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Effect of Using Mathematics Manipulatives on the Student's Academic Achievement

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Abstract

Mathematics has served as a base for many modern science and technology courses. In all academic disciplines, mathematics has played an essential role in learning and expanding the boundaries of existing knowledge. In this research study, the researcher examined the effect of using mathematics manipulatives on students' academic achievement. A quasi-experimental, pretest/posttest research study with non-equivalent groups was used to examine the effect of using mathematical manipulatives on grade 3 students' learning about numbers, fractions and geometry concepts. From district Abbottabad, the researcher selected two government primary schools on a convenient basis in the same locality. One school included control group students (32) who were taught with the traditional method and the other school included experimental group students (31) taught through mathematical manipulatives. Mathematics achievement of students was measured through the Achievement test. The test was comprised of 20 MCQs items measuring learning about numbers, fractions, and geometry. The duration of the experiment was four weeks. Mean, standard deviation, and independent t-test were used to analyze the post-test scores. An analysis of the results revealed a significant difference in mathematics achievement between the experimental and control groups on the posttest scores. This study offers information for teachers and students to use manipulatives in mathematics education. The study also recommended the curriculum developers to develop a mathematical kit containing manipulatives aligned with the textbook.

Keywords: Fraction, geometry, grade3, manipulative, mathematics education

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Introduction

Telling was not coaching, and only listening was not wisdom. Yet, again several learning progressions revolved about the tutor, where the students were merely inactive information receivers. Whereas, young students focusing the studying process and the teachers being just facilitators or guides, was an important factor of modern-day education. In this process, the learner learned according to their desires and pace (Akinoglu & Ruhan, 2006). Both students and teachers tried to resolve these challenges in special ways in the light of their previously received perceptions and experiences. In this regard, it was a model for the young students to prepare themselves for challenges via the capacity of dealing with real-life situations in their gaining knowledge of the environment and discovering suitable solutions to their problems. In the case of this mastering process, now learning has been used not as an everyday technique but as a personalized process (Chin & Chia, 2004).

Students' do not understand the Mathematics concepts at the primary and they merely develop their abstract reasoning. . Teachers teach mathematics mostly with a conventional approach i.e. deductive. They use the deductive method in the class and start the lesson by dictating mathematics formulae by writing it on board and students are supposed to memorize those formulas to practice mathematical exercises. Students are supposed to be passive and responded only when teachers ask questions and often restricted interactions with other students.

Education in Pakistan had always been subject to examination, and mathematics education in Pakistan had almost always been a process of knowledge transfer, rather than a process of constructing meaning. Direct instruction was seen as the best method for mathematics teaching and learning. A typical lesson consists of introducing a new concept through examples, during which the teacher would provide step-by-step guidance to the students. The students were then given notes and problems to complete in the textbook, with teachers observing them working on those problems. Mathematics lessons were planned to a large degree from the official textbooks, which presumed that absolute knowledge existed, and it must be presented to the students. Students would only need to first learn the piece of information and then master it through drilling exercises. It was the voice of the textbooks that tend to play a major role in deciding and coordinating the relationships between teacher and student. Consequently, the teaching approach to mathematics was common in Pakistani schools. Teachers were seen as the main authority for mathematics in the classroom. They used authoritative, rigid, and

critical language, where they were often perceived as distant or impersonal.

Teachers around the world followed many teaching methods when bringing their courses into practice, each of which was based on different sets of rules according to which contact, and interaction were used in the classroom. Teaching of mathematics by using concrete materials might supply young students with a way to bridge from the rote learning of abstract mathematical concepts to understandings that would be required of them as they analyze arithmetic, algebra, and geometry in extreme school. To develop the abstract thinking of students by using concrete material mathematics manipulatives can be used to teach mathematics (Kelly, 2006). Teachers, who choose interesting tasks and use manipulatives that engaged young students in mathematical wondering, will help students construct their perceptions of facts as well as associations amongst facts (NCTM, 2000).

Mathematics manipulatives may be one alternative to deductive and abstract forms of teaching. Clements (1999) elaborated that manipulatives can be used to grant young pupils in constructing, firming, and concerning a volume of depictions of mathematical thoughts. The roots of manipulatives were observed in Friedrich Froebel, in 1837, formed the world's first playgroup and placed at the same time "Froebel Gifts," which had been two different sorts of portable blocks.

