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Learning Manipulatives and Pupils' Mathematical Skills

Cherryme E. Tagalog[1], Richard M. Oco[2]

[1] Southern de Oro Philippines College, Cagayan de Oro City, Philippines

[2]DepEd- Misamis Oriental Division, Misamis Oriental, Philippines

ABSTRACT: This study aimed to determine the Mathematical skills of the pupils. It further aimed to identify the level Mathematical skills among the control and experimental groups of pupils based on their pretest and posttest scores in terms of classifying, patterning, and numeracy skills with the aid of manipulative objects. It was conducted to sixty-four (64) pupils of which half or thirty-two (32) of the pupils were under the control group while the other thirty-two (32) were under the experimental group from one of the schools in the Division of Misamis Oriental, School Year 2024-2025. Pupils were purposively chosen by the researcher. The study utilized the quasi-experimental research design and used an adopted manipulatives material and questionnaires. Frequency, Percentage, Mean, Standard Deviation, t-test, F-test (ANOVA) and Post Hoc Test were the statistical tools used to interpret and analyze the data. Findings revealed that pupils' pretest on mathematical skills were at Low level but improved to Moderate level in the control group and was High level in the experimental group with the aid of learning manipulatives. A significant difference was registered on pupils' performance using the manipulatives. Utilizing of manipulatives can be maintained by the teachers and parents at home, considering its substantial benefits to the learners.

KEYWORDS: classifying, manipulatives, mathematical skills, numeracy, patterning

I. INTRODUCTION

To fully understand Mathematics as a discipline, one must constantly practice and study the subject. Nonetheless, Mathematics has been recognized as one of the most insightful and enjoyable discourses in human knowledge, as well as a logical discipline of distinction. Since every pupil is different and has strengths and weaknesses, Mathematics teachers need to provide their pupils with resources that will enable them to study the subject more efficiently. Acquiring knowledge in Mathematics education, manipulatives play a crucial role, particularly when it comes to improving pupils' understanding and proficiency.

Learning manipulatives provide concrete examples of Mathematical concepts, which help teachers teach the pupils. To help in learning, pupils can visualize, handle, and manipulate these objects. Using manipulatives, educators can demonstrate mathematical ideas and connect them to relevant vocabulary. By bridging the gap between intangible concepts and concrete experiences, this approach improves pupils' access to and pleasure of their education.

Pupils can see, feel, and manipulate physical learning manipulatives. According to Marasigan et al. (2019), pupils can create their own cognitive models for abstract mathematical concepts and procedures when manipulatives are used in Mathematics instruction. Additionally, they give pupils and teachers a common language to use when explaining these models and engage them in ways that boost their interest in and love of Mathematics. Additionally, Taley et al. (2023) asserted that the usage of manipulatives in the classroom is the only way to develop pupils' conceptual knowledge of Mathematics. Encouraging pupils from their early stage of learning or studies to learn Mathematics conceptually requires the use of manipulatives in the classroom.

For young children, kindergarten is a type of education that acts as a bridge from home to the start of a more formal schooling. Children should start showing an interest in counting, sorting, creating shapes, measuring, classifying, pattern-making, and estimating in kindergarten. Additionally, it lets pupils experience Mathematics while they explore and play in the real world. Furthermore, children's initial exposure to Mathematics should come from their play and hobbies. Good early Mathematics practice goes deeper and wider than practicing "school skills" in the early grades, claims Guhl (2019). He went on to say that good Mathematics should be enjoyed, not forced. All of a child's early experiences with numbers, space, and patterns add up to good early Mathematics. Youngsters who receive excellent early childhood education are more likely to succeed than those who do not. For this reason, teaching Mathematics to young children is crucial.

Learning Manipulatives and Pupils' Mathematical Skills

Early Mathematics' instruction uses manipulative objects as part of multisensory learning. Kwabena (2022) stated that children should have access to a variety of manipulative materials when studying Mathematics during their early childhood years. Manipulatives are concrete items that are frequently utilized in Mathematics instruction.

