

**EFFECTIVENESS OF MANIPULATIVE MATERIALS IN TEACHING
MATHEMATICS AT SECONDARY LEVEL**

A

THESIS

BY

MANI PRASAD LUITEL

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Letter of Certificate

This is certify that **Mr. Mani Prasad Luitel**, a student of academic year **2070/71** with Campus Roll Number **709**, Thesis Number **1329**, Exam Roll Number **280450** and TU Registration Number **9-2-290-87-2006** has completed this thesis for the period prescribed by the rules and regulations of Tribhuvan University, Kirtipur, Kathmandu, Nepal. This thesis entitled **Effectiveness of Manipulative Materials in Teaching Mathematics at Secondary Level** has been prepared based on the results of his investigation. I, hereby, recommend and forward that his thesis be submitted for the evaluation as the partial requirements to award the degree of Master of Education.

.....

(Assoc. Prof.Laxmi Narayan Yadav)

Head

Letter of Approval

This thesis entitled **Effectiveness of Manipulative Materials in Teaching Mathematics at Secondary Level** submitted by **Mr. Mani Prasad Luitel** in partial fulfillment of the requirements for the Master's Degree in Education has been approved.

Viva Voce Committee

Signature

Assoc. Prof. Laxmi Narayan Yadav
(Chairman)

.....

Prof. Dr.Hari Prasad Upadhyay
(External)

.....

Ms.SaralaLuitel
(Supervisor)

.....

Date:

Recommendation for Acceptance

This is to certify that **Mr. Mani Prasad Luitel** has completed his M.Ed. thesis entitled **Effectiveness of Manipulative Materials in Teaching Mathematics at Secondary Level** under my supervision during the period prescribed the rules and regulations of Tribhuvan University, Kirtipur, Kathmandu, Nepal. I recommend and forward his thesis to the Department of Mathematics Education to organize final viva-voce.

.....

(Ms. Sarala Luitel)

Supervisor

Date:

Declaration

This thesis contains no material which has been accepted for the award of other degree in any institutions. To the best of knowledge and belief this thesis contains no material previously published by any authors except due acknowledgement has been made.

.....

Mani Prasad Luitel

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Dedication

To My respected parents:

Khum Prasad Luitel and Khem Kumari Luitel

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.....

Mani Prasad Luitel

Abstract

The purpose of this study was to compare the effectiveness of manipulative materials on students' achievement in parallelogram and circle of geometry at grade IX. A pre-test and post-test of quasi-experimental research design was used to compare the achievement of two groups experimental and control. The researcher chose 36 students of grade IX of Shree Bhanu Bhakta Acharya Secondary School, Galyang-3, as an experimental group and 39 students of Shree Janasewa Secondary School, Waling-14 as a control group. After completion of the targeted chapters, researcher collected the data from mathematics achievement test and a set of questionnaire related to five point Likert scale. The mathematics achievement test were used for the first objective as to compare the effectiveness of the manipulative materials in parallelogram and circle, similarly; questionnaire and observation were used for second objective as to analyse the students view towards the feeling of using manipulative materials in learning parallelogram and circle.

The results indicated that there was a significant difference between the average achievement score of experimental and control groups on post-test. This finding illustrated that the students in the experimental group performed better when using manipulative materials than the control group without using manipulative materials. Additionally, a set of questionnaire based on Likert scale was used for the finding of students view; and change was recorded under observation. Then, the result had shown positive view about manipulative materials in learning parallelogram and circle of geometry.

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Abbreviations

i.e.	:	That is
d.f.	:	Degree of Freedom
P	:	Difficulty Level
D	:	Discrimination Index
F	:	F-distribution
t	:	t-distribution
r	:	Reliability of Coefficient
r_{xy}	:	Pearsons's Correlation Coefficient
α	:	Level of Significance
%	:	Percentage

Chapter I

INTRODUCTION

Background of the Study

Mathematics is an important part of human civilization. It is essential for day to day life as well as for higher study in science and technology. It is essential for everyone, rich or poor, in every activity related to the mankind. The importance of mathematics has been realized and accepted since the beginning of school education in Nepal. Students apply mathematical concepts, skills and logical reasoning to solve different kinds of problems in mathematics. To make clear concepts of mathematical problems, the use of manipulative materials plays a major role. Students get the idea about it by touching, looking and feeling it and can make a concrete model in their brain about the topic.

There are different types of materials which support the teaching in the class such as literature, audio visual, models and manipulative. Among them manipulative materials is one which plays a vital role for teaching learning process. Manipulative materials that are designed to be touched or handled by the students, which develop their perceptual skills, psychomotor skills etc. are called manipulative materials. Oxford dictionary “Manipulative materials are those materials which skillfully used by hands, “*Wikiansawer.com* -“Manipulative materials are the materials that are used to aid in interference of information from one to another”.

Although many efforts have been made to enhance the standard of mathematics, there exist many shortcomings in this field. The major drawback is teaching without using manipulative materials. In geometry, there is a tradition of solving problems being based on parroting certain formulae. Students do not

understand the application of the solved problems, though they reach the correct answer. So, various manipulative aids are necessary to be used while teaching/learning geometry. In this study, the researcher has made a humbly attempt to explore the effectiveness of manipulative materials while teaching geometry.

Those instruments, which are useful, essential for teaching learning activities in classroom are called instructional materials. These are essential for the mathematics teacher as spices for the chef. These materials are necessary, extra ingredients, which make teaching and learning mathematics a pleasant, satisfying experience. They also give simple way to achieve mathematical goals. Since mathematics is an abstract and logical science, mathematics teachers have especial need for manipulative materials, which tends to reality to the mathematical ideas.

Dent writes about manipulative materials "All the materials used in the classroom or in the teaching situations, to facilitate the understanding of the written and spoken word is manipulative materials" (Cited, Upadhyay, 2061 B.S. P. 134).

About the importance of educational materials, Upadhyay, (2061 B.S.) describes: the importance of educational materials in mathematics teaching are to motivate students towards abstract concepts, to work as a catalyst for our sensory organs, to remove verbal complexity to think out and analyze the verbal and written problems and to facilitate as a whole. But, Risk (1947) emphasis about importance of visual materials in following ways:

The use of visual materials play an important role in mastering abstract or general concepts, visual materials are aid to thinking an abstract terms and to seeing abstract relationships. They are not helpful because we want an accurate image of thing used but because they make it easier to

concentrate on or see the relationships. They thus facilitate learning because we can attend to concrete things more reality than imagined things.

