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THE USE OF MANIPULATIVES AND ITS EFFECTS ON THE STUDENTS' MATHEMATICS ACHIEVEMENT: AN EXPERIMENTAL STUDY

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ABSTRACT

The purpose of this study is to investigate the effect of manipulatives (tangible learning materials) both on the mathematics' achievement of 9th grade students. Pretest-posttest control group experimental model, which is one of the quasi-experimental research designs, was used in the study. The study group consisted of 86 ninth grade students (42 in experiment group and 44 in control group) studying in Camanlangan National High School in school year 2022-2023. As a result of the research, posttest mathematics academic achievement scores of experimental and control groups were found to differ significantly in favor of posttests in both groups. Hence, the use of manipulatives in teaching students helped improved their performance in mathematics.

KEYWORDS: *manipulative, mathematics achievement, secondary school students Camanlangan National High School*

Chapter I

INTRODUCTION

The Problem and its Background

The use of manipulative in teaching mathematics helps make abstract ideas concrete. This is a teaching strategy that uses physical objects that are designed to represent concretely mathematical ideas that are abstract (Moyer, 2001). It is described as physical things or concrete objects students may use to investigate and acquire an understanding or comprehension of a mathematical idea. The most common manipulatives are number lines, spinners, decimal blocks, geoboards, integer tiles, tools for measurement, fraction tiles, geared clocks, and a graphing mat. The usage of these affords realistic means for students to learn abstract mathematical topics.

A study was conducted in Southwest Laurens Elementary School in Georgia, USA which revealed that students tend to be motivated and enjoy mathematics more when using manipulatives. They became more actively engaged in learning new concepts and there was much more communication between students instead of just between the students and the teacher. Based on the pretest and posttest scores, it indicated that the learning of the math concepts was significantly improved when teaching using manipulatives (Taylor, 2009).

During the academic year 2014–2015, a study was also done in the public school in the Southeast of Turkey. The research revealed significant differences between the posttest mathematics academic achievement scores of the experiment and control groups, favoring posttests in both groups, for the study group of 48 seventh grade students (24 in the experiment group and 24 in the control group).

It was also revealed in the study of Cautivo (2022) which was conducted in Cateel Central Elementary School, Cateel, Davao Oriental that using manipulatives stimulates learners' interest, increases their mathematical skills, and develops concentration and perseverance skills while learning about cause and effect and creatively analyzing and solving problems.

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In Camanlangan National High School, the current work station of the researcher, she observes that there is a need for teachers to use manipulatives in teaching mathematics concepts. Teachers who settled for conventional method of teaching experienced difficulties especially if lessons are too abstract and difficult to comprehend. Traditional teaching method in mathematics deprives the students to be more critical and creative which is one of the basic 21st century skills. With this, the researcher finds it interesting to know the effectiveness of using manipulatives to bridge the competency gap or the least learned competencies which are very observable among the students.

Statement of the Problem

The main purpose of this experimental study was to determine the effectiveness of the utilization of manipulative as a teaching strategy to bridge the competency gap in mathematics and increase students' academic achievement. Specifically, it sought to answer the following questions:

1. What is the achievement level of students in control and experimental group in the Pretest?
2. What is the achievement level of students in control and experimental group in the Posttest?
3. Is there a significant difference in the achievement level of students in control group as reflected in their pretest and post-test?
4. Is there a significant difference in the achievement level of students in experimental group as reflected in their pretest and post-test?
5. Is there a significant difference in the achievement level of students in control and experimental groups in terms of their pretest scores?
6. Is there a significant difference in the achievement level of students in control and experimental group in terms of their post-test score?

Null Hypotheses

The null hypotheses below are tested at 0.05 level of significance:

HO_1: There is no significant difference in the mathematics achievement levels of students in the control group in terms of their pretest and post-test scores.

HO_2: There is no significant difference in the achievement level of students in the experimental group in their pretest and post-test scores.

HO_3: There is no significant difference in the pretest mean scores of students both in control and experimental groups.