According to Quane (2022), techniques for assessing mathematical accomplishment must adapt if manipulative materials are included in the teaching of Mathematics. He went on to say that the assessment scope is limited by the use of paper and pencil methods; therefore, teachers will want alternative means of evaluation in order to gauge their pupils' conceptual knowledge. The evaluation of Mathematics learning ought to be closely linked to the teaching of Mathematics, which frequently makes use of models and/or manipulatives (Monte, 2021).

The capacity to use, comprehend, and communicate mathematical knowledge to solve problems in the real world is known as mathematical abilities. Among these is the understanding of basic Mathematical operations including addition, subtraction, division, and multiplication. The use of mathematical, statistical, graphical, and spatial ideas as well as the ability to evaluate and apply the data to real-world situations are examples of higher-level numeracy skills. According to Pitogo and Oco (2023), mathematical skills is one of the most important skills that a pupil needs to master. Teachers began teaching pupils how to solve problems in elementary school and how to use it as a practical skill in everyday life. Being numerate means knowing how to confidently identify numbers, counting, and recognizing numbers. It also means knowing how to apply basic operations and problem-solving skills to comprehend complicated ideas. Mastering Mathematics is the key to understanding and progressing in the subject. It is among the main areas of focus for teachers, along with literacy, as these are the Department of Education's most recent concerns in the Philippines.

All these skills can be absorbed and mastered by the pupils through the process of repetitive exercises. This strategy will aid the teachers in helping the pupils learn and master the necessary skills at their grade level. Through the concept of repetition, the pupils will perform the needed skills to be mastered in repetitive manner via series of activities until they master it and be able to remember the process and concept correctly and consistently. This might be monotonous for older pupils but for the young ones that are just starting to experience the formal setting of education and learning it can be fun and exciting specially when the activities are partnered with manipulatives.

The study is based on Jean Piaget's theory of developmental phases, as referenced by Mcleod (2024). The hypothesis outlines the sequential progression of children's development; however, the timing may vary among individuals. Piaget claimed that childhood included four primary stages of cognitive development. The initial phase he referred to as the sensorimotor stage, which includes newborns and children up to around 2 years old. At their current stage of development, children are mostly focused on their own physical movements. Their mental activities are also restricted to what they can see through their senses. Put simply, newborns acquire knowledge predominantly through their motor skills and sensory perception.

The pre-operational stage, which occurs between the ages of two and seven, is the second stage of development. At this developmental period, children lack the ability to engage in cognitive tasks known as "operations," as described by Piaget, including the understanding of conservation. In addition, children at this stage exhibit egocentrism, a cognitive bias where they perceive those others have the same thoughts and perspectives as themselves due to their belief that they are the focal point of the world. Consequently, they struggle to acknowledge and accept differing viewpoints from their peers. Furthermore, it is imperative to have direct personal encounters, and educators should refrain from using theoretical ideas.

Children transitions from the pre-operational stage to the concrete operational stage typically between the ages of 7 and 11 years old. At this stage, children's egocentrism diminishes and they acquire the ability to understand the concept of conservation. However, they are not yet capable of solving abstract problems that involve mental manipulation.

The final stage is the formal operational stage, which begins at the age of 12 and continues into adulthood. An individual at this stage possesses the ability to solve abstract problems. The researcher specifically examined the pre-operational period, which corresponds to the developmental phase of kindergarten-aged children. According to Cherry (2024), this stage, based on Piaget's theory, is marked by the development of the capacity to represent objects and information through imitation, symbolic play, drawing, mental imagery, and spoken language. According to Piaget, human beings can learn in three ways: through the physical world, the social world, and the construction of mental relationships. Physical knowledge refers to the acquisition of information about items by seeing their exterior characteristics, such as their color and weight. Acquiring social knowledge, such as holidays, religion, language, and other related topics, is a process of learning through the social world. One method of learning is through the development of cognitive connections, such as understanding the concepts of counting, seriation, numeration, and conservation, which is sometimes referred to as logico-Mathematical learning. (Cherry, 2024).

This study aimed to address the development and evaluation of manipulative materials designed to assess fundamental Mathematics skills in kindergarten pupils, focusing on identifying the types of materials created and the methods employed to determine their reliability and validity.

