Teaching Selected Topics in Geometry Using Manipulative Instructional Materials Among Grade 7 Students in Community Vocational High School

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***Abstract*— With the advancement of learning management, the researcher employed quasi-experimental method of research using the pretest and posttest group design with sixty Grade 7 students, of whom thirty were taught using manipulative materials and other thirty were taught without manipulative materials. The level of pretest performance of the control group for the undefined terms, angles and polygons are 6.63, 6.50 and 6.97 which described as low while the posttest of the control group are 12.83 high, 11.53 average and 12.93 high. Also, the experimental group, 9.13 average, 6.50 low and 10.23 average while the posttest of the experimental group are 17.93 very high, 15.73 high and 14.23 high. Moreover, the difference in the level of pretest and posttest performances of the control group for the three indicators mentioned is shown by the computed t-value of 7.68, 8.11 and 7.96. While, in experimental group the computed t-value of 15.77, 18.47 and 6.66 which both group exceeded the critical-t value of 1.70 with 29 degrees of freedom. Therefore, the null hypothesis is rejected and there is significant difference between the variables. In addition, the difference in the level of pretest performance of the control and experimental groups for the three indicators are 3.19 rejected for the undefined terms, 0 accepted for the angles, and 4.58 rejected for polygons. There is no significant difference in the level of pretest performance of control and experimental groups in angle, while the two indicators have significant difference. For posttest level, there is a significant difference in undefined terms and angles with 5.12 and 5.35, and no significant difference in terms of polygons with 1.64 compared with critical-t value of 1.67 of 58 degrees of freedom. Considering the results, the instructional design was crafted to help the teachers in managing day to day lessons in Geometry.**

Keywords— ***geometry, undefined terms, angles, polygon, manipulative materials***

I. INTRODUCTION

The advancement of science and technology has brought about numerous innovations in education. These innovations must be given due consideration so that those that are necessary and relevant would be adopted. Mathematics education has received greater attention in the more advanced countries of the world particularly in scientific and industrial research activities. Through their discoveries there is now an increased scientific and industrial application of Mathematics.

The world knew that Mathematics is the oldest of all sciences that have developed through the ages and have a direct impact to the quality of human life. It is one of the important and useful subjects taught in school. It is the backbone of students to achieve and develop the skill in reasoning and thinking. In this modern world of advanced science and technology the importance of learning Mathematics is essential. While, geometry is one of the branches of Mathematics, that developed most of man's modern life today.

However, it cannot be denied that in spite of its usefulness, importance and influence, Mathematics, particularly Geometry is disliked by many students. It is a subject most feared by students from the primary school to secondary schools (Choudhury and Das, 2012). Teachers face certain problems in teaching the subject. Among such problems are the poor foundation and low performance levels of the students which could be due to many factors. Thus, it means that the teacher's role in the teaching of Mathematics is of vital importance.

As of today's curriculum, K-12, the concepts of Geometry is in the spiral progression throughout the grades advancing in level of difficulty. It is essential that the basic concepts in Geometry like undefined terms, angles and polygons must understand clearly to be applied in the real life scenario. Learning difficulties could be overcome if students' interest is stimulated the use of more teaching materials and different approaches arouse interest and makes the learning process more pleasant, meaningful and fruitful.

The teacher, therefore, should decide on the instructional procedure most suitable to a particular Mathematics lesson. Likewise, Hidalgo (2011) cited in his article that the teacher's knowledge of content and how to teach effectively; their knowledge of how students learn; and the teacher's teaching practices that support learning, including the learning experiences they provide, immensely affect the learning process of students. Thus, educators have endless quest for innovative approaches to make learners learn better in a productive and optimum level.

On the other hand, innovative instruction like manipulative materials are of great help in imparting to the students the importance of the subject and of the things available around them thus making the concepts more meaningful particularly undefined terms, angles and polygons.

In connection with this, Oladejo et al. (2011) viewed that manipulative teaching materials are concrete, hands-on models from the real world which can be moved, played or touched by students. When students are given chance to interact with this concrete models, young children will be learned mathematical concepts better. It is because students like to manipulate and experiment. Therefore, to address the fear and difficulty of students that are mentioned above, Mathematics should be enjoyable with the use of manipulative instructional materials.

The challenge of achieving effective results in the teaching of mathematics is being met by new programs of instruction, new teaching materials, and new teaching methods in the area of mathematics education. With the use of these changes and innovations in modern mathematics teaching, highly abstract concepts become more consistent with reality.

One of the goals of the researcher is to find tools on how the lessons in Mathematics are learned with fun and enjoyment by the students. Also, this in response to the institution's plan to further improve the level of quality of Mathematics instruction as evidenced by the annual increase in the Mean Percentile Scores (MPSs) in the National Achievement Test (NAT).