Mathematics is an abstract and logical science. So, the mathematics teacher at any level, has an especial need for manipulative materials. This material implies the visual representation of different mathematical concepts. There are many kinds of manipulative materials. According to Piaget, the intellectual development of children passes through four different age stages, sensory motor, and pre - operational, concrete operational and formal operational stage. The student in secondary level concern to concrete operational stage (11/12 - 14/15 years). On this stage, they do not know about abstract concepts easily. So to teach them any mathematical concepts, concrete materials should be used.

Most of the schools in Nepal are still teaching without using manipulative materials characterized by ministry of subject matter through drill, repetition and memorization. The subject matters are presented with limited teaching aids, few textbooks, chalkboard as the main manipulative materials since 1961/62. Janak Education Material Centre (JEMC) was established, which was government institution for the development, production and distribution of teaching materials for government schools. Moreover, NESP - 1971 has emphasized on making mathematics life oriented and practical by introducing revised content, textbooks and conducting teacher training programme and supervision system.

Statement of the Problem

Use of manipulative materials in teaching mathematics plays a vital role in effectiveness of learning. Pupils learn from the materials they touch and they can

build a solid foundation of the concept about mathematics. In our country many schools in the remote areas even do not get their textbooks on time. They do not get any supporting materials for their learning. So the manipulative are very far from them. The researcher in this research was going to find out the effectiveness of manipulative. The researcher had tried to find out the answers of the following questions from this research:

- What are the differences in the achievement of students in mathematics using manipulative materials and without using manipulative materials?
- What is the feeling student towards the use of manipulative materials?

Objectives of the Study

The following were the objectives of this study:

- To compare the effectiveness of the manipulative materials.
- To analyze the students view towards the feeling of using manipulative materials.

Hypothesis of the Study

Hypothesis means a mere assumption or some supposition to be proved or disproved. It related an independent variable to some dependent variable. The two types hypotheses were formulated in this study, they are as follows:

Research Hypothesis

Using manipulative materials provide effective result based on the achievement of the students to comparison without using manipulative materials while teaching theorems of parallelogram and circle of geometry.

Statistical Hypothesis

The null and alternative hypothesis as follow:

- a. **H₀**: There is no significance difference between the mean achievement score of experimental and control groups i.e. $\mu_1 = \mu_2$ on pre-test

H₁: The mean achievement score of experimental group is not equal to the control group i.e. $\mu_1 \neq \mu_2$ on pre-test

- b. **H₀**: There is no significance difference between the mean achievement score of experimental and control groups i.e. $\mu_1 = \mu_2$ on post-test

H₁: The mean achievement score of experimental group is higher than the control group i.e. $\mu_1 > \mu_2$ on post-test

Significance of the Study

This study would be helpful for teaching mathematical concepts and it will always encourage the teachers teaching in secondary level to use teaching materials. This study would provide the guideline to educators, researchers and curriculum planners. It would also provide the ideas of manipulative materials for the concept formation for the students. It would also provide some suggestions for the textbook writers to elaborate their examples with the help of manipulative materials. Ultimately this study would help to improve the teaching learning procedure in secondary level to remove the fear of mathematics from the students.

Delimitations of the Study

This study will be delimited under the following ways:

- The researcher of this study has utilized manipulative materials (geo board and circle-board) particularly theorems of parallelogram and circle of geometry to the grade IX students.
- The study was delimited to the two government schools of Syangja district.
- In the experimental group 36 students of Shree Bhanu Bhakta Acharya Secondary School were for the study. In which the researcher was taught in the experimental group by using manipulative materials.
- In the control group 39 students of Shree Janasewa Secondary School were for the study. In which the researcher was taught in the control group without using manipulative materials.
- The experimentation period of this research was based on completion of targeted chapters around one month.
- Tests have been made by the researcher himself with help of the subject teacher, expert, and supervisor.

Definition of Key Terms

The key terms of this study were defined as below:

Manipulative Materials: Teaching materials which can be touched, felt and looked by the Teacher as well as students in the classroom. While teaching geometry the researcher used geo-board and circle-board.

Experimental Group: The group of student taught by using manipulative materials.

Control Group: The group of students taught by traditional method and without using manipulative materials.

Achievement: It is defined in term of the score obtained by the students in mathematics.

Effectiveness: The measure of effect for this study includes the increase in the average achievement of students in mathematics and students positive response towards the feeling of using manipulative materials.

Traditional Method: It is a teaching strategy in which teachers use lecture method most of time. And it concerned with the teacher being the controller of the learning environment. Power and responsibility are held by teacher and they play the vital role.

Chapter II

REVIEW OF RELATED LITERATURES

A review of literature is the process of locating, obtaining, reading and evaluating. It is the source of further study of research task. The review of literature provides the researcher in making his/her problem more realistic, precise, researchable and meaningful. It helps to conduct the research program and gives a better idea of surveying and research. Then it guides towards conclusion. Thus, the review of literature is an important and essential guideline of research planning. This chapter deals with the study of the literature related to this study.

Review of Empirical Literature

Many studies have been conducted about teaching methods, teaching problems, faced by the teachers, instructional materials, and student's achievement in mathematics in different grades in school level. So far as the researchers is concerned, there is not exactly same research has been done on the effectiveness manipulative material in learning mathematics at secondary level. The researcher has tried to find out the literatures related to identification and analysis if errors committed by the students. Some of them are illustrated as follows:

Amatya(1978) did a research entitled “A study of the effectiveness of teaching mathematics with and without the use of instructional materials.” In this research the researcher concluded that the performance of students taught with the use of instructional materials was significantly when compared with the performances of the students taught without the use of instructional materials.

Baral(2006) did a research work on “Effectiveness of instructional material in teaching geometry at primary level.”He made two groups of students, one

experimental and another control. The experimental group was taught using instructional materials where control group was taught without using manipulative materials. The researcher concluded that the achievement of the students of experimental group was better than that of the control group. So, geometry teaching in group A by using different instructional material has better achievement than without using instructional materials.