HO_4: There is no significant difference in the achievement level of students in the control and experimental groups in terms of their post-test scores.

Chapter II
METHODS

This chapter discusses the research methods of the study. It includes research design, research locale, subjects of the study, research instruments, validation of instrument, data gathering procedure, and statistical treatment.

Research Design

This study employed the quantitative quasi-experimental two-group pretest posttest design which compared the change that occurs within two different groups on some dependent variable. This design was utilized to determine the effectiveness of the usage of manipulative as a teaching strategy in teaching mathematics in two sections of Grade 9 Junior students in Camanlangan National High School. Experimentation design is particularly helpful in answering evaluation queries concerning the efficacy and impact of programs (Gibbons % Herman, 1997).

Pre-test	Treatment	Post-test
O1	X	O2
O3		O4

Subjects of the Study

The 44 Grade 9 students in control group and 42 from experimental group were the subjects of the study. Section Narra served as the control group while section Angelo served as the experimental group. Experimental group was taught using math manipulatives while the control group was taught with conventional way of teaching. Table 1 below shows the information about the subjects.

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Table 1
Subjects of the Study

Sections	Total number of Students
Narra (Control group)	44
Angelo (Experimental group)	42
TOTAL	**86**

Research Instrument

A 15-item adapted and 15-item researcher made pretest was prepared and at the same time this was also used as posttest after the intervention. A table of specifications was prepared to show the variation of the questions based on the cognitive domain which included the six levels: knowledge, comprehension, analysis, application, synthesis and evaluation. The learning competencies included were those competencies identified as the most essential learning competencies in mathematics of Grade 9 for the third quarter namely: identify quadrilaterals that are parallelograms; determine the conditions that guarantee a quadrilateral a parallelogram; use properties to find measures of angles; sides and other quantities involving parallelograms; prove theorems on the different kinds of parallelogram, rectangle, rhombus, square; prove the Midline Theorem; and prove theorems on trapezoids and kites.

Validation of Instrument

The researcher-made questionnaire was subjected for validity. It was validated by the five external and internal validators identified by the Dean of the Graduate School. After its validation, modifications were applied if suggested by them after which it was pilot tested to 1 section of Grade 9 students in the same school who were not part of the study. Test and re-test were applied for its reliability. This would mean that the test questionnaire was tested to identify its relevance, reliability and validity. The final revision of the test was based on the result of the pilot testing.

Research Procedure

The researcher followed these procedures.

Permission to Conduct the Study. The researcher asked an endorsement letter from the Dean of the Graduate School with the letter of intent to conduct the study and submitted it to the Schools Division Superintendent (SDS) for approval. Upon the issuance of permission from the SDS, the researcher coordinated with the school principal of Camanlangan National High School for the approval of the permit.

Administering the Pretest and Posttest. To start the study, a pretest was given to the two sections of Grade 9, 44 students from control group and 42 students from experimental group. The result was computed and analyzed. After which the experimentation began. Using the lesson plans prepared, the researcher started facilitating the teaching-learning process with the introduction of manipulative as a teaching strategy in facilitating mathematical competencies. The intervention lasted for four weeks and the researcher had recorded her daily observations focusing on the participation of the students. After the intervention, the posttest was administered. The results of the pretest and posttest for both groups were compared to determine the effectiveness of the intervention and whether the students mastered the competencies being taught using manipulative as a strategy.

Statistical Treatment of Data

The researcher collected the data, tabulated them, and then used statistical analyses. The following statistical tools were used:

Class Proficiency. This was used to determine the achievement level of Grade 9 Mathematics students in control and experimental groups in terms of their pretest and post-test scores.

$$CP = \frac{\bar{x}(100)}{HPS}$$

Where $\bar{x}$ = mean

HPS – Highest possible score

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Independent t-test. This was used to test the significant difference in the achievement level of students in the control and experimental groups in terms of their pretest and post-test scores. The formula in computing t-test is:

t-test $t = \frac{\bar{x}_1 - \bar{x}_2}{s_{Dx}}$

where t - significant difference of the control and experimental group (pretest and post-test)
$\bar{x}_1$ - the mean scores of control group
$\bar{x}_2$ - the mean scores of the experimental group

Paired t-test. This was used to compare the means of control and experimental groups in terms of their pretest and post-test scores.