Notably, Community Vocational High School registered an increasing pattern in the National Achievement Test results in Mathematics in three consecutive years from SY 2012-2013 of 45.86%, SY 2013-2014 of 58.68% and SY 2014-2015 of 54.40%. However, it still indicated low mastery and failure to meet the 75% mean percentage score (MPS). At this status, the researcher saw fit to conduct the study on hand, though the traditional approach in teaching has been substantially used for so many years, to determine the improvement employ in the performance of the students.

II. METHODS

This study employed a quasi-experimental method of research using the pretest and posttest group design. The performance of the respondents in Geometry in terms of undefined terms, angles and polygons in their pretest and posttest were compared. This study was conducted in Community Vocational High School. It is located at Masipit, Calapan City with the total area of 5000 square meters. It is not a fiscally autonomous school composed of 20 male and 37 female teachers and has a total population of 1272 students for the academic year 2018-2019. This is the lone school in the Schools Division of Calapan City headed by a Principal II that facilitates the use of Strengthened Technological and Vocational Program (STVEP), with electives such as Special Program in Journalism and Special Program in Foreign Language.

This study was composed of sixty (60) Grade 7 students, of whom thirty (30) were taught using any manipulative instructional materials and another thirty (30) were taught without using manipulative instructional materials. The respondents of this study were chosen using the non-proportional stratified random sampling technique to generate the groups of proficient (85-89), approaching proficiency (80-84) and developing (75-79).

A self-made test was the main instrument of this study. It was composed of 20 items for undefined terms, 20 items for angles and 20 items for polygons. The instrument had undergone content validation through the expertise and assistance of the two Master Teachers of Mathematics from Community Vocational High School and Porfirio G. Comia Memorial National High School; and the Principal of Community Vocational High School. The validators were expert teachers with vast experiences in test construction, performance assessment and teaching in their field. The experts' opinions were considered in the content validation. Their suggestions and comments were taken for the improvement of the instrument.

Data gathered were described using descriptive and inferential statistics namely: frequency, percentage, and mean. The hypotheses were tested using t-test analyses. For descriptive statistics, frequency was used to show the number of times a particular result occurs in a statistical survey absolute frequency. While, percentage was used to determine the quantity of the occurrences of the score in the pretest and posttest for the control and experimental groups and arithmetic mean was used to determine the average scores in every topic for both control and experimental groups. Moreover, t-test as inferential statistics was used to determine the correlated and uncorrelated means.

III. RESULTS AND DISCUSSION

1. Level of pretest performance of the control group

1.1 Undefined terms

Table 1.1 shows the frequency and percentage distribution on the level of pretest performance of the control group in undefined terms. Sixteen (16) students or 53.33% obtained scores ranging from 5 – 8 described as low. Seven (7) out of thirty (30) students or 23.33% of the respondents obtained scores ranging from 0 – 4 described as very low. Six (6) students or 20% obtained scores ranging from 9 – 12 described as average. There was one (1) or 3.33% of the respondents who got scores ranging from 13 – 16 described as high. The mean score was 6.63 described as low.

The result implies that the control group demonstrates fairly satisfactory performance in undefined terms. This means that they have limited knowledge with these lessons because the lessons on geometry during elementary years focused only on plane and solid figures. This further indicates that the students' learning on undefined terms is also attributed to the pedagogical approaches employed by the teacher since in most cases the lessons on point, line and plane are delivered through the use of chalk-talk, or the use of illustrations but not the use of concrete or manipulative materials to better understands the lesson. The finding supports Kontas' (2016) notion which pointed out that manipulatives are effective in increasing the achievement scores of the students.

Table 1.1. Level of pretest performance of the control group in undefined terms

Score	Frequency	Percentage	Description
17 – 20	0	0	Very High
13 – 16	1	3.33	High
9 – 12	6	20	Average
5 – 8	16	53.33	Low
0 – 4	7	23.33	Very Low
Total	**30**	**100.00**	

Mean: 6.63
Description: Low

1.2 Angles

Table 1.2 shows the frequency and percentage distribution on the level of pretest performance of the control group in angles.As indicated, thirteen (13) students or 43.33% obtained scores ranging from 5 – 8 described as low. Nine (9) out of thirty (30) students or 30% of the respondents obtained scores ranging from 0 – 4 described as very low. Six (6) students or 20% obtained scores ranging from 9 – 12 described as average. There were two (2) or 6.67% of the respondents who got scores ranging from 13 – 16 described as high. The mean score was 6.50 described as low.

The finding implies that the control group performs fairly satisfactory in angles. This maybe because the students cannot apply even the simple lessons they have learned in angles. This also means that they are not familiar with some lessons like pair of angles since these are not taken in their early studies. Obviously, students tend to simply guess their answers without any basis or reference to guide them.