Manipulatives should be of one of three types. First, manipulatives should be items that have been conscious in every-day life, such as beads, buttons, coins, dice, and sticks. Second, manipulatives should be substances that had been common manmade and had many likely informative functions but happen mainly intended for some other reason such as youngsters' developing chunks, tangram puzzles, Legos, and Play Toys. Third, manipulatives ought to be substances that had been normally planned to be used in instructing mathematics, such as attribute blocks, base-ten blocks, coloration tiles, Cuisenaire rods, geoboards, pattern blocks, tangrams, and Unifix cubes (Spikell, 1993). It was very important to select an appropriate type of manipulative according to the intellectual level of students. At grade 3 students have specific needs and learning styles. So, it was obvious that they must be facilitated with manipulative suitable for them (Strom, 2009).

According to the National Curriculum for Mathematics (2006), there was a need to change the teaching from the transmission of knowledge to understanding Mathematical concepts with the focus on the active involvement of learners. There is a need to examine the effectiveness of teaching methods using manipulatives in the mathematics classroom

Several educational systems around the world had exercised such manipulatives and the Pakistani program wanted to follow it. According to the Education Policy of Pakistan (NEP, 2009), the focus should be on active learning. Today's mathematics instructors needed to use mathematics manipulatives to make mathematics principles concrete as an alternative to abstract.

The objectives of this study were to:

- Develop a teaching intervention by using manipulatives for grade 3 students.
- Examine the effect of teaching on grade 3 students' academic achievement taught through traditional teaching and educating by the use of manipulatives in mathematical concepts of numbers system, fractions, and geometry.

Null Hypotheses

H_{01}: There was no significant difference between the mean achievement scores of grade 3 students' in mathematics taught through manipulatives and traditional teaching.

H_{02}: There was no significant difference between the mean achievement scores of grade 3 students' in mathematics taught through manipulatives and traditional teaching on test items of the number system.

H_{03}: There was no significant difference between the mean achievement scores of grade 3 students' in mathematics taught through manipulatives and traditional teaching on test items of fraction.

H_{04}: There was no significant difference between the mean achievement scores of grade 3 students' in mathematics taught through manipulatives and traditional teaching on test items of geometry.

Methodology

It was a quantitative study that tried to determine the effect of manipulative materials as tools for effective learning. The research design of the study was Quasi-Experimental. The participants were not assigned randomly to conditions or conditions orders (Cohen, Manion, & Morrison, 2007; Cook & Campbell, 1979). This research design was appropriate to examine the use of grade 3 math manipulative students learning about the concepts of numbers, fraction, and geometry. The

researchers allocated the experimental and control treatments to intact groups, administered a pretest to both groups, performed experimental treatment practices only with the experimental group, and then administered a post-test to determine the discrepancies between the two groups (Creswell, 2014).

There were 1,264 government primary schools in Abbottabad District according to the 2017-2018 annual school census. The number of students, 36,060 were enrolled in 3rd grade at all the Abbottabad district public school was a study population. Contrary to random sampling, the nonprobability samples were selected. The researcher selected two schools on a convenient basis and took two intact groups one from each school. Researchers took non-equal 32 students in the control group and 31 students in the experimental group of grades 3.

Validity and Reliability of Research Tool

The instrument used in this study was the Mathematics Achievement Test; It was used to measure the accomplishment of pupils before and after an intervention. The pretest used to be the same as the posttest. It was consisting of Multiple-Choice Questions. The items used in this study were developed by the researchers themselves. Table of specification used in the construction of test items. In curriculum 2006, three chapters of mathematics grade 3 have 20 learning outcomes in which 6 learning outcomes were related to the Number system, 10 for Fraction and 4 for Geometry. Therefore, the same ratio was ensured in the MAT e.g. 30% items related to Numbers, 50% items for Fraction, and 20% items for geometry. These learning outcomes cover up the lower order thinking skills of Blooms' taxonomy, knowledge 35%, understanding 30%, and application 30%. The test items covered all the text material incorporated in the related three units of the textbook of mathematics for 3rd grade published by Khyber Pakhtunkhwa Textbook Board published 2018. Initially, 28 items were developed. Then the items were validated by five experts who were subject specialists in the mathematics of which two were lecturers and three were school teachers. In the light of their suggestions the items had been slightly modified, the changes were related to the statement of questions, and some picture's size was changed and made it clear and visible, four items were removed because they were measuring the same ability. The final test of 24 items was piloted on 30 subjects at grade 3. The result of piloting was as follows.

