The Effect of Using Manipulatives on the Mathematical Achievement of the First Grade Students

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Abstract

This study aimed at examining the effect of using manipulatives in the mathematical achievement of the first graders at UNRWA schools in Jerash area in Jordan. The sample of the study consisted of 155 students representing four sections, who were divided into two groups: An experimental group which was taught "numbers from 0-9" subjects using manipulatives, and a control group which was taught by the traditional method. After the completion of the study application, an achievement test was applied and a 2-way ANOVA analysis was used to test the hypotheses of the study.

The study results revealed that there were statistically significant differences between the two groups in favor of the experimental group, which was taught by using manipulatives; whereas there were no significant differences between students' marks due to sex or the interaction between group and sex.

Key words: Manipulatives, achievement, mathematics.

1. Introduction:

Teachers are always interested in looking for effective methods to make their math teaching meaningful. Mathematical meaning is not intrinsic but develops out of interaction with other people and environment and reveals itself as a new individual interpretation **(Yackel, Cobb & Wood, 1999).**

Piaget suggested four stages of intellectual development, which were: sensori-motor stage (from birth to about two years), pre-operational stage (about 2 to 7 years), concrete operational stage (about 7 to 11 years) and formal operation stage (about 12 and up).

In the third stage (concrete), the child reaches a satisfactory level in terms of intellectual development, but what is done or thought by him is done on a concrete level **(Mangal, 2004)**. His thought processes are limited to real events observed or the actual objects operated by him. He is unable to think in abstract terms.

In the National Council of Teachers of Mathematics **(NCTM, 2000)** Principles and Standards for School Mathematics, representation was identified as one of the important processes in the teaching and learning of mathematics. Being able to teach mathematics effectively requires educators to choose the kinds of representations that will support meaningful mathematics learning in classrooms. These kinds of representations have a direct impact on students learning of mathematics **(Pape, 2001)**. Through presenting an activity with the three components (activity, technology, formalizing) not only we give students with different learning styles different ways to see a problem, but also we give them the extra time they may require for learning.

Using Manipulatives in mathematics teaching and learning is one of the most important kinds that represent mathematical concepts and ideas. Research in mathematics instruction revealed that students' mathematics understanding will be more effective if manipulative materials are used **(Cotter, 2000; Clements & Battista, 1990)**.

Individual students learn in different ways. When manipulatives are used, the senses are brought into learning: students can touch and move objects to make visual representations of mathematical concepts.

Manipulatives can be used to represent both numbers and operations on those numbers.

Manipulative materials are concrete models that involve mathematics concepts, appealing to several senses, that can be touched and moved around by the students. The purpose of using manipulatives in mathematics classroom is the concrete modeling of abstract mathematical ideas **(Olkun; Toluk, 2004)**. While it is virtually impossible to show a mathematical concept directly by means of a manipulative, it might be possible for a learner to construct a concept or discover a mathematical relationship through an appropriate use of a manipulative in a meaningful task environment.

It is suitable to paraphrase a Chinese proverb that describes the importance of involving students in mathematics activities to get good understanding; this proverb says: "Tell me mathematics and I forget; show me mathematics and I may remember; involve me… and will understand mathematics. If I understand mathematics, I will be less likely to have math anxiety. And if I become a teacher of mathematics, I can thus begin a cycle that will produce less math anxious students for the generations to come."

(Burns, 2005) mentioned seven steps for teacher for using manipulatives:

1- I talk with students about why manipulatives help them learn math.
2- From day one, I set ground rules for using materials.
3- I set up a system for storing materials and familiarize students with it.
4- Time for free exploration is worth the investment.
5- For easy reference, I post class charts about manipulative materials.
6- Manipulatives are natural for writing assignments.
7- I let parents get their hands on manipulatives, too.

Using mathematical manipulatives and models offers many benefits **(Shaw, 2002)**. Just as a picture can be worth a thousand words, manipulatives can provide visual representations of ideas, helping students to know and to understand mathematics. Manipulatives enhance the abilities of students at all levels to reason and communicate. Working

with manipulatives deepens understanding of concepts and relationships, and makes skills practice meaningful.

