X	O_2
G_2	O_3	--	O_4

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

where: G_1 is the experimental group exposed to the use of paper folding in teaching Geometry;
G_2 is the control group exposed to direct instruction in teaching Geometry;
O_1 and O_3 are the pretests;
O_2 and O_4 are postests; and
X is the experimental intervention which refers to the use of paper folding in teaching Geometry.

Research Environment

The study was conducted at Lawaan National High School located in Barangay Lawaan, in the city of Danao. It is situated approximately 25 kilometers away from Poblacion, Danao City. It operated since 1975 and became the first public school in the mountain barangays of Danao, catering more than 15 barangays. Since it is a public high school, its Mathematics curriculum follows the K to 12 curriculum guide approved by the Department of Education. Currently, due to the existence of new high schools and integrated schools around the area, it offers junior (JHS) and senior (SHS) high school education offering Academic Track – General Academic Strand and Technical-Vocational-Livelihood Track – Electrical Installation and Maintenance with around 300 students.

Research Subjects

This research utilized the existing two Grade 9 sections of Lawaan National High School which had 41 students each. The two sections were grouped into control group and experimental group. Only 32 and 33 students were included in the control and experimental groups respectively. The control group was taught using the Direct Instruction Approach while the experimental group was taught through the Paper Folding Approach.

Data Gathering Procedure

The researcher secured permission from the Principal of Lawaan National High School (see Appendix A). Upon approval, a prescribed pretest from the Department of Education as found on the students' Learner's Material was administered. This was followed by the conduct of the experiment. The control group was taught through direct instruction while the experimental group was taught with the use of paper folding. Consequently, posttest was administered and the results were gathered to answer the problems of the study.

Pedagogical Approach

Two pedagogical approaches were used to conduct this study. Direct Instruction was applied to the control group while the use of Paper Folding was applied to the experimental group. The time and amount of instruction for both groups were the same and were taught using the prescribed instructional plan by the Department of Education Division of Danao City following the method of 3Ps (Preparation, Presentation, Practice) and 2As (Assessment and Assignment).

The study focused on the topics under the Third Grading of Grade 9 Mathematics; Properties of Quadrilaterals and Triangle Similarities as it was conducted in the entire third quarter of the S.Y. 2017 – 2018.

Control Group

In the control group, the teacher taught the competencies of the aforementioned topics through lecture method. This was followed by a teacher – guided practice such as drill and board work. Then formative test was conducted. This was repeated until the whole module was covered. Lastly, posttest was administered.

Experimental Group

On the other hand, in the experimental group, the group was given at most two sessions to explore and familiarize the basic concepts of paper folding. In order to learn the concept, the teacher distributed a guide sheet and students were given time to follow the written instructions and use paper folding in deriving the concepts with the help of guide questions from the teacher (see Appendix I). Just like the other group, they underwent a teacher – guided practice but on the abstraction of the concept. Then formative test was administered. The same process happened until the whole module was taken up and posttest was conducted. Questionnaires were given in order to evaluate the student's attitude towards paper folding.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Research Instruments

The main research instruments are two 25 – item test in Geometry which covers Properties of Quadrilaterals and Triangle Similarities. The test items were taken from the pretests found on the Learning Materials of Mathematics 9 and summative tests from the Teaching Guide of Mathematics 9. These materials were distributed by the Department of Education to all the public schools in the country. Although the pretest and posttest were not identical, they have the same level of difficulty. Another instrument used in this research is a Mathematics Attitude Scale adapted from Maxima Ruyca (1994).

Statistical Treatment

The following statistical treatments were used in order to answer the problems in this study:

1. To determine the level of performances of the control and experimental groups in the pretest and posttest in Geometry, the *z* test of single and large sample was used.
2. In order to determine whether there is a significant mean gain in the performance of the students in Geometry from the pretest and posttest in Geometry, the *t* test for correlated samples was utilized.
3. The *t* test of two independent samples was used to compare the performances between the experimental and the control groups.
4. To determine the students' attitude towards Paper Folding Approach in Geometry, the weighted m the four-point Likert Scale was calculated.
5. To establish the relationship between the attitude of the students and their performance in Geor Pearson Product-Moment Coefficient of correlation, *r* was used.

RESULTS AND DISCUSSIONS

Performance Level of the Grade 9 Students in Geometry

The performance levels of the Grade 9 students were obtained from the pretest and posttest conducted before and after the experimentation.

Table 1 shows the pretest performance in Geometry of the Grade 9 students.