Table 1
Reliability of Items

Item No	Cronbach's Alpha if Item Deleted	Item No	Cronbach's Alpha if Item Deleted
1.	.688	13	.586
2.	.712	14	.547
3.	.522	15	.586
4.	.701	16	.563
5.	.590	17	.557
6.	.502	18	.571
7.	.711	19	.712
8.	.510	20	.561
9.	.521	21	.690
10.	.616	22	.583
11.	.712	23	.571
12.	.518	24	.582

Table 1 showed the reliability of test items, initially, the reliability coefficient of MAT was .528, as researcher-made 24 MCQ's and if items deleted 2,7,11,19 then reliability was .712 which shows that this check used to be suitable for facts collection and it could supply dependable data. The degree of interior uniformity as assessed by way of Cronbach's alpha for the universal MAT was 0.712. The final test was comprised of 20 items. Four alternative preferences had been supplied for the right answer for each item. The total mark of achievement test was 20. The time duration for the test was 35 minutes (1.5 min for each MCQ). A correct response on an item scored 1 mark and an incorrect response awarded 0 marks.

Development of Mathematics Manipulative Intervention

The gaining knowledge of arithmetic relied upon intently on its coaching. Mainly, the everyday coaching deductive technique of teaching was workouts in Pakistan. The researcher made a module for educating arithmetic to third grade with arithmetic manipulatives. The researcher made a lesson plan for numbers, fractions, and geometry. The subtopics of numbers were place value, compare two numbers by symbols <,>,=, ascending and descending order, number line, while fractions were equivalent fractions, proper fraction, improper fraction, compare fraction, the addition of fraction with the same denominator, subtraction of fractions with same denominator and geometry had point, ray, line segment, quadrilaterals, triangles, parts of a circle such as a radius, diameter, perimeter of triangle and quadrilateral. The researcher

made a lesson plan for each topic and made manipulatives and worksheets aligned with each lesson plan and learning outcomes. Manipulatives were physical objects that were easily made and economical. The module additionally consisted of assessment strategies such as asking the important questions verbally at some point of the lesson, lecture room tests, homework, and worksheets. The instructing module was validated by two experts.

Researchers made mathematics manipulatives aligned with content, the researcher studied about manipulatives through internet saw many videos about manipulatives, these manipulatives were used in different countries, to validate manipulatives from experts, researchers arranged three meetings with the teachers of private primary schools, in which researchers discussed in detail manipulatives and content of numbers, fraction and geometry with the expert. Experts validated the Mathematics Manipulatives Intervention and gave their suggestions later on researchers incorporated all the observations of experts in the intervention before the experiment.

Profile of Mathematics Teachers

A mathematics teacher from a public school was involved in this study to teach the control group and had a 5-year experience of teaching, her qualification was M.Sc. mathematics with M.Ed. The experiment was conducted in one group in one school and simultaneously conventional teaching was taken place in the control group in the second school. Treatment began in September and ended in mid of October 2019 it used to be a 4-week experiment. This period was appropriate due to the fact it used to be nearly equal to the period specified on the scheme of study, which offers the feature of the total time allotted in the tutorial time for the concern of mathematics in accordance to the content of KPK institutions. Before the administration of the treatment, teachers from each faculty were invited to talk about an experiment. During the dialogue, the instructors had been brought by the researcher to the goals and strategies of the study. They mentioned the mathematics period used to be altering as 2nd period in time desk in each school, identical content material used to be taught in both organizations at the same time were also discussed. On the first day, the researcher gave the mathematical achievement test as a pretest to experimental and control groups students. The researcher first taught the experimental group and used a variety of manipulatives such as fraction squares, fraction pie, fraction strips, fraction cubes, paper strips, geoboards, polka sticks, silver beads, while

the control group taught by using a typical approach which was deductive. The content material strands had been imparted as per the order agreed in the program and the textbook of mathematic for class three. In this study, the duration of each type was 35 minutes. The instructor taught the control group with the ordinary method and taught the experimental group with a module. At the stop of the scan after four weeks of intervention, the post-test was once conducted.