When manipulatives are used in teaching mathematics, the methods of evaluation that teacher uses will be changed **(Heddens, 1997)**. Teacher will receive more information about students' mathematics understanding by several ways: first, he can listen to students talk about their mathematical thinking. Second, he can observe students working individually and in cooperative groups. Third, he can change his questions from yes or no to why and how questions. And fourth, he can have students write a solution to a problem rather than by only responding with correct or incorrect values.

(Grupe; Huffman & Bray, 1996) presented some strategies and the corresponding manipulative strategies for "how much is 3 + 5?". They are:

strategy	corresponding manipulative strategies
Sum	Count out 3 bears, count "1,2,3". Count out 5 bears, count "1,2,3,4,5". Begin counting again at 1, "1,2,3,4,5,6,7,8".
Verify One Addend	Verify one addend with bears and then continue counting other addend without verifying. Verify "1,2,3", then continue on "4,5,6,7,8".
Count Out Bears as Unit	Pick up bears as a unit to represent each addend, then begin counting bears from one. Grab up three bears all at once, then grab up five bears at once, then count out five more, "1,2,3,4,5,6,7,8".
Successive Count	Count bears successively by laying them out one-by one while counting. As they lay out bears one by one, "1,2,3,4,5,6,7,8".
Representation Drop Out	Begin successive count from one with bears, but as counting continues, child stops using bears (drops representation component).
Count from First Addend	Say "3,4,5,6,7,8" or "4,5,6,7,8", while laying out a bear for each count.
Min	Count from larger addend by saying, "5,6,7,8" or "6,7,8", while laying out one bear for each count.
Recognition	Lay out 3 bears, lay out 5 bears, say "8" without counting.

(Bellonio, 2001) mentioned some manipulatives that can enhance math skills, such as:

- **Calculators** for: counting, decimals, number concepts, patterns.
- **Money** for: classification, counting, decimals, equivalence, probability.

- **Number cubes (Dice)** for: counting, mental math, number concepts.
- **Playing cards** for: counting, number theory-prime, even, odd.
- **Rulers** for: area, fractions, decimals, estimation, measurement, volume.
- **Capacity containers** (cups, pints, quarts, gallons, liters, etc.) for: estimation, fractions, measurement, volume.
- **Clocks** for: fractions, measurement, whole numbers.
- **Cubes** for: area, classification, percent, square/cubic number, fractions.

Using manipulative materials in teaching mathematics will help students in many aspects of learning. **(Heddens, 1997)** mentioned that student can learn:

1- to relate real world situations to mathematics symbolism.

2- to work together cooperatively in solving problems.

3- to discuss mathematical ideas and concepts.

4- to verbalize their mathematics thinking.

5- to make presentations in front of a large group.

6- that there are many different ways to solve problems.

7- that mathematics problems can be symbolized in many different ways.

8- that they can solve mathematics problems without just following teachers' directions.

2. Research importance:

- The use of manipulatives will enhance what teachers tend to reach, namely, by directing their attention toward introducing the facilitation of students understanding and conceptualization of mathematical ideas.

- The use of manipulatives gives the teacher an additional alternative assessment method to measure students' performance in a real situation.
- This study is considered a rare study in the Arab world that examines the effect of using manipulatives in enhancing students learning.

3. Research problem:

The current study aims to examine the effect of using manipulatives in mathematics on the achievement of the first-grade students. Specifically, this study tried to answer the following general question:

Does using manipulatives in teaching mathematics affect first-grade students' achievement?

This general question is branched into the following two questions:

1- Are there any significant differences between means of the experimental group (which was taught by using manipulatives), and control group (which was taught traditionally) on the achievement test?

2- Are there any significant differences between the two groups due to sex and interaction between group and sex?

The current study aimed at testing the following hypotheses[(1)] :

1- There are no statistically significant difference at a significance level (α=0.05) between mean scores of the experimental group (which was taught by using manipulatives), and control group (which was taught traditionally) on the achievement test.

2- There are no statistically significant difference at a significance level (α=0.05) between the mean scores of the two groups due to sex and interaction between group and sex.

4. Procedural definitions:

- **Manipulatives**: are small, usually very ordinary objects that can be touched and moved by students to introduce or reinforce a

mathematical concept, in the subject "numbers from (0-9)" in the first grade curriculum in mathematics.

(1) see **(Pagano, 1986)**, pages 349-373.