Table 1. Pretest Performance Level of the Grade 9 Students in Geometry

Groups	n	Hypothetical Mean	Actual Mean	S_d	Difference between Means	Test Statistics			Qualitative Description
						Computed z	Tabled z-value	P-value	
Control (Direct Instruction Approach)	32	15	8.34	2.10	6.66	17.94*	1.96	0.0001*	Below Average
Experimental (Paper Folding Approach)	33	15	8.79	2.97	6.21	12.01*	1.96	0.0001*	Below Average

Hypothetical Mean is equal to the 60% of the total number of points in the test.
*significant at 5% level of significance with $n-1$ degree of freedom.

Table 1 showed that the control group obtained an actual mean 8.34 with an SD of 2.10, while the experimental group had an actual mean of 8.79 with an SD of 2.97. The computed z values of the control group and the experimental group were 17.94 and 12.01 which were greater than the tabled z-value which was 1.96. The p-value of the control group was 0.0001 which was less than $\alpha = 0.05$, hence Ho_1 was rejected. This meant that there was a significant difference between the hypothetical mean and the actual mean of the control group which indicated a performance of Below Average. Likewise, the p-value of the experimental group was 0.0001 which was less than $\alpha = 0.05$, Ho_1 was rejected. Therefore, there was a significant difference between the hypothetical mean and the actual mean of the experimental group which also indicated a Below Average performance. The pretest performance level of the control and experimental group did not meet the 60% standard criterion of the Department of Education. This below average performance of both groups could be attributed to the fact that the students might have little or no knowledge on the subject as it was not discussed yet, considering it was a pre-assessment.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

The level of posttest performance of the Grade 9 students in Geometry was revealed in Table 2.

Table 2. Posttest Performance Level of the Grade 9 Students in Geometry

Groups	n	Hypothetical Mean	Actual Mean	S_d	Difference between Means	Test Statistics		Qualitative Description
						Computed z	P-value	
Control (Direct Instruction Approach)	32	15	17	1.78	2	6.36*	0.0001*	Above Average
Experimental (Paper Folding Approach)	33	15	17.64	2.64	2.64	5.72*	0.0001*	Above Average

*significant at 5% level of significance with $n - 1$ degree of freedom.

Table 2 indicated that the actual mean of the control group is 17 with a standard deviation of 1.78. The computed z-value is 6.36 with the p-value of 0.0001 which was less than $a = 0.05$, thus significant and therefore rejected Ho_1. This meant that there was a difference between the hypothetical and actual means, thus expressed Above Average performance in the posttest indicating that the students performed way above the 60% criterion. This can be attributed to the Direct Instruction Approach applied in teaching Geometry where the students got all the information which were explicitly taught by the teacher.

This finding supported the study of Kay (2013) where the students were able to performed better in the understanding and application of knowledge when direct instruction was applied.

Similarly, the experimental group had an actual mean of 17.63 and a standard deviation of 2.64. It was higher than the hypothetical mean of 15. The computed z-value was 5.72 with a p-value of 0.0001 which was less than $a = 0.05$. Both tests were significant, thus the rejection of Ho_1. The performance of the experimental group in the posttest was Above Average which meant that the students who were exposed to the Paper Folding Approach were able to go beyond the 60% standard criterion of the Department of Education. This Above Average performance may imply that the students might have learned the topics with the help of Paper Folding. This could be attributed to the fact that Paper Folding enabled the student to visualize the concepts through the use of folds and creases in the paper which served as models of the geometrical concepts.

This finding supported the study of Boakes (20011) which expressed that the art of paper folding are beneficial to the students.

Mean Gain of the Grade 9 Student's Performance in Geometry

In order to check the improvement in the performance from the pretest to the posttest in Geometry of the control group who were exposed to Direct Instruction and the experimental group who were taught through the Paper Folding Approach, the results were presented in Table 3.

Table 3. Mean Gain of the Performance of the Students in Geometry

Groups	n	Pretest Mean	Posstest Mean	Mean Gain	S_d	Test Statistics	
						Computed t	p – value
Control (Direct Instruction Approach)	32	8.34	17	8.66	3.08	15.91*	0.0001*
Experimental (Paper Folding Approach)	33	8.78	17.64	8.86	3.56	14.27*	0.0001*

*significant at 5% level of significance with $n - 2$ degree of freedom.

It can be seen from Table 3 that the control group obtained a mean gain of 8.66 (Sd=3.08) while the experimental group recorded a mean gain of 8.85 (Sd=3.56). The computed t-values of the control group was 15.91

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035
Thank you for embracing the culture of research with us!