Pokhrel(2010) did a research on “Effectiveness of Zoltan P. Dienes’s learning strategies in Mathematics teaching at primary level”. He took the population of Kaski District and took the sample of one of the school of Pokhara to find the effectiveness of Zoltan P. Dienes’s learning theories strategies in mathematics teaching in primary level. He made two groups of students and for one group he used traditional teaching method where for the group he used Dienes Strategies. He took a test and tested with different testing methods. He concluded that Dienes learning theories strategies is more effective than traditional method in teaching mathematics for area, perimeter and volume i.e. mensuration portion of mathematics at primary level.

Bhushal(2000) did a research on “A study on the effectiveness of teaching geometry using discovery module and expository module of teaching in secondary level” with the aim to find out whether the discovery module of teaching in geometry is more useful than expository to prove geometrical theorems as well as to compare the achievement between the groups of the students taught by using discovery and expository model of teaching. They were taught for 3 weeks. He then took a test to find their achievement level. The T-test was applied to analyze the data. From his research he draw a conclusion that discovery model of teaching mathematics was better than that of expository model of teaching geometry.

Basnet(2004) did an experimental research on “The effects of constructivism, an achievement of grade IV students in mathematics.” The main aim of the study was to experiment scores of conventional method and constructivist method in Nepal. For this study the researcher selected 54 sample students from two schools involving one control group and another experimental group. After completing the experiment, an achievement test was administered on both groups and mean scores were calculated. The result was drawn on the basis of t-test and bar diagram. The researcher found that constructivist method of teaching was better than the conventional method of teaching mathematics.

Budhathoki(2004) did an experimental research on “Effectiveness of co-operative learning method in teaching mathematics at primary level”. Thirty two students were sampled and divided into two equivalent groups. They were taught for one month. T- Test was applied to test whether the co-operative learning method is more effective than traditional method in teaching mathematics. He concluded that co-operative learning method was better than traditional method of teaching probability.

Ghimire, (2008) studied “Effectiveness of Piaget’s cognitive learning theory in teaching mathematics at primary level”. For this research he sampled 30 students of class five and he divided them into two groups. He applied traditional method for one group and for another one he followed cognitive learning theories suggested by Piaget. At last he administered an achievement test for both groups and t-test was calculated for both groups. He obtained that the Piaget’s learning theory is effective in classroom than traditional method.

Neupane(2001) did an experimental research on “Effectiveness of play-method in teaching at primary level”. To compare the achievement of students taught by play-way method versus traditional method, the researcher divided the students in two groups and they were taught for four weeks in grade II. The researcher had taken a pre-test to make equivalent groups and he conducted a post achievement test. There were two school

sampled. The t-test was applied to conclude that the play-way method was significantly better over traditional teaching method.

Regmi(2006) did a research on “Effectiveness of Instructional Materials OHP(overhead projector) in teaching geometry at secondary level” with an aim to determine the impact of teaching materials by comparing the students’ achievement who were taught using the teaching materials. The pre- test, post-test and equivalent group design was adopted for the purpose of the study. The forty students of grade IX of AVM higher secondary school were the sample of the study. On the basis of pre-test scores, students were divided into two groups. The researcher himself taught both groups, test was conducted and means achievement of two groups were compared to determine the relative effectiveness of the OHP on teaching mathematics. The researcher adopted t-test at $\alpha=0.05$ level of significance to compare the achievement of the students taught by OHP is greater than without using OHP.

Dhakal (2010) did a researcher on “Effectiveness of Van Hiele model f learning geometry at primary level”. He took the sample of 30 students of Harvard Academy, Pokhara. He divided the sample students into two groups experimental and control. He used traditional method for the control group and Van Hiele model for the experimental group. After the completion of the teaching, he conducted a post achievement test and tested t-scores for both groups. He found that the achievement score of experimental group was better.

After analyzing and revising above students, the researcher arrives at the conclusion that the research study would be fruitful to find the higher achievement of secondary level Grade IX students in geometry teaching with using manipulative materials than without using manipulative materials.

Theoretical Review

The use of the term manipulative materials raises a fundamental question "what are manipulative materials?" In this context manipulative materials are objects or things that the students are able to feel, touch, handle, and move. There may be real object which have social application in our everyday affairs. In other words, there may be several objects which are used to represent an idea. For example: number line, triangle, quadrilateral, parallelogram, charts, place value table ,base ten block, geo - board , rubber band, geometric model, set square, meter scale, abacus, flannel board, graphs, different types of geometrical shapes etc. which are to be related to the students' real world. Research in England, Japan, China and united- states support the idea that mathematics instruction and students' - mathematics understanding will be more effective if manipulative materials are used. In mathematics, manipulative materials are defined as any materials or object from the real world. The children move around to show a mathematical concept.

Criteria for Selecting Manipulative Materials

A. Pedagogical Criteria for Selecting Manipulative Materials

Pedagogically there are many criteria to consider in selecting manipulative materials. One of the most important considerations is whether the materials serve the purpose for which they are intended. The following criteria should be included to identify pedagogical considerations in the selection of manipulative materials.

- The materials should clearly represent the mathematical concepts.
- The materials should be motivating.
- The materials should be multi - purposive if possible.
- The materials should provide a basis for abstraction.

- The materials should provide for individual manipulation.

B. Physical Criteria for Selecting Manipulative Materials

Physical criteria are important, since many sources of information available to teachers describe features of the materials. A careful watching physical criterion would be helpful in initially screening manipulating materials. Among the physical characteristics to consider in selecting manipulative materials are as follows:

Attractiveness, Durability, Simplicity, Size and Cost

The materials should appeal to a child's natural curiosity and his desire for action. Materials in themselves should not divert attention away from the central concept being developed. Similarly, the device must be strong enough to withstand normal use and handling by children. When maintenance is needed, it should be readily available at reasonable cost. On the other hand, the design of materials shouldn't time consuming, disturbing the class, and collection of large number of facts etc. Also the materials should be designed to accommodate children's physical competencies and thus be easily manipulated. Thus the cost estimate for manipulative materials should reflect the need of materials as well as the expenditure for materials.

Functions of Manipulative Materials

There have been several fine lists summarizing uses and functions of teaching materials. Many such lists apply specifically to manipulative materials. Among the most common use of the manipulative materials, some uses are to provide individual differences, to provide active participation by pupils, to provide an opportunity for students to discover relationships and formulate generalization, to provide concrete representations of abstract ideas, to provide experiences in actual problem solving situations, to increase motivation related, not to a single mathematic topic, but to learning in general and to vary instructional activities.