- **Achievement**: is the knowledge, understanding, and skills that student exquisite as a result of a specific educational experience. The achievement is measured by the students mark on the achievement test, which is developed by the researcher to be applied in this study.
- **First-grade students**: students with age 6-7 years, who were in the first grade in the scholastic year 2005/2006.

5. Limitations of the study:

- Instruments of the study were developed by the researcher, so the interpreting of the results depends on the validity and reliability of these instruments.
- The research was applied to UNRWA schools in Jerash, and this makes the generalization of results specified to study community or a similar community.
- The research was applied to first-grade students, and this limits the generalization of results to other grades.

6. Literature Review:

(Chester; Davis & Reglin, 1991) examined the effect of a teaching method emphasizing manipulative use on the mathematics achievement of third-grade students. Two third-grade classes in North Carolina with 26 students, each were selected to participate in the study. A 2-week geometry unit was administered in both classes. The experimental group teacher used mathematics manipulatives to teach the concepts presented in the unit, and the control group teacher used only drawings and diagrams to teach concepts. Analysis of covariance revealed that the experimental group using mathematics manipulatives scored significantly higher in mathematics achievement on the post-test scores than the control group.

In a study about using language and visualization to teach place value, **(Cotter, 2000)** studied 32 first-grade students at a rural Minnesota elementary school in USA. There were two classes of 16 students each. To teach place value, the experimental classroom used the "Asian" method, using language patterns and visualization with abacuses and base-10 blocks, while the control classroom used a traditional approach. Using interviews with the two teachers and the students, the researcher concluded that the students taught in the "Asian" method exhibited a better understanding of place value.

Kelly Reimer and Patricia Moyer conducted an action research in the year 2005 in Drexel School of education in USA, about Fractions Using Virtual Manipulatives on Third Graders **(Deubel, 2005).** " A Classroom Study, provides a look into the potential benefits of using these tools for learning. Interviews with learners revealed that virtual manipulatives were helping them to learn about fractions, students liked the immediate feedback they received from the applets, the virtual manipulatives were easier and faster to use than paper-and-pencil, and they provided enjoyment for learning mathematics. Their use enabled all students, from those with lesser ability to those of greatest ability, to remain engaged with the content, thus providing for differentiated instruction"[(1)] . Results from their pre-test/post-test design indicated a statistically significant improvement in students' posttest scores on a test of conceptual knowledge, and a significant relationship between students' scores on the posttests of conceptual knowledge and procedural knowledge.

In a qualitative research, **(Lackey; Reglin, 1991)** investigated the effects of manipulative instructional approach and traditional instruction on the achievement of Math subtraction facts for 30 second graders in a rural North Carolina public school. The 30 subjects were : below / average, average, and

(1) see **(Deubel, 2005)**, page 1.

above average in ability. The 30 students were broken down into two groups. One group used a traditional approach to the subtraction facts. The other group used a manipulative approach. The data was collected through tests, and the ability to communicate their understanding of

subtraction. It was concluded that greater gains in achievement were of subtraction basic facts occurred with the manipulative instruction approach.

To investigate the effectiveness of manipulatives and manipulative software on computational skills and spatial sense, **(Terry, 1996)** conducted a research on students in grades two, three, four, and five in St Louis area. There were three treatment groups: manipulatives only, manipulative software, and both manipulatives and manipulative software. Students participated in a three week unit focusing on computation (addition in grades two and three and multiplication in grades four and five) and a one week unit on spatial sense. Base Ten Blocks were used in the computation unit and attribute blocks in the spatial sense unit. Both were used in concrete and software form. A three way analysis of variance was used to interpret the data. In four of the six ANOVAs for computation, there was a significant difference for the group using both concrete manipulatives and software. With regard to spatial sense, there was no significant difference detected. There was no significant gender interaction effect.