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

and 14.28 for the experimental group respectively. The p-value of both groups was 0.0001 which was less than $\alpha = 0.05$. Since both tests were significant, Ho_2 was rejected. This meant that both the control and experimental groups obtained significant mean improvement from the pretest to the posttest in Geometry. This implied that the two approaches, Direct Instruction and Paper Folding Approach, were effective in enhancing the performance of Grade 9 students in Geometry.

The significant improvement of the control group could possibly be because the students might have exhibited substantial understanding of the concepts of quadrilaterals and triangle similarities regardless of the fact that the teacher predominantly input the concepts during the classroom instruction.

This result supported the studies of Kay (2013), Mansyur (2015), Klahr (2017), and Zhang (2017) that Direct Instruction can effectively improve the student's performance.

This finding affirmed the Theory of Direct Instruction by Engelmann in which the teacher uses structured daily lesson which are straightforward using clear and direct language.

This finding reinforced the claim of Lesh (1979) that manipulatives can effectively be an intermediary between the mathematical concepts to the real world. This further supported the studies of Bouck (2015), Pableo (2016), and Templa (2017) which revealed that the use of manipulative improves the students' academic performance in Mathematics.

This finding affirmed the Experiential Learning Theory of David Kolb and John Dewey's "learning by doing" that experiential lessons provide students with an opportunity to experience concepts first-hand, and as such, give students more meaningful understanding of course concepts.

Comparison on the Mean Gains in Geometry between Control and Experimental Groups

It was hypothesized that there is no significant difference between the mean gain of the control and the experimental groups.

Table 4 compared the performance of the control and experimental groups in terms of their mean gains in Geometry.

Table 4. Difference in Mean Gains between Control and Experimental Groups

Groups	n	Mean Gain	S_d	Difference between Mean Gains	Test Statistics	
					Computed t	p – value
Control (Direct Instruction Approach)	32	8.66	3.08	0.19	0.23[ns]	0.82 [ns]
Experimental (Paper Folding Approach)	33	8.85	3.56			

[ns] not significant at $\alpha = 0.05$

Table 4 revealed that there was only a difference 0.19 in mean gains in Geometry in favor of the experimental group. The computed t-value was 0.231 with a p-value of 0.82 which was greater than $\alpha = 0.05$, thus not significant and therefore failed to reject Ho_3. There was no significant difference between the mean gains of the control group and the experimental group. This meant that the performance of the experimental group under Paper Folding Approach was comparable to that of the performance of the students in the control group which used Direct Instruction. Although the teacher acted mainly as a facilitator in the Paper Folding Approach with less talk on the teacher's part, the students were able to perform comparably with those who were exposed to Direct Instruction where the teacher explicitly discussed the topics.

This supported the study of Zhang (2017) on visual working memory training and direct instruction. Both groups of students enhanced their working memory and enhanced their performance in general geometric problems. One group improved through direct instruction and the other group improved through visual working memory training using manipulatives.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Attitudes of the Grade 9 Students in the Experimental Group towards Paper Folding Approach in Geometry

Table 5 illustrated the attitude of the experimental group towards Geometry after being exposed to the Paper Folding Approach.

Table 5. Attitudes of Grade 9 Students in the Experimental Group towards Paper Folding Approach in Geometry

Experimental (Paper Folding Approach)	**Mean Attitude**	**SD**	**Qualitative Description**
n = 32	3.02*	0.33	Positive

*3.26 – 4.00 (Very Positive)
2.51 – 3.25 (Positive)
1.76 – 2.50 (Negative)
1.00 – 1.75 (Very Negative)

Based on the results presented in Table 5, the students of the experimental group had a mean attitude of 3.02 (Sd=0.33). This meant that the students displayed a positive attitude towards Geometry after being exposed to the Paper Folding Approach. This may mean that the use of manipulative might have given the students with meaningful and exciting learning experiences which made them like the subject.

During the conduct of the study, some students in the experimental group evidently displayed enthusiasm towards the Paper Folding Approach verbally. They expressed that they enjoyed paper folding because it did not feel like the usual Mathematics class with ample of equations and formulae to be memorized and solved.

However, there were also some students who displayed confusion and anxiety with the Paper Folding Approach. Some of them experienced difficulty in following some steps in discovering and constructing geometrical figures. Nevertheless, with the guidance of the teacher, they were able to utilize the manipulative effectively.