JASP- This was used as an open-source statistics program that offers standard analysis procedures to this study.

Chapter III

RESULTS

This chapter includes the presentation, analysis and interpretation of the results and findings of the study. The sequence of the presentation was based on the problems presented and the null hypotheses formulated.

Achievement Levels of Grade- 9 Mathematics Students.

Table 2 shows the academic performance of students in the Pretest

Table 2
Academic performance in the Pretests of Control and Experimental Groups

Parameters	Value	
	Control Group	Experimental Group
N	44	42
HPS	30	30
HSO	18	16
LSO	5	6
Mean	10.432	9.929
Class Proficiency	34.77%	33.10%
Standard Deviation	2.697	2.088

Table 2 presents the academic performance of the control and experimental groups for the pretest. It is revealed that the highest scores obtained by the examinees were 18 and 16 respectively, while the lowest scores obtained were 5 and 6, respectively. The overall mean of the control group was 10.432 while the experimental group had an overall mean of 9.929. The mean of the two groups were interpreted as 34.77% and 33.10% proficiency level, respectively, which are translated into below mastery level. Therefore, the students of the control and experimental groups had low mastery level in the competencies tested.

Table 3 shows the academic performance of students in the Posttest

Table 3
Academic Achievement in the Posttest of Control and Experimental Groups

Parameters	Value	
	Control Group	Experimental Group
N	44	42
HPS	30	30
HSO	20	24
LSO	10	14
Mean	14.0	19.524
Class Proficiency	46.66%	65.08%
Standard Deviation	2.459	2.189

The same number of students took the posttest in the control and experimental groups. The highest score obtained by the students in control group was 20 while in the experimental group was 24. On the other hand, the lowest score obtained by student in control group was 10 and 14 for the experimental group. The overall mean obtained by control group was 14.0 while the experimental group had an overall mean of 19.524, which equivalent to 46.66% and 65.08% proficiency level respectively. The results were interpreted

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as moving towards mastery (MTM) level; thus, students were moving towards mastery level in their academic performance. Further, the results proved that manipulatives had helped students learned more of the topics discussed resulting to improved academic performance.

There is no significant difference in the pretest and post-test mean scores of students in the control group.

Table 4 below shows the gain scores in pretest and posttest of control and group.

Table 4
Pretest and Posttest Mean Achievement of the Control Group

Type of test	N	$\bar{x}$	Df	P-Value	Tabular Value	Findings	Conclusion
Pretest	44	10.432					
Post-test	44	14.00	43	0.001	-17.485	Reject HO	Significant

*Significant at 0.05 level

Table 4 above shows that the pretest mean score of students of 10.432 was increased to 14.00 in their post- test. T-test yielded a computed value of 0.001 which is greater than the tabular value of -17.485 at 5% level of significance. Thus, suggested to reject the null hypothesis and there is a significant difference between the pretest and post-test scores of students in the control group. Consequently, teaching students without the aid of manipulatives still enhanced the achievement level of students in Mathematics.

Although the control group did not receive the intervention of which mathematics manipulatives were used, the group still learned the lesson which is indicated in the table where there is an increase of more than four points of the mean. In this regard the traditional way of teaching which is more on lecture and drill is still effective since the students are already used to it. The use of the blackboard and the chalk is also effective but using manipulatives is better than this. A combination of these two strategies would yield higher performance of the students.

There is no significant difference in the pretest and posttest mean scores of students in the experimental group.

Table 5 shows the gain scores in pretest and post-test of the students in experimental group.