The finding conforms to Mitchelmore and White's study (2010) which concluded that the major difficulty in learning to identify a physical angle situation lies in identifying the two linear parts of the angle.

This further confirms Good's (2010) study which concluded that the technique of teaching executed by the teacher in presenting the subject-matter to the pupils is very important.

Table 1.2 Level of pretest performance of the control group in angles

Score	Frequency	Percentage	Description
17 – 20	0	0	Very High
13 – 16	2	6.67	High
9 – 12	6	20	Average
5 – 8	13	43.33	Low
0 – 4	9	30	Very Low
Total	**30**	**100.00**	

Mean: 6.50
Description: Low

1.3 Polygons

Table 1.3 shows the frequency and percentage distribution on the level of pretest performance of the control group in polygons. There were thirteen (13) students or 43.33% obtained scores ranging from 5 – 8 described as low. Ten (10) out of thirty (30) students or 33.33% of the respondents obtained scores ranging from 9 – 12 described as average. Seven (7) students or 23.33% obtained scores ranging from 0 – 4 described as very low. None got scores ranging from 13 – 16 and 17 - 20. The mean score was 6.97 described as low. This implies that the control group demonstrates fairly satisfactory performance in polygons. This could be attributed to the fact that respondents have shown difficulty in understanding and performing word problems in polygons. This supports Orteza's (2011) claim which stated that students encountered difficulty in Mathematics because they lack of computational skills and analysis in solving problems.

Table 1.3. Level of pretest performance of the control group in polygons

Score	Frequency	Percentage	Description
17 – 20	0	0	Very High
13 – 16	0	0	High
9 – 12	10	33.33	Average
5 – 8	13	43.33	Low
0 – 4	7	23.33	Very Low
Total	**30**	**100.00**	

Mean: 6.97
Description: Low

2. Level of posttest performance of the control group.

2.1 Undefined terms

Table 2.1 shows the frequency and percentage distribution on the level of posttest performance of the control group in undefined terms. The table demonstrates that ten (10) or 33.33% of the respondents obtained scores ranging from 17 – 20 described as very high. Eight (8) or 26.67% of the respondents obtained scores ranging from 13 – 16 described as high. There were four (4) or 13.33% of the respondents who got scores ranging from 9 – 12 described as average. However, there were five (5) or 16.67% of the respondents who got scores ranging from 5 – 8 described as low. And there were still three (3) or 10% of the respondents who got scores ranging from 0 – 4 described as very low. The mean score obtained by the respondents was 12.83 described as high.

It implies that the control group demonstrates very satisfactory performance in the posttest. This indicates that the students' learning on the lessons covering undefined terms are facilitated using traditional approach such as group activities. The respondents tend to show mastery in different mathematical tasks. The finding supports Barte et al.'s study (2016) which suggested that teachers need to utilize innovative strategies and present the lesson in a more interactive manner.

Table 2.1. Level of posttest performance of the control group in undefined terms

Score	Frequency	Percentage	Description
17 – 20	10	33.33	Very High
13 – 16	8	26.67	High
9 – 12	4	13.33	Average
5 – 8	5	16.67	Low
0 – 4	3	10	Very Low
Total	**30**	**100.00**	

Mean: 12.83
Description: High

2.2 Angles

Table 2.2 shows the frequency and percentage distribution on the level of posttest performance of the control group in angles. Data revealed that seventeen (17) or 56.67% of the respondents obtained scores ranging from 9 – 12 described as average. Five (5) or 16.67% of the respondents obtained scores ranging from 13 – 16 described as high. There were four (4) or 13.33% of the respondents who got the same ranging from 17 – 20 and 5 -8 described as very high and low respectively. None got scores ranging from 0 – 4 described as very low. The mean score obtained by the respondents was 11.53 described as average.

The finding implies that the control group performs satisfactory in the posttest in terms of angles. This means that the respondents have not fully learned their lessons in angles using the lecture-discussion with exercises to better develop their thinking skills.

The finding supports Pascuala's study (2014) which revealed that the instructional practices engaged the students into actively participate in their own learning and enhanced the development of complex cognitive skills.

Table 2.2. Level of posttest performance of the control group in angles

Score	Frequency	Percentage	Description
17 – 20	4	13.33	Very High
13 – 16	5	16.67	High
9 – 12	17	56.67	Average
5 – 8	4	13.33	Low
0 – 4	0	0	Very Low
Total	**30**	**100.00**	

Mean: 11.53
Description: Average

2.3 Polygons

Table 2.3 shows the frequency and percentage distribution on the level of posttest performance of the control group in polygons. Twelve (12) or 40% of the respondents obtained scores ranging from 13 – 16 described as high. Eight (8) or 26.67% of the respondents obtained scores ranging from 9 – 12 described as average. There were five (5) or 16.67% of the respondents who got scores ranging from 17 – 20 described as very high and ranging from 5 – 8 described as low. None got scores ranging from 0 – 4 described as very low. The mean score obtained by the respondents was 12.93 described as high.