This supported the study of Carbonneau (2015) which revealed that learning is improved when the instruction is conducted with high levels of guidance and is affected by the perceptual qualities of manipulatives.

Relationship between the Students' Attitude towards Paper Folding Approach in Geometry and their Performance in the Subject

To establish the relationship between the attitude of the students towards Paper Folding in Geometry and their performance, the Pearson Product-Moment Coefficient of correlation, r was computed and the results were presented in Table 6 below.

Table 6. Correlation between the attitude and the performance of the students in Geometry using Paper Folding

Variables	**n**	**Mean**	S_d	**Computed r**	**Description**	**p - value**
Attitude	33	3.02	0.33	0.27^{ns}	Low	0.129
Performance	33	17.63	2.64			

^{ns} not significant

Legend:

0.0	no correlation
±0.01 - ±0.20	negligible
±0.21 - ± 0.40	low/slight
±0.41 - ± 0.60	marked/substantial
± 0.61 - ±0.80	high
±0.81 - ± 0.99	very high
±1.00	perfect

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR P - ISSN 2984-7567 E - ISSN 2945-3577
The Exigency P - ISSN 2984-7842 E - ISSN 1908-3181

As reflected in Table 6, the computed r is 0.27 and the p - value which is 0.129 which is greater than $\alpha = 0.05$. These values were not significant which failed to reject Ho_4. This means that there was no significant relationship between attitude and performance. The attitude of the experimental group towards Paper Folding Approach in Geometry had no bearing on their performance in the subject which implies that the performances of the students were not attributed to their attitude towards the subject. This means that students who expressed a positive attitude towards the subject might have high or low performance in the subject. Likewise, students who did not exhibit a positive attitude towards the subject might also have high or low performance. Therefore, the performance of the student toward Paper Folding Approach in Geometry could not be predicted through their attitude towards the subject. This finding supported Pableo's (2016) study on the use of manipulative in teaching polynomial factoring in intermediate algebra. He claimed that the students' attitude was not a predictor of their performance.

Conclusions

Understanding and applying geometric concepts have not been easy for students. Their performance level on the subject varies according to different factors. The most significant factors are comprehension and mastery of the topics. However, these are hardly met due to the large number of theories and concepts that are expected to be learned in a certain period of time. In this regard, teacher's pedagogical approaches might also help students' understanding geometrical concepts.

Based on the findings of the study, the Paper Folding Approach was comparably effective as the Direct Instruction Approach in teaching geometric concepts as evidenced by enhanced learning of the Grade 9 students. So, there is no single method that is best for teaching geometrical concepts. Teachers therefore may use a variety of ways and methods considering that the artistry of teaching depends on the teacher's skill in blending several methods into a unified teaching.

Kolb's (1984) Experiential Learning Theory which emphasized that a student should be engaged in direct experience in order to increase knowledge and develop skills and Engelmann's (1975) Direct Instruction Theory which focused on the straightforward approach in teaching by using clear and direct language, were affirmed by the findings of this study.

Recommendations

Based on the results and conclusions, the following were recommended:

1. that teachers include Paper Folding approach in their repertoire of teaching methods, and use this approach in teaching geometrical concepts (Properties of Quadrilaterals and Triangle Similarities) because it was found to be comparably effective in enhancing the performance level in Geometry of the Grade 9 students in Lawaan National High School;
2. that trainings and seminar-workshops be conducted to expose, train, and encourage teachers on the utilization of manipulatives in teaching Geometry as it will help students of different learning styles;
3. that teachers make their own manipulatives as instructional aid in order to enhance students' Mathematics performance;
4. that instructional materials such as manipulatives be made accessible to teachers and students in order to achieve higher level of performance in Geometry;
5. that future researches be conducted on utilizing paper folding in other topics in Mathematics; and
6. that longer time for experimentation be used to gain more conclusive results of its effects.

REFERENCES

Association of Foundations (2016). State of Philippine Education. Retrieved from http://afonline.org/afnewsroom/state-of-philippine-education/

Basic Philosophy on Direct Instruction (2015). Retrieved from National Institute for Direct Instruction: https://www.nifdi.org/15/index.php?option=com_conten t&view=article&id=52&Itemid=27

Boakes, N. J. (2011). *The effects of origami lessons on students' spatial visualization skills and achievement levels in a seventh -grade mathematics classroom* (Order No. 3233416). Available from ProQuest

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035
Thank you for embracing the culture of research with us!

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Dissertations & Theses Global. (304985255). Retrieved from https://search.proquest.com/docview/3049 85255?accountid=47253

Boakes, N. J. (2011). *Origami-Mathematics Lessons: Paper Folding as a Teaching Tool. Mathtitudes* (1)1, pp. 1-9.