Chapter III

METHODS AND PROCEDURES

Research methodology is the most important aspect of research work. It is a bridge to achieve the objectives of the study in systematic way. Simply it means way to gather information. Authenticity and reliability of any research depends upon the tools and methods used for data collection. Hence, the primary purpose of this chapter is to discuss and design the framework for the research.

Research Design

Research design is the design of path about how does the research was conduct. It is the detail path of the investigation. Thus, research design comprises the overall strategy followed in collecting and analysing data (Gay et al., 2012).

To meet the objectives of the study, the researcher used experimental design. According to Gay et al. (2012), in experimental research the researcher manipulates at least one independent variable, controls other relevant variables, and observes the effect on one or more dependent variables. It involves a comparison of two groups like experimental and control group.

Among the various experimental designs, pre-test and post-test design of quasi-experimental design was preferred most in this study because this design is often used in classroom experiments when experimental and control group are naturally assembled groups as intact classes. The paradigm of the study is as follows:

Table 3.1: Design of Study

Groups	Pre-test	Treatment	Post-test
Experimental	O ₁	x	O ₂
Control	O ₃	–	O ₄

Where,

O₁, O₃= Pre-tests given to the students.

X= the treatment given to the experimental group.

O₂, O₄= Post-tests given to the students.

To fulfil the objectives of this research, two groups of students were formed from homogeneous as possible as by selecting school of similar status and focusing same cognitive structure of students.

In this design, O₁ and O₂ represented the pre-test and post-test for experimental group, and O₃ and O₄ represented the pre-test and post-test for control group. Both groups were given the same achievement test (pre-test) before treatment. Pre-test has used to assess similarities between groups. After pre-test, the experimental group of students had been taught by regularly using manipulative materials known as treatment X. But the control group of students had been taught by regularly without using manipulative materials. Here traditional method also includes teaching without using manipulative materials. And their activities were noted by regular observation. At the end of the experimentation time, achievement test (post-test) have been conducted to both group and their score were compared and analysed. And scale of students view on manipulative materials has been conducted only experimental group and their view were analysed.

Sample and Sampling Strategy

In this research work, Syangja district was selected as a research site. Students of grade IX of Syangja district have been considered as population. Using convenience sampling researcher selected two government schools of Syangja district students of grade IX have been preferred as sample.

In particularly, 36 students of Shree Bhanu Bhakta Acharya Secondary School and 39 students of Shree Janasewa Secondary School were the sample of this study. These two schools are located in Syangja district. Two groups of students were found homogeneous as possible as by selecting school of similar status and focusing same cognitive structure of students by tossing the coin.

Table 3.2: Composition of Sample

Group of students	No. of students	Percentage
Experimental	36	48%
Control	39	52%
Total	75	100%

Variables

Variables are key ideas that researcher seek to collect information on to address the purpose of their study. A concept which can take on different quantitative values is called a variable. Also variables is a characteristic or attribute of an individual or an organization that researcher can measure or observe and varies among individuals or organizations studied (Creswell, 2012).

Different variables used in educational research. An independent variable is an attribute or characteristic that influences or affects an outcome or dependent variable.

A dependent variable is an attribute or characteristic that is dependent on or influenced by the independent variable (Creswell, 2012). It means if one variable depends upon or is a consequence of the other variables. It is termed as a dependent variable, and the variable that is antecedent to the dependent variable is termed as an independent variable. Variables that are not related to the purpose of the study, but may affect the dependent variable are termed as extraneous variables. The variables in this study were classified as:

- **Independent variable:** In this study, using manipulative materials (geo board and circle-board) are manipulative variables arranged mainly as independent variables.
- **Dependent variables:** In this study, students' score on mathematics achievement test (post-test) and students' view on Manipulative materials in learning parallelogram and circle of geometry are considered as dependent variables.
- **Extraneous variables:** Selection of school, instructor/teacher, subject matter, group, experimental time, test, scoring, student's labor and home environment are considered as extraneous variables in this study.

Some Major Affecting Variables Controlled in the Experiment

- **Selection of School:** Such two schools were selected in sample which is similar in status like socio-economic, facilities, result of student etc.
- **Instructor/Teacher:** Researcher himself was taught for the experimental and control group.
- **Subject Matter:** In experimental period the chapter parallelogram and circle of geometry of grade IX was taught for the both groups.

- **Group:** Experimental and control group of students have been made by naturally assembled.
- **Experimental Time:** Researcher had provided equal time to both groups.
- **Test:** Same test paper had conducted for the both groups before and after the time of experimentation.
- **Scoring:** Researcher himself had gave the score of students in text paper appeared by the students.

Some Extraneous Variables in the Experiment are not controlled

- Student's labor: Students may labor more or less than expected by the researcher and self-study of the students may affect in the result of research, which is out of control.
- Student's home environment: Student's home environment has great effect on student's behaviour and attitude but it cannot be controlled by the researcher.

Experimental Process

Experimental process is divided into three stage which as follow:

Pre-experimental Stage: In the pre-experimental stage, the researcher developed the test item and questionnaires. The test item was related to the parallelogram and circle of grade IX. Test item included the both objective and subjective questions. The questionnaire related to five point Likert scale was based upon the students view about manipulative materials. After developing test items, mathematics achievement test items were piloted on the group of students that are not included in sample for pre-test and post-test. And analysed the result of pilot test and select the pre-test and post-test item of mathematics achievement test. After selected test item of

mathematics achievement test, pre-test was administered among the students of experimental and control groups for the purpose of group comparable. The pre-test consisted of ten objective questions and six subjective questions.

Experimental Stage: In this stage, researcher himself was taught for the experimental and control group regularly one month. The experimental group of students was taught by using manipulative materials but the control group of students was taught by taught by without using manipulative materials. In the experimental process, teaching episode was developed for experimental group (see teaching episode in Appendix-1). And also the observation of students in both groups was done regularly for the time of experimentation.

Post-experimental Stage: In post-experimental stage, the post-test was administered among both groups. The post-test consisted of ten objective questions and six subjective questions. Also a set of questionnaire was administered only on experimental groups. It consisted ten statements related to students view about manipulative materials. After collecting the students answer and response, the data was analysed.