The result implies that the control group demonstrates very satisfactory performance in polygons. This indicates that the students learn better on the lessons covering polygons through illustration of figures when taught using traditional approach which eventually help them in enhancing their critical thinking skills. This finding provides support to Wambui's study (2013) which revealed that when the relationships are presented visually, they became much easier to comprehend. This finding is also parallel to Gal and Linchevski's notion (2010) which pointed out that children prefer to rely on a visual prototype rather than a verbal definition.

Table 2.3. Level of posttest performance of the control group in polygons

Score	Frequency	Percentage	Description
17 – 20	5	16.67	Very High
13 – 16	12	40	High
9 – 12	8	26.67	Average
5 – 8	5	16.67	Low
0 – 4	0	0	Very Low
Total	**30**	**100.00**	

Mean: 12.93
Description: High

3. Level of pretest performance of the experimental group.

3.1 Undefined terms

Table 3.1 shows the frequency and percentage distribution on the level of pretest performance of the experimental group in undefined terms. A total of thirteen (13) or 43.33% of the respondents got scores ranging from 9 – 12 described as average. Eleven (11) or 36.67% of the respondents obtained scores ranging from 5 – 8 described as low. There were four (4) or 13.33% of the respondents who got scores ranging from 13 – 16 described as high. However, there were two (2) or 6.67% of the respondents who got scores ranging from 0 – 4 described as very low. And no one got scores ranging from 17 – 20 described as very high. The student respondents have shown average performance as indicated by its mean score of 9.13. The result implies that the experimental group demonstrates satisfactory performance in undefined terms. This indicates that students from the experimental group have an inadequate background or prior knowledge regarding undefined terms since these competencies are not basic in their elementary levels. The finding supports Furner and Worrel's (2017) study which suggested that teachers need to encourage student exploration and related discussion about the prospective Math concept they teach.

Table 3.1. Level of pretest performance of the experimental group in undefined terms

Score	Frequency	Percentage	Description
17 – 20	0	0	Very High
13 – 16	4	13.33	High
9 – 12	13	43.33	Average
5 – 8	11	36.67	Low
0 – 4	2	6.67	Very Low
Total	**30**	**100.00**	

Mean: 9.13
Description: Average

3.2 Angles

Table 3.2 shows the frequency and percentage distribution on the level of pretest performance of the experimental group in angles. Data revealed that eighteen (18) or 60% of the respondents got scores ranging from 5 – 8 described as low. Seven (7) or 23.33% of the respondents obtained scores ranging from 9 – 12 described as average. There were five (5) or 16.67% of the respondents who got scores ranging from 0 – 4 described as very low. And no one got scores ranging from 13 – 16 and 17 – 20 described as high and very high respectively. The student respondents have shown low performance as indicated by its mean score of 6.50. The result implies that the experimental group demonstrates fairly satisfactory performance in angles. This may be attributed to their weak foundation in elementary grades. This means that they lack enough knowledge on these lessons which involve the basic concepts of angles. The finding supports Clements' study (2017) which revealed that students have great difficulty in learning angles such that it is a multifaceted concept.

Table 3.2. Level of pretest performance of the experimental group in angles

Score	Frequency	Percentage	Description
17 – 20	0	0	Very High
13 – 16	0	0	High
9 – 12	7	23.33	Average
5 – 8	18	60	Low
0 – 4	5	16.67	Very Low
Total	**30**	**100.00**	

Mean: 6.50
Description: Low

3.3 Polygons

Table 3.3 shows the frequency and percentage distribution on the level of pretest performance of the experimental group in polygons. As indicated, sixteen (16) or 53.33% of the respondents got scores ranging from 9 – 12 described as average. Eight (8) or 26.67% of the respondents obtained scores ranging from 13 – 16 described as high. There were five (5) or 16.67% of the respondents who got scores ranging from 5 – 8 described as low. However, there was only one (1) or 3.33% of the respondents who got scores ranging from 0 – 4 described as very low. And no one got scores ranging from 17 – 20 described as very high. The student respondents have shown average performance as indicated by its mean score of 10.23. The result implies that the experimental group demonstrates satisfactory performance in polygons. This finding indicates that the respondents show inadequacy on the knowledge about polygons especially in those word problems on the interior and exterior angles of a polygon. The finding provides supports Cuizon's study (2015) which suggested that Mathematics' teachers should maximize the use of innovative teaching strategies for these will help students' mathematical performance.