To examine the effect of using manipulatives in teaching money concepts, **(Tracy; Fanelli, 2000)** selected 72 First and Second graders in a Midwestern metropolitan area in Michigan, they used proportional money model, coins for four half hour sessions over 8 weeks. Two first grade classes used the concrete and visual money model. A third first grade classroom used traditional teaching method and were randomly pre post tested. The second grade classes were selected randomly do pre and posttests. The results of the study revealed that in first grade, students show near mastery of learning coin names but lower ability to match coin with value. Both the traditional method and money model group had an overall post-test score of less than 50%. In skip counting, first graders were good with pennies but had difficulty with nickels, dimes, and quarters. Only 7/35 students were successful in counting a set of mixed coins cognition and value. Posttest revealed that among second graders in the money group 100% could correctly skip count dimes, nickels, pennies in a set, with quarters at 67%. Data indicates that students' ability to count on with a variety of coins is developmentally appropriate among second grader suburban students.

The result of the studies, which have been reviewed, revealed that using manipulatives in teaching and learning mathematics gives good results and positive impact on achievement in mathematics.

7. Methodology and procedures:

7.1. Study sample:

The community of the study consisted of all first-grade students at UNRWA schools in jerash (n=395), and was distributed on ten sections (5 for boys and 5 for girls) in the scholastic year 2005/2006.

The sample of the study consisted of four sections (two for boys and two for girls), which were randomly assigned from the ten sections. One section (of the two for boys and for girls) was selected randomly as an experimental group, which was taught by using manipulatives, and the other section was selected as a control group, which was taught by the traditional method.

The following table shows the distribution of the sample in the groups:

Table (1)

Distribution of the sample in the two groups

Sex / Group	male	female	Sum
Experimental	38	40	78
Control	39	38	77
sum	77	78	155

To verify that the two groups (experimental and control) are equivalent, a pre-test was applied and T-test was used for analyzing the data. Table (2) shows T-test results:

Table (2)

T-test results for comparing between the experimental and control groups to verify the equivalent of the two groups

Group	Number of students	Mean	Standard deviation	T- value	Critical value
Experimental	78	6.53	3.11	0.327	1.98
control	77	6.36	3.06		

Table (2) reveals that T value of the pre-test was 0.327 which was less than the critical value, and this means that the two groups: (experimental and control) are equivalent.

7.2. Study instruments:

7.2.1. Manipulatives:

The content of the material that taught during the research period, consisted of the following subjects: Shape, color, volume, (greater than, less than), (inside, outside), (over, under), (right, left), patterns, and numbers from (0-9).

The manipulatives that used in this research to achieve the content subjects were:

1- Money.

2- Number cubes.

3- Capacity containers (cups, gallons, liters).

4- Pieces of metal (different colors).

5- Pencils and rulers.

7.2.2. The Achievement test:

Depending on content analysis, a specification table was developed, and the achievement test was constructed and consisted of twenty 3-alternatives items related to the mathematical knowledge taught in unit "Numbers from (0-9)", from the first grade mathematics curriculum in the scholastic year 2005/2006.

The 20 items that formed the achievement test was distributed over three categories: Procedural knowledge (6 items), Conceptual knowledge (8 items) Problem solving (6 items).

After the completion of the workout of the achievement test, it was given to a panel of judges to give notes about the validity of the items and the overall test. These notes were taken into consideration, and the corrections were made.

To establish the reliability of the achievement test, it was applied to 30 students; and by using a Split-Half method, a Spearman-Brown Formula, it was found that the reliability coefficient for the overall test was (0.87) which is an accepted value for the research purposes.

7.3. Study procedures:

- A pre-test was applied to both the experimental and control group, to ensure that the two groups are equivalent.
- The experimental-group teachers who were participated in the application of the study were trained how to use manipulatives in the teaching process.
- The experimental group was taught the unit "Numbers from 0-9" by using manipulatives that mentioned in the study instruments, meanwhile, the control group was taught by traditional method through using the activities in the textbook.
- The study application period was 30 days (20 lessons).
- A post-test (which was the same as the pre-test) was applied to the two groups, and the results of the test were analyzed by using SPSS program to test the hypotheses of the study.

7.4. Study variables:

1- Independent variables:

a) group: It has two levels (experimental, control).

b) Sex: It has two levels (male, female).

2- Dependent variable: Achievement.

7.5. Statistical treatment:

To test the hypotheses of the study, means and standard deviations were computed to students' marks on the achievement test, and a 2-way ANOVA was used to compare between the means of the groups.

8. Study results:

8.1. Descriptive statistics:

A post-test data revealed that the greatest mark was (19/20) which refers to the experimental group males; meanwhile, the least mark was (4/20) which refers to both control group males and females.