Experiment Procedure

The lecture room was set up with procedures and standards that were closely similar to every public education schoolroom. The first day was spent on a pre-assessment (which would emerge as the post-assessment on the remaining day of the program) and the instructor and students getting to be aware of each other. Every day following had a method as follows:

- Students got into the study room with their mathematics manipulatives that were made by them earlier than one day.
- The instructor had defined what the goal for the day was for their students.
- A brief recap of the work completed earlier in the day had been answered and any questions students had asked.
- Students had been given the manipulations and instructions to start working.
- Every student worked for my part guided by the teacher.
- As young students were working, periodically teachers would stop to talk about what students had been finding, struggles they were having, questions, and anything the students determined interesting or interesting.
- For the students, a closing activity took place nearby to furnish purpose which means the undertaking.
- A post-activity sheet was given to students that included questions or issues associated with the work.

The last day of the 4-week intervention was spent on students taking the post-assessment (the identical test given the first day of the program) and an ending ceremony. Every day, the researcher, before leaving the room, examined the post-activity sheets from their students. This furnished feedback and occasionally adjusted how the subsequent day's work would look. If the student research indicated that the majority of

students no longer completely closed the ideas or the pupils liked the way the material was present then each pupil study room made changes to the plan of the following day. They were equally used for when students demonstrated that the material was too trivial. Then, the material was updated to be greater difficult and meaningful. This procedure of evaluating a day's work in the classroom and assessing scholars getting to know and understanding was consistent with what teachers do on an everyday basis. Adjustments and small modifications from a personal trip could now and then made the difference between students studying and wasting their time. Even behind the scenes, the program was once designed to furnish the most correct and representative getting to know environment as that of a public classroom.

Results

The study was quantitative. Before the analysis of data, the normality of data was checked through Shapiro-Wilk statistics.

Table 2
Shapiro-Wilk test of normality

Scale	Statistics	df	Sig
MCT	.937	57	.002

Table 2 shows that the significant value was found to be .002. It means the null hypothesis was rejected, and an alternative hypothesis about the data was accepted, and the data was normal.

Table 3
Comparison of control and experimental group students mean scores on post-test

Groups	N	M	SD	df	t	Sg
Control groups	29	10.61	3.68	60	-4.32	.000
Experimental group	28	16.78	3.71			

The consequence and common variance of the arithmetic success ratings in the post-test, as reasonable as the results of the independent-samples evaluations for each of the faculties were added in Table 3, the penalties of the independent-samples t evaluations indicated that there was a major difference between the experimental and control groups in the mathematic success rankings. Besides, the mean scores of the experimental group were students was higher than that of the control

group, representing that the experimental organizations carried out especially better than the control group in the mathematic fulfillment test containing items of numbers, fractions, and geometry.

Table 4
Comparison of control and experimental group student's mean scores on posttest items related to Number System.

Groups	N	M	SD	df	t	Sg
Control	29	4.81	2.37	60	-3.376	.001
Experimental	28	6.84	2.36			

Table 4 presents the mean and famous variance of the mathematical success rankings in the post-test, that there was a big difference between the experimental and control organizations for each institution in the mean mathematical success rate, at $p<.05$, suggesting that there was a great distinction between the experimental and control companies in unit numbers, thereby indicating that the experimental crew scored substantially higher than the control team in the numbers.

Table 5
Comparison of control and experimental group students mean scores on posttest items related to Fraction

Groups	N	M	SD	df	t	Sg
Control	29	4.81	2.37	60	-3.376	.001
Experimental	28	6.84	2.36			

Table 5 shows the effects of the independent-samples t exams exhibit that there was once a great change in the mean mathematical attainment rankings among the experimental and control group for both institutes in content strand fractions. As $p<.05$ it indicated that the experimental set carried out drastically higher than the control group in the fractions content.

Table 6
Comparison of control and experimental group students mean scores on posttest items related to Geometry

Groups	N	M	SD	df	t	Sg
Control	29	2.77	1.230	60	-3.203	.002
Experimental	28	3.58	0.672			

Table 6 presented the outcomes of the independent-samples assessments and exhibited that there was a huge distinction in the mean arithmetic accomplishment rate among the experimental and control group for both

institutes in content material strand geometry, however as $p<.05$ indicating that there was a sizable difference in mathematics success among the experimental and control corporations in geometry, which indicated that the experimental crew achieved considerably higher than the control team in the geometry.