Sources of Data

This study is based on experimental design. In order to carry out study, the following sources of data were adopted. I have used the primary data only.

Primary Source: The primary source only based on test items and questionnaires. The questionnaire was related to Likert scale.

Data Collection Tools and Techniques

To success the research work within time, research tools and techniques would be necessary and appropriate for particular research work. The researcher of this study was used the following data collection tools and techniques:

Achievement Test: The achievement test was developed by the researcher himself with the help of pilot test. Pilot test was administered at Shree Kali Gandaki Secondary School, Waling-14, Syangja. The pre-achievement test (pre-test) was used to determine the achievement level of students in both groups. This test consists of ten objective and six subjective questions, where objective question was of the weight one marks, two subjective questions was of the weight two marks and four subjective questions was of the weight four marks. The tool was used as a pre-test for group comparable. This was administered before the experimentation process. At the end of experimental time post-achievement test (post-test) was administered for the purpose of this study. Post-test was included same question of pre-test with same weight. The researcher had taught from 10:15 am to 11:00 am. for experimental group and from 3:15 pm to 4:00 pm for control group. See the both pre-test and post-test questions in Appendix- 2 and 3.

Questionnaires: The questionnaire related to five point Likert scale was used to analyse the students view on manipulative materials in learning parallelogram and circle of geometry. In this study, the set of questionnaire contains ten statements using Likert scale of '1-Strongly disagree, 2-Disagree, 3-Undecided, 4-Agree and 5-Strongly agree' for positive statement and for negative statement the scoring process was reversed. See the questionnaire in Appendix - 9. This questionnaire was adapted on modified based on Denbel (2015) study and Shadaan and KwanEu (2013) study.

ObservationNote

An observation note was prepared regarding participation of the students, regularity of the students, interest of students towards manipulative teaching - learning activities, motivation of students on manipulative teaching - learning activities, self - control of students while teaching using manipulative materials, perseverance (how students behave and feel while using manipulative materials in teaching geometry) and teachers response towards manipulative materials were used. Based on these mentioned tools, qualitative data have been collected and analyzed.

Validity and Reliability of Tool

To ensure the good quality of the test (tool), validity was more important, what it means that the test must have the test items which truly assess the skill and abilities as indicated by given learning outcomes. Validity of the achievement test and questionnaire was established by the help of subject teacher, expert and supervisor.

Reliability of the test was very important of this study. For this purpose, every test items were piloted and reliability was checked before it was administered. In this study, the mathematics achievement test piloted, involving 25 students of grade IX in Shree Kali Gandaki Secondary School, Waling-14, Syangja. The response of the students was analysed. Employing the split-half method of reliability of the test was determined. The test found to have $r = 0.94$ (see Appendix-6). It indicates that the mathematics achievement test was highly reliable.

Item Analysis of the Test

In item analysis, the difficulty level (P-Value) and discrimination index (D-Value) of the test was computed to check which item accept for achievement test and also to check quality of the test item. The researcher conducted the pilot test among

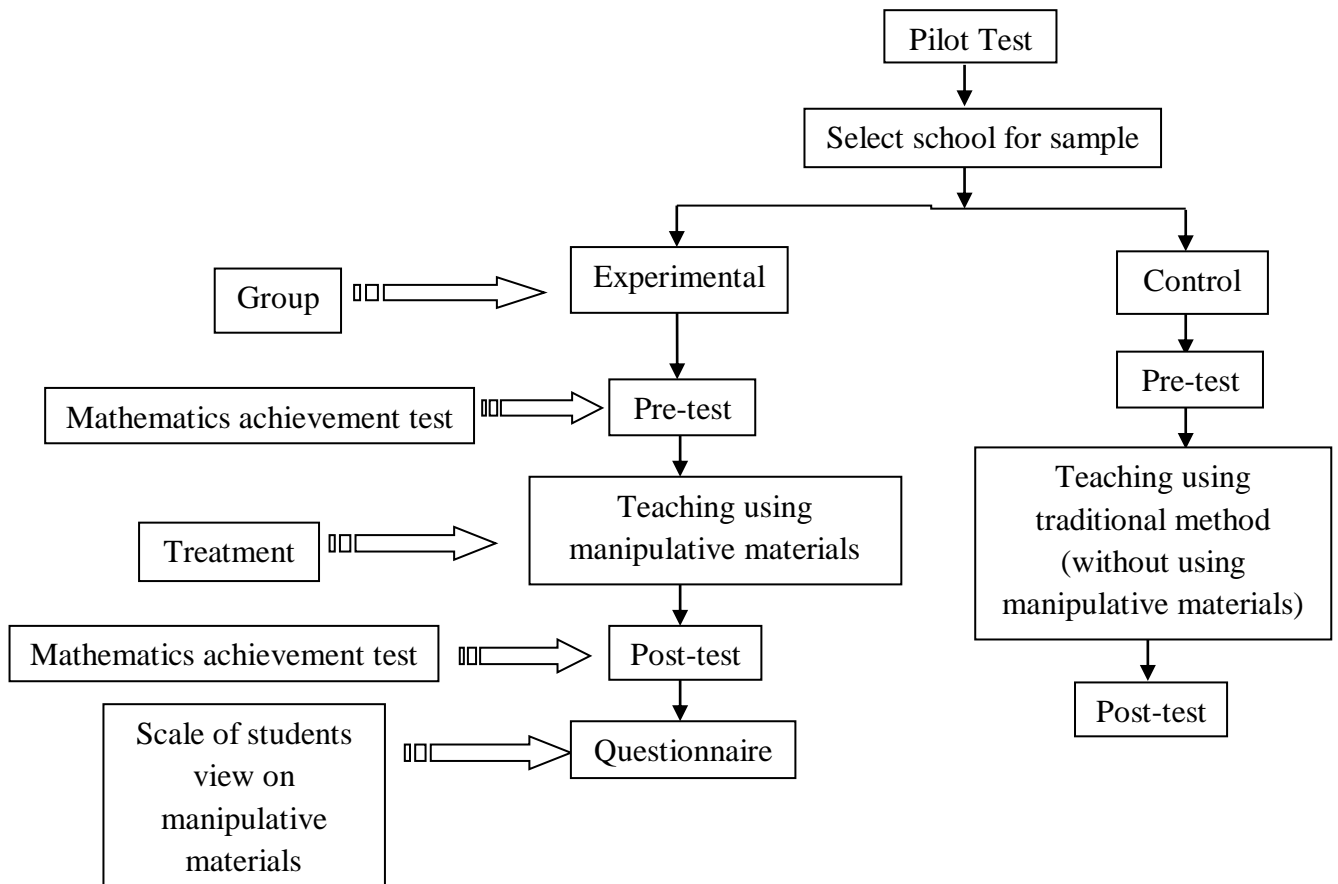
25 students of Shree Kali Gandaki Secondary School. After collected students' response, first divide the total number of students into two groups which were appeared in pilot test by 50% of high scorer students and 50% of low scorer students from total. Out of them choose 27% high scorer students and 27% low scorer students. So, researcher took 7 upper 27% and 7 lower 27% scores students out of 25 students. The table of item analysis of test is given in Appendix-5 and Appendix-6. By using statistical formula, only those item were selected whose P-Value was ranging between 26% to 74% and D-Value was ranging between 0.20 to 1.00. The other items were rejected and modified. The nine items were rejected from 20 objective questions and three items were rejected from ten subjective questions. After cancelling and modifying the items, the refined instrument of achievement test was prepared (see Appendix-2 and 3).