Table (3) shows the frequency distribution of students' marks on the post-test:

Table (3)

The frequency distribution of students' marks on the post-test

Marks rate	Experimental group		Control group	
	males	females	males	females
20 - 16	14	13	8	5
15 - 11	15	16	18	20
10 - 6	7	9	10	11
5 - 1	2	2	3	2
Sum	38	40	39	38

Table (3) shows that the number of the experimental group students in the highest marks rate was greater than the number of control group students in the same rate.

Table (4) reveals the means and standard deviations of students' marks on the post-test:

Table (4)

The means and standard deviations of students marks on the post-test

	Experimental group			Control group		
	males	females	Males & females	males	females	Males & females
Mean	13.63	13.03	13.32	11.97	11.68	11.83
Std. Dev.	3.85	3.97	3.90	3.88	3.35	3.61

Table (4) shows that the means of the experimental group males and females was greater than the means of the control group males and females.

8.2. Analytic Statistics:

The two hypotheses of this study were:

1- There are no statistically significant difference at a significance level (α=0.05) between mean scores of the experimental group (which was taught by using manipulatives) and control group (which was taught traditionally) on the achievement test.

2- There are no statistically significant difference at a significance level (α=0.05) between the mean scores of the two groups due to sex and interaction between group and sex.

To examine these hypotheses, ANOVA was used to compare between the marks of the two groups, which was achieved through the post-test.

Table (5) reveals ANOVA results to compare between the two groups on the post-test:

Table (5)

ANOVA results to compare between the two groups on the post-test

source	Sum of squares	Degrees of freedom	Mean square	F - value	Critical value
Group	87.032	1	87.032	6.104	3.92
Sex	7.786	1	7.786	0.546	3.92
Group * Sex	0.970	1	0.970	0.068	3.92
Error	2153.002	151	14.258		
Total	2247.742	154			

(1) see **(Pagano, 1986)**, pages 349-373.

Table (5) revealed that there were statistically significant differences between the means of the two groups, since F-value was 6.104, which was greater than the critical value.

Restitution to table (4), and comparing the means of the groups, the mean of the experimental group (13.32) was greater than the mean of the control group (11.83), and this means that the experimental group was better than the control group. And this result interprets the rejection of the first hypothesis.

Table (5) also revealed that there were no statistically significant differences due to sex or the interaction between group and sex, since the

F-value was less than the critical value. Therefore, this result interprets to accepting the second hypothesis.

9. Results discussion:

The results of the study revealed that using manipulatives in math teaching and learning affects students' achievement in mathematics, and there were significant differences between the achievement of students who were taught by using manipulatives in comparison with the students who were taught traditionally.

This result seems to be a logical result, since mathematics teaching and learning requires giving attention toward the facilitation of students understanding, which can be supported by using manipulatives to aid this aim.

Moreover, when using manipulatives, we not only give students with different learning styles and different ways to see the problem, but we also give them an extra time they may require for learning.

In addition, when teachers use manipulatives, they can assess students' abilities by observing their performance, which is a good alternative assessment method, which enhances students learning and increases their achievement levels.

The result of the current study about the effect of using manipulatives, agreed with the studies of: (Chester; Davis & Reglin, 1991), (Deubel, 2005), (Cotter, 2000), (Lackey; Reglin, 1991), (Terry, 1996).

The results of the study revealed that there were no significant differences in the achievement due to sex and interaction between group and sex. This result may occur because males and females in each group were taught by the same method, either the experimental group by manipulatives, or the control group by a traditional method, so they faced the same situations and opposed the same conditions. This means that they ought not to be widely different in achieving knowledge. The result of the current study about the effect of sex and interaction between group and sex, concords with Terry as shown above.

Finally, we can say that using manipulatives in teaching mathematics at UNRWA schools for the first-grade students can prove efficiency for better achievement of the students in mathematics.

10. Recommendations:

According to the results of the current study, which revealed that there was an efficiency of using manipulatives in improving students' achievement in mathematics, the following can be recommended:

1- Using manipulatives in teaching and learning mathematics, especially in the lower basic grades.

2- Training math teachers on using manipulatives as an alternative method of students' performance assessment.

3- Conducting other researches on samples of other grades and other studious communities.

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