Table 5
Pretest and Post-test Mean Achievement of the Experimental Group

Type of test	N	$\bar{x}$	Df	P-Value	Tabular Value	Findings	Conclusion
Pretest	44	9.929					
Posttest	44	19.524	41	0.001	-25.007	Reject HO	Significant

*Significant at 0.05 level

Table 5 shows that the post-test mean scores of students in experimental group is 19.524 which is higher than the pretest mean score of 9.929 at 0.05 level of significance. It further shows that the P-Value of 0.001 is greater than the tabular value of -25.007 at 0.05 level of significance. Therefore, the null hypothesis is rejected and there is a significant difference between the mean scores of students. The pretest is in a low level and increased into a high level in the post test, hence manipulatives contributed to the increased in mathematics achievement of Grade -9 students.

The result is a clear indication that the use of manipulatives in teaching mathematics is an effective strategy. The result suggests a big leap in the mean score from 9.929 to 19.524. Using manipulatives as a strategy would motivate the students to get involved in the learning pace whereby all of them will have the hands on. Through it, students are engaged and generated their own understanding of the things they manipulated. Seeing and hearing alone are not enough to retain information but by the use of manipulatives they are allowed to demonstrate about the application of the concept to real life situation.

There is no significant difference in the mathematics achievement levels of students in the control and experimental groups in terms of their pretest scores.

Table 6 below shows the gain scores in pretest of students in both control and experimental.

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Table 6
Comparison of Pretests Mean Achievement of the Control and Experimental Groups

Students	N	$\bar{x}$	Df	P- Value	Tabular Value	Findings	Conclusion
Control Group	44	10.432	84	0.338	0.964	Accept HO	Not Significant
Experimental Group	42	9.929					

*Significant at 0.05 level

Table 6 shows the significant differences of compared pretest results of control and experimental groups. The data shows the computed value of 0.338 which is less than the tabular value of 0.964 at 0.05 level of significance. Therefore, the null hypothesis is accepted thus, there is no significant difference between the pretest mean scores of the students in control and experimental groups. This implies that both groups were equivalent in terms of their academic standing before the intervention for the experimental group.

The results above suggested that the achievement levels of Grade-9 mathematics students for both control and experimental groups were initially comparable. In this case, both groups of students were regarded suitable for comparative study.

There is no significant difference in the achievement level of students in the control and experimental groups in terms of their post-test scores.

Table 7 shows the gain scores in post-test of students in control and experimental group

Table 7
t-test Comparison of Post-test Mean Achievement of the Control and Experimental Groups

Students	N	$\bar{x}$	Df	P- Value	Tabular Value	Findings	Conclusion
Control Group	44	14.00	82	0.001	-9.032	Reject H_O	Significant
Experimental Group	42	19.524					

*Significant at 0.05 level

Table 7 shows the compared post-test both for control and experimental groups which resulted to a p- value of 0.001 which is greater than the tabular value of -9.032 at 0.05 significance level, it suggests that the null hypothesis is rejected since there is a significant difference between the achievement scores of controls and experimental groups. Furthermore, the mean score of control group at 14.00 and the mean score of experimental groups of 19.524 concluded that the experimental group performed better compared to control group, thus manipulatives significantly improved the mathematics achievement of Grade-9 students.

Chapter IV

DISCUSSIONS AND CONCLUSIONS

This chapter presents the discussions, conclusions and recommendations of the study.

Discussions

After the analysis and interpretation of data, the following findings were gathered.

Level of Academic achievement of the students in pretest and posttest. Academic Results revealed that the achievement level in pretest mean scores of control group was 10.432 while 9.929 for the experimental group. Hence, it was interpreted as 34.77% and 33.10%, respectively. Both groups belong to the Low Mastery level (LM).