Table 3.3. Level of pretest performance of the experimental group in polygons

Score	Frequency	Percentage	Description
17 – 20	0	0	Very High
13 – 16	8	26.67	High
9 – 12	16	53.33	Average
5 – 8	5	16.67	Low
0 – 4	1	3.33	Very Low
Total	**30**	**100.00**	

Mean: 10.23
Description: Average

4. Level of posttest performance of the experimental group.

4.1 Undefined terms

Table 4.1 shows the frequency and percentage distribution of the level of posttest performance of the experimental group in undefined terms. It could be seen in the table that twenty-five (25) or 83.33% of the respondents obtained scores ranging from 17 – 20 described as very high. Four (4) or 13.33% of the respondents got scores ranging from 13 – 16 described as high. There was one (1) or 3.33% of the respondents who attained scores ranging from 9 – 12 described as average. The respondents got a mean score of 17.93 described as very high. It implies that the experimental group demonstrates outstanding performance in undefined terms. This indicates that students best learn undefined terms when given manipulative materials such as pompoms, pick up stick, ribbon lace, and cardboard in the delivery of these lessons. This further shows that the students' cognitive skills have been developed thus, facilitating their learning. Such case likewise proves that the experimental group demonstrates greater interest toward the lessons when exposed to the use of manipulative materials. The results support the Cognitive Learning Theory by Piaget (1980) which viewed that children can acquire the skills to reason and drive generalizations through concrete experiences. This further confirms Gates' (2011) view which stated that manipulative instructional materials are still effective for the understanding of new mathematical concepts.

Table 4.1. Level of posttest performance of the experimental group in undefined terms

Score	Frequency	Percentage	Description
17 – 20	25	83.33	Very High
13 – 16	4	13.33	High
9 – 12	1	3.33	Average
5 – 8	0	0	Low
0 – 4	0	0	Very Low
Total	**30**	**100.00**	

Mean: 17.93
Description: Very High

4.2 Angles

Table 4.2 shows the frequency and percentage distribution of the level of posttest performance of the experimental group in angles. Fourteen (14) or 46.67% of the respondents obtained scores ranging from 17 – 20 described as very high. Thirteen (13) or 43.33% of the respondents got scores ranging from 13 – 16 described as high. There were two (2) or 6.67% of the respondents who attained scores ranging from 9 – 12 described as average. However, there was only one (1) or 3.33% of the respondents obtained score ranging from 5 – 8 described as low. The respondents got a mean score of 15.73 described as high. It implies that the experimental group demonstrates very satisfactory performance in their posttest in terms of angles. This indicates that the students' learning on the lessons covering angles is facilitated when taught using manipulative materials such as match stick, popsicle stick, made clock, and protractor. It also shows that students appreciate the use of manipulative materials as these could serve as stimulus to learn angles. This finding supports the Enactive representation of Constructivism Learning Theory by Bruner (1973) which viewed that children learn about the world through actions on physical objects and the outcomes of these actions.

Table 4.2. Level of posttest performance of the experimental group in angles

Score	Frequency	Percentage	Description
17 – 20	14	46.67	Very High
13 – 16	13	43.33	High
9 – 12	2	6.67	Average
5 – 8	1	3.33	Low
0 – 4	0	0	Very Low
Total	**30**	**100.00**	

Mean: 15.73
Description: High

4.3 Polygons

Table 4.3 shows the frequency and percentage distribution of the level of posttest performance of the experimental group in polygons. The table demonstrates that twenty-two (22) or 73.33% of the respondents obtained scores ranging from 13 – 16 described as high. Four (4) or 13.33% of the respondents got scores ranging from 9 – 12 described as average. There were three (3) or 10% of the respondents who attained scores ranging from 17 – 20 described as very high. There was one (1) or 3.33% of the respondents got scores ranging from 5 – 8 described as low. The respondents got a mean score of 14.23 described as high. It implies that the experimental group demonstrates a very satisfactory performance in their posttest in terms of polygons. This indicates that the students learn very well on the lessons covering polygons when taught using manipulative materials such as cardboard, string, matchsticks, and protractor. These manipulative materials are the tools to stimulate the interest of the students when they are engaged in different activities particularly in discovering the relationship between the sides and angles of a polygon. This finding supports to Sulistyaningsih et.al' s view (2016) which cited that teachers are needed to use manipulative materials to facilitate students' understanding of the concept of Mathematics. This conforms to Bruner's Theory of Iconic Representation (1973) which explained that the learning can be obtained through using models and pictures.