II. METHODOLOGY

A pretest-posttest is part of the quasi-experimental research strategy used for this study. The quasi-experiment as defined by Farnell (2021) differs from an actual experiment in that participants are not assigned at random. This idea led to the formation of two groups. There will be two groups: the control group and the experiment group. The experimental group received treatment, whereas the control group did not. A pretest and posttest will be administered by the researcher of this type in order to investigate change over time. To find out if two variables responded similarly to a given modification, it assessed two variables that are assumed to be similar.

This method was applied in a single case where the researcher purposefully matched control group participants to treatment group participants based on traits that could be connected to the desired outcome. A one-to-one match between the individuals in the two groups can be achieved by doing this matching at the individual level.

The following statistical tools were used to analyze the data for each problem. Problems 1 and 2 utilized Frequency, Percentage, Weighted Mean and Standard Deviation (SD) in analyzing the Pretest and Posttest scores of the pupils from controlled and experimental groups and in determining the level of mathematical Skills of the pupils. Problem 3 utilized T-test and problem 4 utilized F-test (ANOVA) with Post Hoc Test Tukey HSD (Honestly Significant Difference) in analyzing the significant difference between the dependent variables (Posttest) based on its significant level and critical value. These tools were used to determine the association brought by the learning manipulatives in the level of mathematical skills among the pupils.

III. RESULTS AND DISCUSSION

Problem 1. What is the level mathematical skills among the control and experimental groups of pupils based on their pretest scores in terms of:

1.1 classifying skills;
1.2 patterning skills; and
1.3 numeracy skills?

Table 1. Overall Level of Mathematical Skills Based on Pretest

	Control-Pretest			Experimental-Pretest		
Mathematical Skills	**Mean**	**SD**	**Level of Skills**	**Mean**	**SD**	**Level of Skills**
Classifying	9.59	2.01	Moderate Mathematical Skills	7.16	2.07	Low Mathematical Skills
Patterning	8.07	2.09	Low Mathematical Skills	7.08	2.08	Low Mathematical Skills
Numeracy	8.97	1.56	Low Mathematical Skills	7.41	2.05	Low Mathematical Skills
Overall	**8.88**	**1.89**	**Low Mathematical Skills**	**7.22**	**2.07**	**Low Mathematical Skills**

Note: 17 – 20 scores Very High Mathematical Skills
13 – 16 scores High Mathematical Skills
9 – 12 scores Moderate Mathematical Skills
5 – 8 scores Low Mathematical Skills
0 – 4 scores Very Low Mathematical Skills

Table 1 shows the overall level of mathematical skills based on pretest. For the control group, the overall Mean was 8.88 with SD=1.89, described as Good Start and with the interpretation of Low Mathematical Skills. The pupils performed the highest with Classifying with the Mean of 9.59 with SD= 2.01, with the description of Almost There and interpretation of Moderate Mathematical Skills. They also performed lowest on Patterning skills with the Mean of 8.07 with SD=2.09, described as Good Start and interpreted as Low Mathematical Skills. The data imply that although the pupils have better performance for their classifying skills, overall, it still belongs to the Low Mathematical Skills as the other two (2) skills were at the lowest level. Mathematical skills development must be in holistic approach. Therefore, all of it must be developed at the same level as much as possible. According to Mohamed & Kandeel (2023), mathematical skills in Mathematics are all of equal importance. Teachers and parents must work hand in hand to ensure that the pupils will receive the appropriate and best assistance whether at school or at home.

For experimental group, it registered an overall Mean 7.22 with SD=2.07 interpreted as Low Mathematical Skills. Moreover, Numeracy skills was rated the highest with the mean of 7.41 with SD=2.05, described as Good Start and interpreted as Low Mathematical Skills. The data imply that the mathematical skills development of the pupils requires extra efforts coming from the teachers and the parents. In this way, it will be properly addressed through additional practices and time for reviews and study. According to Sutapa et al. (2021), teachers must be ready with various strategies and techniques that will help them in preparing and choosing the best form of assistance that will be given to the pupils so that they can improve their Mathematical skills according to their learning capacity and capability.