Data Collection and Scoring Procedures

In the present study, data collection procedure was very important. The procedures of data collection describe how the relevant information was gathered. This study is mainly based quantitative data obtained from mathematics achievement test and questionnaire related to five point Likert scale. And students response was calculating mean, standard deviation and percentage by assigned 1 for strongly disagree, 2 for disagree, 3 for undecided, 4 for agree and 5 for strongly agree for all positive statement and for negative statement the scoring process was reversed. Before administering pre-test, pilot test was administered at Shree Kali Gandaki Secondary School. The scores on each item obtained by the students were calculated P-Value and D-Value in items of statistical analysis (see Appendix-4 and 5). And researcher was developed test items (see Appendix-2 and 3) and also reliability of achievement test (see Appendix-6) was found.

In this study, after the standardization of the test, the collection of data from mathematics achievement test was done by following process. Before start experimentation, the researcher meets the principal and subject teacher and took permission for experimentation. After select sampled school, the achievement test (pre-test) was administrated to IX grade students of school in the sample. In the examination, there were 36 students of Shree Bhanu Bhakta Acharya Secondary School, which is known as experimental group and 39 students of Shree Janasewa Secondary School, which is known as control group. Then the score of these students were tabulated (see Appendix-7). The pre-test was administered for group comparable.

After pre-test scores tabulated, experimental group of students was taught regularly one month by using manipulative materials with help of teaching episode (see Appendix-1). The control group of students was taught regularly one month using traditional method (without using manipulative materials). At the end of experimentation time an achievement test (post-test) was conducted to both groups and their score was tabulated (see Appendix-8). The post-test was administered for the purpose of comparing the achievement score. Additionally, a set of questionnaire related to five point Likert scale (see Appendix-9) was administered only on experimental group and their view was recorded. The set of questionnaire was administered for purpose of analysing the students view on manipulative materials in learning parallelogram and circle of geometry. The researcher had taken observation note as data collection. The summary of the data collection procedures of this study was given in the figure below:

Figure 3.1: A Summary of the Data Collection Procedures**Data Analysis Procedures**

Data analysis procedures based upon the data collection tools and techniques. Collected data was analysed by using descriptive and inferential statistical analysis method. Descriptive statistical like: mean, variance and standard deviation were calculated with help of Microsoft Office Excel 2007. Mean, variance and standard deviation were calculated for both groups with their obtained marks in the pre-test and post-test. Also mathematics achievement test scores analysed using inferential statistics, specifically that t-test with two-tailed test at 0.05 level of significance value was used in comparison of pre-test result. Similarly, the t-test with one-tailed test at 0.05 level of significance value was used in comparison of post-test result. For the comparison of both the results, t-test was used for comparing the variances of experimental and control groups. While doing observation the researched found out that the attitude of students towards using manipulative materials was positive. Finally, data was analysed and interpreted.

Chapter IV

ANALYSIS AND INTERPRETATION OF DATA

This chapter deals with the analysis and interpretation of data. An experimental research was done in concern to the topic “Effectiveness of Manipulative materials in Teaching Mathematics at Secondary level”. The objectives of the study were ‘To study the effectiveness in teaching mathematics using the manipulative materials’ and ‘To analyse the students view towards the felling of using manipulative materials’. A pre-test and post-test design of quasi-experimental was adopted for the purpose of the study. A pre-test was taken to make the group comparable. Primarily, the achievement test of the students in post-test was taken to fulfil the first objective of the study. And for the second objective of the study, questionnaires related to Likert scale and observation note were used. The score of the students were analyse using statistical method with help of Microsoft Office Excel 2007 for mean, variance and standard deviation. And the students view on manipulative materials were analyse using Microsoft Office Excel 2007 for mean and standard deviation with based on Likert scale analysis. For fulfil our motto, the data are organized, tabulated, analysed and interpreted as follow:

Analysis of Pre-test Result

In Appendix-7 the pre-test score of students of both groups are presented. The summary of statistical calculation for the experimental and control group on the pre-test is given in Table 4.1 and Figure 4.1 below.

Table 4.1: Result of Pre-test

	Group	
	Experimental	Control
Number of students	$N_1 = 36$	$N_2 = 39$
Mean	$\bar{x}_1 = 6.94$	$\bar{x}_2 = 5.9$
Variance	$s_1^2 = 19.37$	$s_2^2 = 17.73$
Standard Deviation	$s_1 = 4.40$	$s_2 = 4.21$
F	1.09	
Calculated t-value	1.05	
Tabulated t-value	1.96	

The above Table- 4.1 shows us, there were 36 and 39 number of students in experimental and control group respectively. In pre-test 30 marks of mathematics achievement test was administrated (see pre-test questions in Appendix-2 and Appendix-3 and pre-test score of students in Appendix-7). The mean, variance and standard deviation of experimental group were 6.94, 19.37 and 4.40 respectively. Similarly, the mean, variance and standard deviation of control group were 5.9, 17.73 and 4.21 respectively. Since the value of F is 1.09, so that two groups were homogeneous therefore t-test for pooled variance was applied. Here tabulated t-value at $\alpha = 0.05$ level of significance for two tailed test with 73 degree of freedom is 1.96 but calculated t-value was 1.05. Calculated t-value was not lying in critical region i.e. $-1.96 < 1.05 < 1.96$. So H_0 is accepted. Hence it could be concluded that there is no significance difference between the average achievement score of experimental and control groups of pre-test. Thus, both groups were nearly equal in ability.