The achievement level of control and experimental groups in the post-test mean scores were 14.0 which is equivalent to 46.66%, and 19.524 which is also equivalent to 65.08% respectively. These results suggest that students are moving towards mastery (MTM) level. According to Boggan et al., (2010), the majority of researches demonstrate an improvement in mathematics achievement following the use of manipulatives as an intervention strategy. In addition, manipulatives improve mathematical achievement, which is one advantage. Even though they are typically utilized in elementary schools, manipulatives can help students at all levels of schooling. In addition, in a study of (Bjorklund, 2014; Burns & Hamm, 2011; Freer, 2006; Swan & Marshall, 2010), the results concluded that the use of manipulatives help pupils comprehend abstract mathematical ideas and perform better.

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There is no significant difference in the pretest and post-test mean scores of students in the control group. There is a significant difference in the achievement level of control group in terms of their pretest and post-test score. It implied that conventional method of teaching can also improve the academic performance of students. Although the control group did not receive the intervention of which mathematics manipulatives were used, the group still learned the lesson which is indicated in the table where there is an increase of more than four points of the mean. In this regard the traditional way of teaching which is more on lecture and drill is still effective since the students are already used to it. The study of Hiebert & Grouws (2007), support the effectiveness of traditional method of approaches, such as direct instruction and problem-solving, in improving students' mathematics achievement. The use of the blackboard and the chalk is also effective but using manipulatives is better than this. A combination of these two strategies would yield higher performance of the students.

There is no significant difference in the pretest and posttest mean scores of students in the experimental group. There is a significant difference in the achievement level of experimental group in terms of their pretest and post-test score. It implied that using manipulatives in teaching greatly improved the students' academic achievement. Using manipulatives in teaching mathematics provides great opportunity for the students to use objects in learning mathematics competencies. In other words, the students are doing the hands own and allow them to manipulate using practical ways in solving problems. Using manipulatives as a strategy would motivate the students to get involved in the learning pace whereby all of them will have the hands on. Through it, students are engaged and generated their own understanding of the things they manipulated. Seeing and hearing alone are not enough to retain information but by the use of manipulatives they are allowed to demonstrate about the application of the concept to real life situation. These findings also support the results of Cope (Spring 2015), that manipulatives have the potential to help concrete abstract ideas, help students solve problems, and make math lessons more interesting and fun.

There is no significant difference in the mathematics achievement levels of students in the control and experimental groups in terms of their pretest scores. there is no significant difference between the pretest mean scores of the students in control and experimental groups. This implies that both groups were equivalent in terms of their academic standing before the intervention for the experimental group. The results above suggested that the achievement levels of Grade-9 mathematics students for both control and experimental groups were initially comparable. In this case, both groups of students were regarded suitable for comparative study.

There is no significant difference in the mathematics achievement levels of students in the control and experimental groups in terms of their posttest scores. It was found out statistically that there is a significant difference in the achievement level of students in control and experimental groups in terms of their post-test scores. The result implied that students who were taught using manipulatives had better academic performance compared to those who were exposed in traditional method of teaching. Thus, the use of concrete objects significantly improved the mathematics' achievement of Grade -9 students. In the opinion of Shaw (2002), the use of mathematical models and manipulatives has various advantages. similar to how a photograph may give visual representations of concepts, which can be worth a thousand words and aid pupils in understanding and comprehending math. Moreover, the study of Munger (2007) affirmed that the effective use of educational resources aids in students' comprehension of lessons. Their use improves learning outcomes by helping students acquire knowledge, retain information, and retain its performance. The usage of the manipulatives piques the students' interest and encourages involvement in the lesson.

Conclusions

Based on the evidences presented, it can be concluded that the use of math manipulatives was found to be effective compared to traditional way of teaching. Although teaching students without manipulatives also helped them performed better, still the use of manipulatives in teaching students was more effective in stimulating students' interest and to engage more in the lesson.

Recommendations

Based on the findings and conclusions of the study, the following recommendations are offered:

1. The school administration should encourage teachers to adapt the use of manipulatives or tangible objects in teaching students especially mathematical concepts.

2. Mathematics teachers must attend seminars and relevant trainings for the making and utilization of instructional materials that can really aid in teaching.

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3. The school should invest in procuring long-lasting Math manipulatives that can be used in teaching students especially on the basic concept of Mathematics.

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