Problem 2. What is the level Mathematical Skills of the control and experimental groups of pupils based on their posttest scores in terms of:

2.1 classifying skills;
2.2 patterning skills; and
2.3 numeracy skills?

Table 2 shows the overall level of mathematical skills based on Posttest. For the control group, the overall Mean was 11.97 with SD=1.37, described as Almost There and with the interpretation of Moderate Mathematical Skills. Numeracy Skills has the highest Mean of 12.31 with SD= 1.11, described as Almost There and with the description of Moderate Mathematical Skills. They also performed lowest on Patterning skills with the Mean of 11.78 with SD=1.14, described as Almost There and interpreted as Moderate Mathematical Skills. The data imply that although the pupils have better performance for their overall skills compared to their pretest performance, there are still pupils that were still belong to the Low Mathematical Skills. Mathematical Skills development must be in holistic approach and should be available and beneficial for all. Therefore, all of the pupils must be developed at the same level as much as possible. Struggling learners must be given attention as well as those that were able to master their skills. In this way, no pupils will get bored at the same time no pupils will also feel left out. Teachers can provide set of activities tailored to the needs of the pupils for mastery retention as well as improvement of performance and skills level of those that were not able to gain the ideal level of skills, knowledge and performance (Di-Martino et al., 2023).

Table 2. Overall Posttest Level of Mathematical Skills

	Control			Experimental		
Mathematical Skills	**Mean**	**SD**	**Level of Skills**	**Mean**	**SD**	**Level of Skills**
Classifying	11.82	1.86	Moderate Mathematical Skills	14.38	1.02	High Mathematical Skills
Patterning	11.78	1.14	Moderate Mathematical Skills	14.83	1.08	High Mathematical Skills
Numeracy	12.31	1.11	Moderate Mathematical Skills	15.20	1.01	High Mathematical Skills
Overall	**11.97**	**1.37**	**Moderate Mathematical Skills**	**14.80**	**1.04**	**High Mathematical Skills**

Note: 17 – 20 scores Very High Mathematical Skills
13 – 16 scores High Mathematical Skills
9 – 12 scores Moderate Mathematical Skills
5 – 8 scores Low Mathematical Skills
0 – 4 scores Very Low Mathematical Skills

For experimental group, it registered an overall Mean 14.80 with SD=1.04, described as Got It and interpreted as High Mathematical Skills. Moreover, Numeracy skills was rated the highest with the Mean of 15.20 with SD=1.01, described as Got It and interpreted as High Mathematical Skills. The data imply that the mathematical skills development of the pupils improved with the extra efforts coming from the teachers and the parents. There were pupils that even reach the highest level of Mathematical Skills indicating that the pupils were able to acquire the necessary knowledge and skills. The integration of manipulative teaching materials certainly aided the pupils understanding on the concepts that were presented to them as they have first-hand experience on the information and steps that are necessary to perform in order to master the skills in classifying, patterning and numeracy. According to Johnson-Smith (2020) providing actual learning experiences to the pupils is necessary specially in learning mathematical concepts. This will allow the pupils to appreciate more of the importance of learning the skills and what it can do for them.

Table 3. Incremental Scores on Level of Mathematical Skills (Pretest and Posttest)

	Control			Experimental		
Mathematical Skills	**Pretest**	**Posttest**	**Increment**	**Pretest**	**Posttest**	**Increment**
Classifying	9.59	11.82	2.38	7.16	14.38	7.37
Patterning	8.07	11.78	3.88	7.08	14.83	7.90
Numeracy	8.97	12.31	3.49	7.41	15.20	7.94
Overall	**8.88**	**11.97**	**3.24**	**7.22**	**14.80**	**7.73**

Table 3 shows the incremental scores on level of mathematical skills (Pretest and Posttest). For the control group, it registered an overall Mean of 3.24 indicating that the pupils' gained improvement on their mathematical skills was at low level. This further means that there was part of the concepts introduced to them that were not fully understood and acquired. Thus,

the teachers should make additional efforts by providing the necessary activities that will help the pupils improved their performance and skills. According to Martinez and Lee (2021) mathematical skills is essential for the learners' development and knowledge acquisition in Mathematics. Teachers must help and assist struggling learners so that they will not have more difficulties by the time they will progress to higher level of learning.