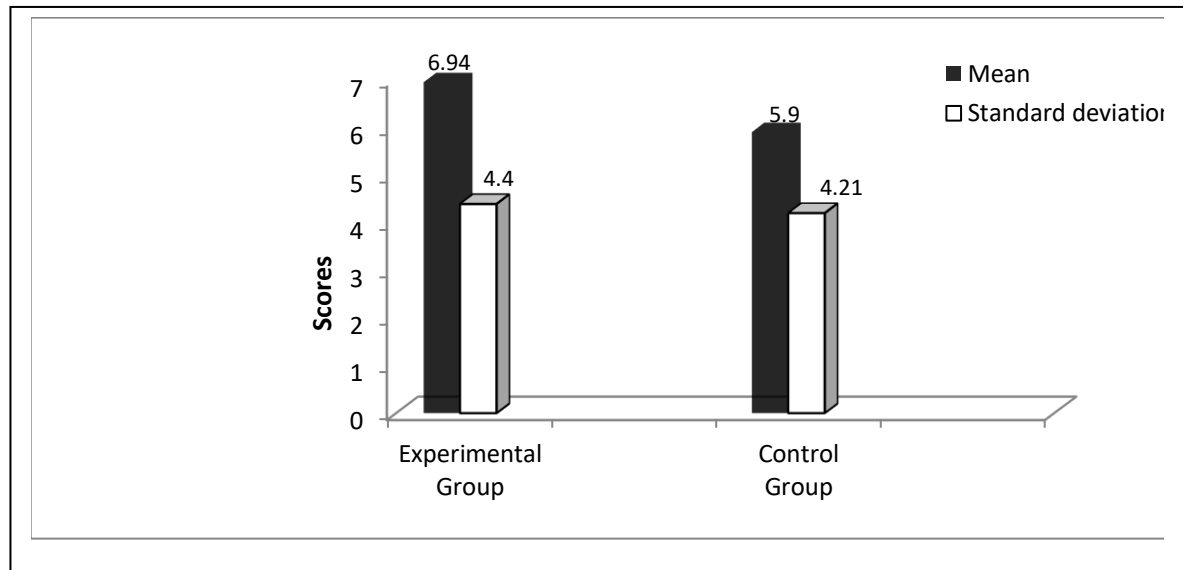


Figure 4.1: Mean and Standard Deviation Scores Distribution of Pre-test Result

The mean and standard deviation scores obtained by the students of each group in the achievement test (pre-test) score have been shown in above diagram (Figure 4.1). This diagram is more interesting for comparison. This shows that there is no difference in achievement score of both groups of students on pre-test.

Analysis of Post-test Result

The post-test score of students of experimental and control groups have been presented in Appendix-8 and the summary of statistical calculation for the both groups on post-test is represented in the Table 4.2 and Figure 4.2 below.

Table 4.2: Result of Post-test

	Group	
	Experimental	Control
Number of students	$N_1 = 36$	$N_2 = 39$
Mean	$\bar{x}_1 = 18.58$	$\bar{x}_2 = 13.05$
Variance	$s_1^2 = 27.79$	$s_2^2 = 20.89$
Standard Deviation	$s_1 = 5.27$	$s_2 = 4.57$
F	1.33	
Calculated t-value	4.86	
Tabulated t-value	1.645	

The above Table 4.2 shows that there are 36 and 39 students in experimental and control group respectively. In post-test 30 marks of mathematics achievement test was administrated (see post-test questions in Appendix-2 and Appendix-3 and post-test score of students in Appendix-8). The mean score of experimental and control group are 18.58 and 13.05 respectively as well as variance are 27.79 and 20.89 respectively. Also standard deviation of experimental group is 5.27 and control group is 4.57. These values were calculated by mathematics achievement test in post-test using Microsoft Office Excel 2007. Since the value of F was 1.33, so both groups were homogeneous hence the method of pooled variance for t-test was applied. Here tabulated t-value at $\alpha = 0.05$ level of significance for two tailed test with 73 degree of freedom is 1.645. But calculated t-value is 4.86. Here $4.86 > 1.645$, so that H_0 was rejected and H_1 was accepted. Hence the average achievement score of experimental group is higher than the control group on post-test. Thus, the students who were

taught by using manipulative materials learned more and so higher achievement than without using manipulative materials of teaching.

The mean and standard deviation scores obtained by the students of each groups in the achievement test (post-test) score have been shown in below above diagram (Figure 4.2).