Table 4.3. Level of posttest performance of the experimental group in polygons

Score	Frequency	Percentage	Description
17 – 20	3	10	Very High
13 – 16	22	73.33	High
9 – 12	4	13.33	Average
5 – 8	1	3.33	Low
0 – 4	0	0	Very Low
Total	**30**	**100.00**	

Mean: 14.23
Description: High

5. **Difference in the level of pretest and posttest performances of the control group.**

5.1 Undefined terms

Table 5.1 presents the t-test results on pretest and posttest performances of the control group in undefined terms. There is a significant difference between the pretest and posttest performances in undefined terms of the control group since the computed t-value of 7.68 exceeded the critical value of 1.70 using 29 degrees of freedom at 5%level of significance. Therefore, the null hypothesis is rejected. This implies that the control group demonstrates distinct performance in their pretest and posttest in terms of undefined terms. This indicates that the control group had shown improvement in their posttest performance with a mean difference of 6.20. It is evident that students have gained knowledge in undefined terms when taught using traditional approach through group activities. The result supports Ball's (2017) study which revealed that students magically learned the Mathematics concept and drew the correct conclusion that the teacher intended her students as derived from the activity. This conforms to Thorndike's Theory which viewed that learning has taken place when a strong connection or bond between stimulus and response is formed.

Table 5.1. T-Test results on pretest and posttest performances of the control group in undefined terms.

Traditional Approach	Mean Scores	Mean Difference	Computed t-value	Critical t-value	Results
Pretest	6.63				
vs.		6.20	7.68	1.70	Significant
Posttest	12.83				

5.2 Angles

Table 5.2 presents the t-test results on pretest and posttest performances of the control group in angles. There is a significant difference between the pretest and posttest performances in angles of the control group since the computed t-value of 8.11 exceeded the critical t-value of 1.70 using 29 degrees of freedom at 5% level of significance. Therefore, the null hypothesis is rejected. This implies that the control group demonstrates comparable performances in their pretest and posttest in terms of angles. The mean difference of 5.03 indicates improvement particularly in their posttest performance. This means that students have learned angles when taught using traditional approach as they demonstrate facility understanding the lessons. This finding supports Piaget Cognitive Learning Theory (1980) which explained that the mental ability of a child in Mathematics depends on the acquisition of the lessons presented by the teachers.

Table 5.2. T-Test results on pretest and posttest performances of the control group in angles.

Traditional Approach	Mean Scores	Mean Difference	Computed t-value	Critical t-value	Results
Pretest	6.50				
vs.		5.03	8.11	1.70	Significant
Posttest	11.53				

5.3 Polygons

Table 5.3 presents the t-test results on pretest and posttest performances of the control group in polygons. There is a significant difference between the pretest and posttest performances in polygons of the control group since the computed t-value of 7.96 exceeded the critical t-value of 1.70 using 29 degree of freedom at 5% level of significance. Therefore, the null hypothesis is rejected. This implies that the control group demonstrates varying levels of performance in their pretest and posttest in terms of polygons. A mean difference of 5.96 indicates that the students show better performance in their posttest. This means that students have learned knowledge in polygons when taught using traditional approach such as showing illustrations of figures in addition to providing them with complete details during the discussion that further help them understand the basic concepts and principles of polygons. This conforms to Dewey's Theory of Inquiry which viewed that there is a basic difference between logic and methodology and the requirements in question subsist prior to and independent of inquiry.

Table 5.3. T-Test results on pretest and posttest performances of the control group in polygons.

Traditional Approach	Mean Scores	Mean Difference	Computed t-value	Critical t-value	Results
Pretest	6.97				
vs.		5.96	7.96	1.70	Significant
Posttest	12.93				

6. Difference in the level of pretest and posttest performances of the experimental group.

6.1 Undefined terms

Table 6.1 presents the t-test results on pretest and posttest performances of the experimental group in undefined terms. There is a significant difference in the level of pretest and posttest performances in undefined terms of the experimental group since the computed t-value of 15.77 exceeded the critical t-value of 1.70 using 29 degrees of freedom at 5% level of significance. Hence, the null hypothesis is rejected. This result implies that the experimental group show better performance in posttest than in pretest in terms of undefined terms as indicated by the mean difference of 8.8. This means that the use of manipulative materials has contributed to facilitate student learning in undefined terms since it can create greater interest and motivation. The result supports the National Council of Teachers of Mathematics' findings (2016) which concluded that the use of manipulative instructional material creates students' understanding of mathematical concepts.

Table 6.1. T-Test results on pretest and posttest performances of the experimental group in undefined terms.