For the experimental group, it registered an overall Mean of 7.73 indicating that the pupils were able to attain the ideal increase of their mathematical skills at high level. The teachers still need to guide and assist the learners for them to sustain their high level of mathematical skills so that they can have easy ways and means in learning other concepts in Mathematics. Furthermore, this only show that the integration of the manipulatives in the teaching and learning process and exercises among the learners have helped them greatly. The actual experience they had helped them understand and remembered the concepts they studied and performed. Marasigan et al., (2019) claimed that the association of manipulative objects towards the learners' mathematical skills and performance was highly positive. Teachers can utilize the manipulatives in introducing the topic or concepts to the learners. When the pupils learn by experience, they become more interested to it at the same time be able to retain the ideas to their minds that when they are asks about it, they can easily remember it.

Problem 3. Is there a significant difference between the pretest and posttest of the control and experimental group of pupils' levels of mathematical skills?

Table 4. Test Difference on Mathematical Skills of Control and Experimental Group (Pretest and Posttest)

Group	t-value	p-value	Decision	Interpretation
Control	4.662	0.032	Reject Ho	Significant
Experimental	7.921	0.001	Reject Ho	Significant

Note: Significant if computed p-value is less than 0.05

Table 4 shows the Test difference on mathematical skills of Control and Experimental group (pretest and posttest). For the control group, it registered a computed t-value =4.662 with the computed p-value=0.032. The computed p-value is less than the p-critical value at 0.05 level of significance. The data imply that there was significant difference between the pupils' scores from their pretest and posttest performance. Thus, the null hypothesis was rejected. This further means that in learning or acquiring the necessary skills like classifying, patterning and numeracy skills of the pupils, it is important to conduct diagnostic test to determine the needs of the pupils as well as have the view on which part should be taken more time and attention. The posttest on the other hand, allows the teachers to measure how far the pupils were able to improve their skills and identify the struggling pupils as well. In this way, they can be given attention, time, and assistance for better results (Adiguzel et al., 2023).

For the experimental group, it registered a computed t-value =9.921 with the computed p-value=0.001. The computed p-value is less than the p-critical value at 0.05 level of significance. The data imply that there was significant difference registered between the pupils' pretest and posttest scores. Thus, the null hypothesis was rejected. The data further presented the extent of the association made by the implemented strategy which was the use of the manipulative objects. Moreover, it also showed the importance of monitoring the pupils' progress through the pretest and posttest activities. Providing the appropriate strategy and intervention to the pupils in their learning journey is crucial to their growth and development. It is important that teachers and parents may collaborate in helping and providing the necessary assistance to the pupils (Kim and Garcia, 2022).

Problem 4. Is there a significant difference between the Mathematical skills of the control and experimental groups based on their posttest scores?

Table 5. Test Difference on Mathematical Skills of Control and Experimental Group (Posttest and Posttest)

Group	F-value	p-value	Decision	Interpretation
Control	0.214	0.802	Accept Ho	Not Significant
Experimental	18.987	0.001	Reject Ho	Significant

Note: Significant if computed p-value is less than 0.05

Table 5 shows the Test difference on mathematical skills of Control and Experimental group (posttest and posttest). For the control group, it registered a computed F-value =0.224 with the computed p-value=0.802. The computed p-value is greater than the p-critical value at 0.05 level of significance. This data imply that there was no significant difference between the pupils'

scores from their pretest and posttest scores. Thus, the null hypothesis was accepted. The data mean that in learning the mathematical skills, the pupils learn it independently from each other. Meaning they can learn first the classifying and then the patterning skills and then the numeracy skills. This scenario can be time and effort consuming for the teachers and the pupils as it will affect the time allotment and phasing of the teaching and learning process. Moreover, this further means that the pupils' performance in a particular skill do not necessarily have connection to the other skills. According to Davis and Martinez (2022) each of the competencies in a grade level are meticulously programmed and given specific time to be discussed and studied by the pupils. Therefore, the teachers cannot dwell much on a single topic as there are lots of topics to be presented and tackled by the teachers and the pupils as they are considered a requirement to be taught and learned in a quarter and in a grade level.