Boakes, N. J. (2011). *Origami Instruction in the Middle School Mathematics Classroom: Its Impact on Spatial Visulaization and Geometry Knowledge of Students.* Research in Middle Level Education Online, 32(7).

Bouck, E. et al. (2015). Learning Area and Perimeter with Virtual Manipulatives. Retrieved from https://eric.ed.gov/?q=manipulatives+in+teaching&id=EJ 1079416

Carbonneau, K., et al. (2015). Instructional Guidance and Realism of Manipulatives Influence Preschool Children's Mathematics Learning. Retrieved from https://eric.ed.gov/?q=manipulatives+in+teaching&id=EJ1071109

de Dios, A. (2013). The National Achievement Test in the Philippines. Retrieved from http://www.philippinesbasiceducation.us/2013/07/the-nationalachievemen t-test-in.html

Dingal, A. (2016). Integrating Manipulatives in Teaching of Grade 7 Mathematics. University of the Philippines Cebu.

Explicit Instruction (n.d.). The IRIS Center of Vanderbilt University. Retrieved from https://iris.peabody.vanderbilt.edu/module/dbi1/cresource/q2/p07/explicit- instruction/

Hackett, J. (2013). *Roger Bacon (Stanford Encyclopedia of Philosophy)*. Stanford.edu. https://plato.stanford.edu/entries/roger-bacon/

Kablan, Z. (2016). The Effect of Manipulatives on Mathematics Achievement across Different Learning Styles. Retrieved from https://eric.ed.gov/?q=manipulative s+in+teaching&pg=2&id=EJ1087082

Kay, R. (2013). Evaluating the Instructional Architecture of Web-Based Learning Tools (WBLTs): Direct Instruction vs. Constructivism Revisited. *Journal of Interactive Learning Research, 24*(1), 33-51. Waynesville, NC: Association for the Advancement of Computing in Education (AACE). Retrieved May 25, 2018 from https://www.learntechlib.org/primary/p/38591/.

Lee, C.Y. (2014). The Impacts of Virtual Manipulatives and Prior Knowledge on Geometry Learning Performance in Junior High School. Retrieved from https://eric.ed.gov/?q=manipulatives+in+teaching&pg=2&id=EJ1076449

Liu, K. (2017). The Magic and Mathematics of Paper-Folding. Retrieved from https://www.tor.com/2017/06/29/the-magic-and-mathematics-of-paper-folding/

Loewus, L.H. (2014). Study: Struggling Math Students Need Direct Instruction, Not "Fun" Activities. Retrieved from Education Week: http://blogs.edweek.org/edweek/curriculum/2014/06/struggling_math_stud ents_ need_.html

Luke, A. (2013). On Explicit and Direct Instruction. *Australian Literacy Educators' Association.* Retrieved from https://www.alea.edu.au/documents/item/861

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Mansyur, J. (2016). Enhancing Direct Instruction on Introductory Physics for Supporting Students; Mental-Modeling Ability. International Education Studies Vol.9, No. 6. Retrieved fromhttps://eric.ed.gov/?q=direct+instruction &id=EJ1103510

McNeil, N.M., & Jarvin, L. (2007). When Theories don't add up: Disentangling the manipulatives debate. Theory into practice, 46(4), pp. 309-316. doi:10.1080/00405840701593899

Pableo, M. (2016). Use of Manipulatives (Algebra Tiles) in Teaching Polynomial Factoring in Intermediate Algebra. University of the Philippines Cebu.

Sherman, H.J., et al. (2017). Why Do Students Struggle with Mathematics. Retrieved from https://www.education.com/download-pdf/reference/26734/

Smith, M. K. (2011). 'David A. Kolb on experiential learning', *the encyclopedia of informal education.* Retrieved from http://infed.org/mobi/david-a-kolb-on- experiential-learning/

Templa, L. Z. (2017). Virtual Manipulatives as Intervention in Teaching Polynomial Operations in Algebra. University of the Philippines Cebu.

What evidence-based mathematics instructional strategies can teachers employ? (2017). Retrieved from https://iris.peabody.vanderbilt.edu/module/math/ cresource/q3/p06/#content

Zhang, D. (2017). Effects of Visual Working Memory Training and Direct Instruction on Geometry Problem Solving in Students with Geometry Difficulties. Learning Disabilities: A Contemporary Journal 15(1), pp. 117-138.