Manipulative Approach	Mean Scores	Mean Difference	Computed t-value	Critical t-value	Results
Pretest	9.13				
vs.		8.8	15.77	1.70	Significant
Posttest	17.93				

6.2 Angles

Table 6.2 presents the t-test results on pretest and posttest performances of the experimental group in angles. There is a significant difference in the level of pretest and posttest performances in angles of the experimental group since the computed t-value of 18.47 exceeded the critical t-value of 1.70 using 29 degrees of freedom at 5% level of significance. Therefore, the null hypothesis is rejected. This implies that the experimental group has distinct performances in their pretest and posttest in terms of angles. There exists a big mean difference of 9.23 which indicates high improvement particularly in their posttest performance. This means that students perform very well in angles when taught using manipulative materials such as match sticks, popsicle sticks, made clock, and protractor. This tends to show that when the students are involved in a hands-on activity, positive active participation is expected which may lead to better understanding of the lessons. The result supports Kolb's Experiential Learning Theory which stated that experiential learning involves learning from experience.

Table 6.2. T-Test results on pretest and posttest performances of the experimental group in angles.

Manipulative Approach	Mean Scores	Mean Difference	Computed t-value	Critical t-value	Results
Pretest	6.50				
vs.		9.23	18.47	1.70	Significant
Posttest	15.73				

6.3 Polygons

Table 6.3 presents the t-test results on pretest and posttest performances of the experimental group in polygons. There is a significant difference in the level of pretest and posttest performances in polygons of the experimental group since the computed t-value of 6.66 exceeded the critical t-value of 1.70 using 29 degrees of freedom at 5% level of significance. Therefore, the null hypothesis is rejected. This implies that the experimental group demonstrates distinct levels of performance in their pretest and posttest in terms of polygons. The mean difference of 4 indicates that there exists an improvement in their performance particularly in the posttest. This means that students have learned competencies in polygons with the aid of manipulative materials such as cardboard, string, matchsticks, and protractor. The use of manipulative instructional materials in teaching polygons can help facilitate student learning and better motivate the learners to easily learn the topics. The finding conforms to Enki's view (2014) which stated that the use of manipulatives in the classroom enhances students' intrinsic motivation toward Mathematics lessons.

Table 6.3. T-Test results on pretest and posttest performances of the experimental group in polygons.

Manipulative Approach	Mean Scores	Mean Difference	Computed t-value	Critical t-value	Results
Pretest	10.23				
vs.		4	6.66	1.70	Significant
Posttest	14.23				

7. Difference in the level of pretest performance of the control and experimental groups.

7.1 Undefined terms

Table 7.1 presents t-test results on pretest performance in undefined terms of the control and experimental groups. There is a significant difference in the level of pretest performance in undefined terms of the control and experimental groups since the computed t-value of 3.19 exceeded the critical t-value of 1.67 using 58 degrees of freedom at 5% level of significance. Hence, the null hypothesis is rejected. It implies that the control and experimental groups demonstrate differentiated levels of pretest performance in terms of undefined terms. There exists a mean difference of 2.50 which indicates that in undefined terms the pretest performance of experimental group is higher than the control group. It means that although this lesson is introduced in their sixth grade as one of the Mathematics competencies in elementary the experimental group has a better foundation of geometry particularly in undefined terms. The result confirms Thorndike's Theory Law of Readiness (1932) which viewed that a student should learn and understand the basic concepts in their elementary years where they are ready enough to acquire new knowledge and skills.

Table 7.1. T-Test results on pretest performance of the control and experimental groups in undefined terms.

Pretest Results	Mean Scores	Mean Difference	Computed t-value	Critical t-value	Results
Traditional Approach	6.63				
vs.		2.50	3.19	1.67	Significant
Manipulative Materials Approach	9.13				

7.2 Angles

Table 7.2 presents t-test results on pretest performance in angles of the control and experimental groups. There is no significant difference in the level of pretest performance in angles of the control and experimental groups since the computed t-value was 0 which is less than the critical t-value of 1.67 using 58 degrees of freedom at 5% level of significance. Therefore, the null hypothesis is accepted. It implies that the control and experimental groups demonstrate similar in pretest performance in terms of angles. This means that the students have weak foundation or inadequate prior knowledge on angles in their earlier studies which focus only on solid figures like cube, prism, pyramid, cylinder, cone, and sphere. The findings provides support to Piaget's Cognitive Learning Theory (1980) which explained that the different processes concerning learning are in a phase between concrete and formal operational stages.

Table 7.2. T-Test results on pretest performance of the control and experimental groups in angles.