For the experimental group, it registered a computed F-value =18.987 with the computed p-value=0.001. The computed p-value is less than the p-critical value at 0.05 level of significance. The data imply that there was significant difference registered between the pupils' pretest and posttest scores. Thus, the null hypothesis was rejected. This means that the pupils' growth, development and performance on the three (3) Mathematical skills under study was connected with each other. When they are able to increase their level of skills in patterning, there is a possibility that their skills for classifying and numeracy will also increase. This is a great opportunity as this will allow the teachers to be able to follow the allotted timeframe for each competency as well as it will also allow the pupils to learn the skills in an appropriate time and phase.

In this way, they will not necessarily need to take more time dwelling on mastering each of the mathematical skills separately. According to Kim and Garcia (2022) when the teachers and the pupils are on track with the correct phasing of the topics and concepts that needs to be studied, it is likely that they will be able to learn all the necessary concepts without worries of having less time and they will also have ample time to use to help those that are struggling so that by the end of the quarter or school year, every pupils have reach the ideal level of Mathematical skills to be utilized in learning much higher level of Mathematics topics and concepts.

Table 6. Post Hoc Test Tukey HSD (Honestly Significant Difference) – Experimental Group

Mathematical Skills Pairing	F-ratio	Critical-value	Decision	Interpretation
Classifying and Patterning	11.94	1.774	Reject Ho	Significant
Classifying and Numeracy	14.89	1.774	Reject Ho	Significant
Patterning and Numeracy	26.69	1.774	Reject Ho	Significant

Table 6 from the previous page shows the Post Hoc Test Tukey HSD (Honestly Significant Difference) – Experimental Group. The results revealed that classifying skills and patterning skills are significant combinations with each other as well as on the numeracy skills. This means that the combination of the two (2) skills can help the pupils develop their mathematical skills. This further means that when combination of either of the two skills like classifying and patterning or classifying and numeracy, the pupils will have better performance in their Mathematical skills development and achievement. Thus, teachers and parents may consider these combinations in assisting and guiding their pupils. Being able to allow the pupils to learn and master two (2) or three (3) skills at a time means promoting the concepts of higher order thinking skills which is a must in developing the pupils' critical thinking and problem-solving skills. This also allows the teachers to have more time to cover the necessary competencies in a quarter and in a grade level. The concepts or competencies per grade level must be presented and learned by the pupils considering that the new current curriculum is in spiraling nature. The topics from a grade level is almost similar in the next grade level but the samples and problems to be solved are in much higher level. Math is all about series of patterns and sequences. Therefore, familiarization will definitely aid the pupils in their pursuit of higher level of Mathematical knowledge and skills (Martinez and Lee, 2021).

IV. CONCLUSIONS

Using the research's findings, the researcher reached the following conclusions:

1. Pupils have less knowledge on Mathematics during pretest since lessons were not yet introduced on that certain grading period.
2. Pupils improved their mathematical skills since the lessons were already given, especially to those groups exposed to learning manipulatives as seen through their posttest scores.
3. Control group has less skills acquisition compared to the experimental group who utilized manipulatives.
4. Use of manipulatives posited great difference on the pupils' progress on their mathematical skills.

V. RECOMMENDATIONS

Given the study's findings and conclusions, the researcher suggests the following:

1. Mathematical skills of the learners are good to be monitored and determined so that appropriate actions will be planned and made.
2. The use of the manipulatives clearly helped the learners improved themselves in their Mathematical skills indicating it can be utilized by other teachers as well.
3. Teachers and parents may collaborate for the continued improvements of the pupils' mathematical skills and their mastery on the basic Mathematics concepts. They can be both learned and mastered through the use of manipulative objects so that they can assist their learners with great results.
4. Utilizing of manipulatives can be maintained by the teachers considering its substantial benefits to the learners.

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