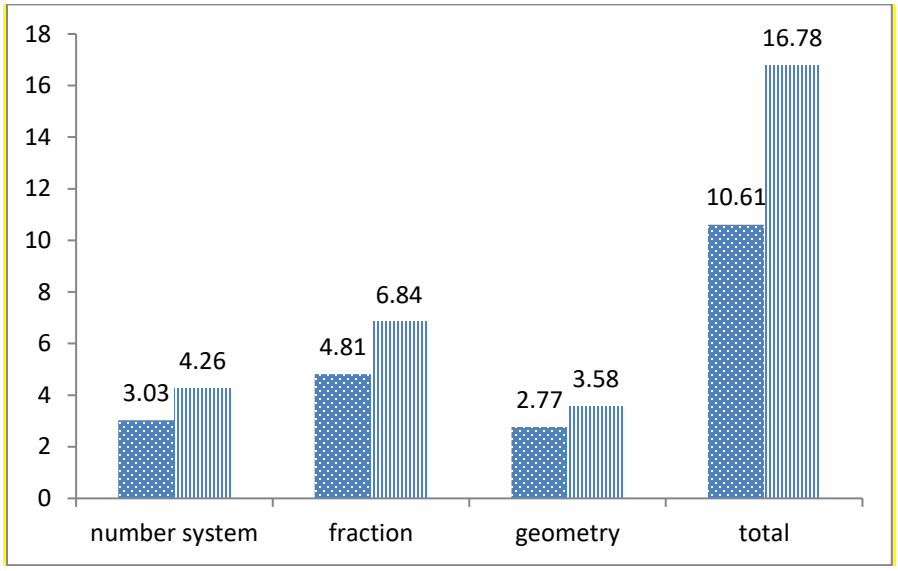

Figure 1: Graph of Comparison students' score on number system, fraction, and geometry.

Figure 1 shows the comparison of students' academic achievement before and after the intervention, there was an enormous difference between the mean value of students' score in post control and post-experimental groups. It also shows the comparison of students' scores in numbers, fractions, and geometry. The overall result of the posttest of the experimental group was highly significant, indicating higher differences in the content of fractions, numbers, and geometry of the experimental group than the control group.

Discussion

The relevant literature to this study was filled with papers applauding the use of manipulations and offering suggestions of how best to use manipulatives. Such posts, however, did not provide evidence of

coercive effectiveness. Proof of the efficacy of coercive use can only be provided by empirical study. Various researchers recently conducted to investigate the effects of manipulatives on instruction in mathematics. It had been observed, according to the findings of those studies, that manipulatives increase the achievement of mathematics (Cope, 2015; Durmuş & Karakırık, 2006; Enki, 2014). Many countries of the world taught mathematics with manipulatives at the primary level, there was a need to examine the use of manipulatives and its effectiveness in the context of Pakistan. Mathematics Manipulatives (MM) made getting to know math interesting and enjoyable. Gave schoolchildren the wish of being employed on a problem web page or fixing a difficulty with interesting and curiously fashioned chunks, and no competition was present. Around the same time, manipulatives plot and inspire young students to understand. There was an urge to undertake a quest for learning to explore the effect of manipulations on the tutorial achievement of the students. This study provided an incentive for curriculum supervisors, teacher educators, professional development personnel, and classroom teachers to include manipulatives in the teaching and learning of mathematics because the likely result would be that student achievement in mathematics would improve.

Conclusion

The use of manipulatives could aid students in learning mathematic standards at some stage in essential training which gave students gain in taking rigorous excessive mathematics and science courses. The consequences of (TIMSS) set up that many students began their high school profession besides association basis in mathematics, closing doorways in advance for further training and better careers. During this study, the use of the manipulatives over the four-week units resulted in greater achievement for the experimental crew. The findings of the posttest rankings revealed that in terms of ordinary achievement of mathematical principles there had been considerable variation between the two groups. This study provides further evidence of the positive effects of using manipulatives. Students who used manipulatives got higher achievement scores.

Recommendations

Based on the findings of this experimental study recommended that curriculum supervisors should confidently propose policies that

incorporate mathematics teaching manipulations in a bid to enhance the math curriculum. It was proposed that primary school teachers choose textbooks that integrate the use of manipulations in the unit of mathematics and suggest budget increases for the gaining of physical manipulative materials through their school districts. This research recommended that a multivariable approach to teaching mathematics need to be considered. Additionally, a longitudinal study could be conducted with students to see if their experience with manipulatives increased their retention of the mathematical concept. Additional experimental studies are needed to be conducted that examined the effects of other manipulative programs on achievement, as well as the effectiveness of manipulatives for other concepts, and for different students. The study also recommended the policymakers develop a mathematical kit contain manipulatives aligned with the textbook.

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