Pretest Results	Mean Scores	Mean Difference	Computed t-value	Critical t-value	Results
Traditional Approach	6.50				
vs.		0	0	1.67	Not Significant
Manipulative Materials Approach	6.50				

7.3 Polygons

Table 7.3 presents t-test results on pretest performance in polygons of the control and experimental groups. There is a significant difference in the level of pretest performance in polygons of the control and experimental groups since the computed t-value of 4.58 exceeded the critical t-value of 1.67 using 58 degrees of freedom at 5% level of significance. Therefore, the null hypothesis is rejected. It implies that the control and experimental groups demonstrate varying levels in their pretest performance in terms of polygons. A mean difference of 3.26 indicates that in polygons the pretest performance of both groups differs. The experimental group performs better than the control group. It means that the experimental group has a background or prior knowledge in polygons than the control group. This tends to show that the experimental group has learned better this concept when taught in their earlier grade level. The result supports Bruner's Constructivism Learning Theory which viewed that learning is an active process in which learners construct ideas or concepts based upon their current or past knowledge.

Table 7.3. T-Test results on pretest performance of the control and experimental groups in polygons.

Pretest Results	Mean Scores	Mean Difference	Computed t-value	Critical t-value	Results
Traditional Approach	6.97				
vs.		3.26	4.58	1.67	Significant
Manipulative Materials Approach	10.23				

8. Difference in the level of posttest performance of the control and experimental groups.

8.1 Undefined terms

Table 8.1 presents t-test results on post-test performance of the control and experimental groups in undefined terms. There is a significant difference in the level of post-test performance of the control and experimental groups in terms of undefined terms since the computed t-value of 5.12 exceeded the critical t-value of 1.67 using 58 degrees of freedom at 5% level of significance. Therefore, the null hypothesis is rejected. This implies that the control and experimental groups have distinct posttest performance in undefined terms. The mean difference of 5.1 indicates that the experimental group performs better than the control group since these manipulative materials compared with those taught using traditional approach. This may be attributed to the fact that students can develop better understanding of the lessons when exposed to real life experiences rather than with memorization. This result supports Sulistyaningsih et al.'s (2016) findings which suggested that the teachers need to use manipulative materials to facilitate students' understanding of the concept of Mathematics.

Table 8.1. T-Test results on posttest performance of the control and experimental groups in undefined terms

Posttest Results	Mean Scores	Mean Difference	Computed t-value	Critical t-value	Results
Traditional Approach	12.83				
vs.		5.1	5.12	1.67	Significant
Manipulative Materials Approach	17.93				

8.2 Angles

Table 8.2 presents t-test results on posttest performance of the control and experimental groups in angles. There is a significant difference in the level of posttest performance of the control and experimental groups in angles since the computed t-value of 5.35 exceeded the critical t-value of 1.67 using 58 degrees of freedom at 5% level of significance. Therefore, the null hypothesis is rejected. This implies that both control and experimental groups have varying levels of posttest performance in angles. The mean difference of 4.2 indicates that experimental group performs better than the control group. This means that experimental group has gained more knowledge in angles using manipulative instructional materials which stimulated them to create a construct of concepts which they could use in performing different activities. This results support Ball's study (2017) which concluded that the manipulatives or physical materials are crucial in improving mathematics learning. This result also supports Bruner's Constructivism Learning Theory which explained that development of students' mental images can abstract ideas more completely when they see, touch, take part, and manipulate physical objects.

Table 8.2. Test Results on posttest performance of the control and experimental groups in angles.

Posttest Results	Mean Scores	Mean Difference	Computed t-value	Critical t-value	Results
Traditional Approach	11.53				
vs.		4.2	5.35	1.67	Significant
Manipulative Materials Approach	15.73				

8.3 Polygons

Table 8.3 presents t-test results on posttest performance of the control and experimental groups in polygons. There is no significant difference in the level of post-test performance of the control and experimental groups in polygons since the computed t-value of 1.64 did not exceeded the critical t-value of 1.67 using 58 degrees of freedom at 5% level of significance. Therefore, the null hypothesis is accepted. This finding implies that both control and experimental groups perform almost equally in their posttest in terms of polygons as indicated by the mean difference of 1.3. This means that they both have gained understanding of polygons as a way to better learn this competency when taught using the traditional and manipulative instructional materials. This finding supports the idea of Ball (2017) which claimed that allowing students to use manipulatives would automatically guide them to the correct mathematical conclusions. This result also strengthens the Thorndike's Theory on Law of Exercise which stated that response to a situation may be strongly connected with the situation depending on the number of times it has been so connected and to the average strength and duration of the connection.

Table 8.3.T-Test results on posttest performance of the control and experimental groups in polygons.

Posttest Results	Mean Scores	Mean Difference	Computed t-value	Critical t-value	Results
Traditional Approach	12.93				
vs.		1.3	1.64	1.67	Not Significant
Manipulative Materials Approach	14.23				

IV. CONCLUSION AND RECOMMENDATIONS

Majority of the experimental group demonstrate better performance in their pretest than the control group showing that the experimental group has a better foundation in Geometry. In addition, majority of the experimental group demonstrate better performance in their posttest than the control group in Geometry showing that the use of manipulative materials can develop students' understanding better.

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