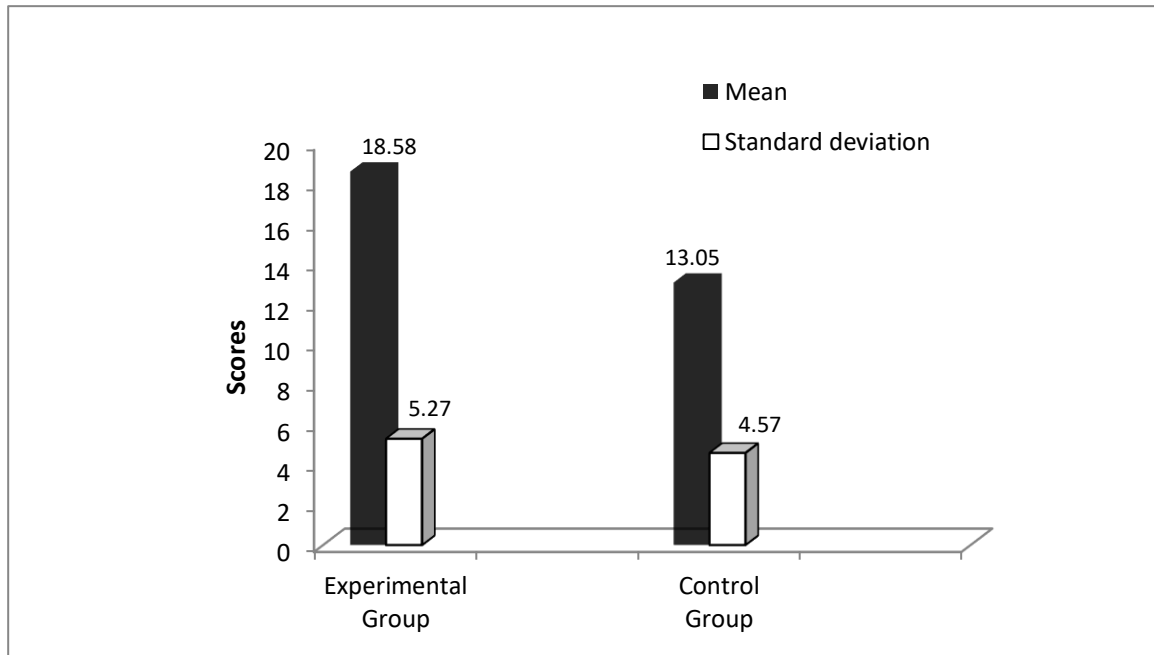


Figure 4.2: Mean and Standard Deviation Scores Distribution of Post-test Result

The column of experimental group of students is longer than that of control group students. This shows that there is a difference in achievement score between experimental group and control group on post-test. Since the difference between the mean, standard deviation on the post-test was 5.53 and 0.7 respectively. Therefore, the diagram (Figure 4.2) indicates that the teaching using manipulative materials is more effective than without using manipulative materials in parallelogram and circle of geometry at grade IX.

Comparison Percentage of Mean Score on Pre-test and Post-test

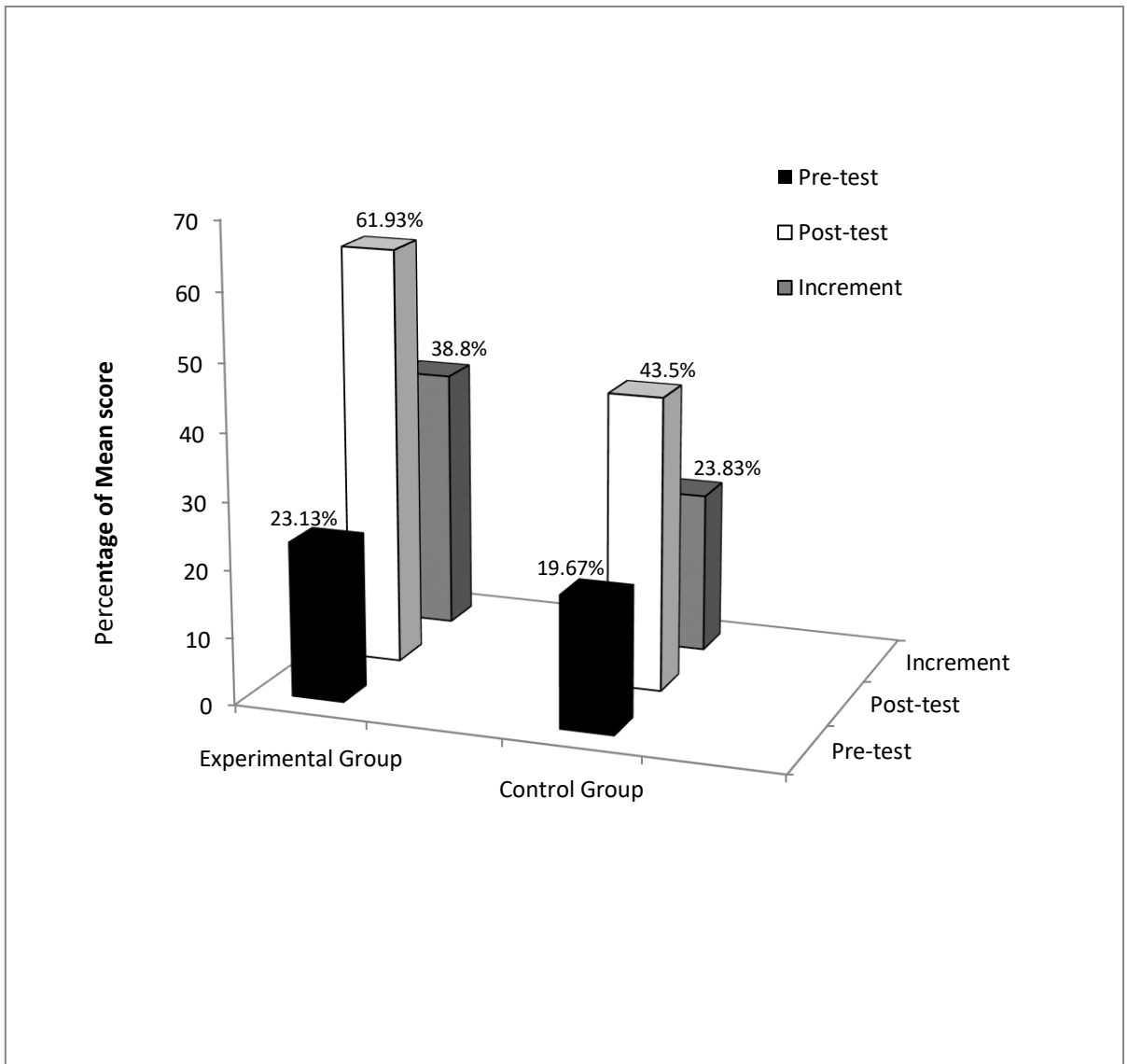


Figure 4.3: Percentage of Mean Score of Experimental and Control Groups

The above diagram (Figure 4.3) shows that percentage of mean score on pre-test of experimental and control group are 23.13% and 19.67% respectively. But percentage of mean score on post-test of experimental group is 61.93% and control group is 43.5%. So 38.8% increment in mean score of experimental group but 23.83% increment in mean score of control group. Therefore, percentage of mean score of experimental group is higher than control group of students. Thus, the above diagram

shows that the teaching using manipulative materials effective than without using manipulative materials in parallelogram and circle of geometry at grade IX.

Analysis of Students View on Manipulative Materials Result

A questionnaire related to students view about manipulative materials was administered to 36 students of experimental group only (see the scale in Appendix-9) whose response are tabulated, the quantitative data are provided in Table 4.3 (in Likert scale). 5, 4, 3, 2 and 1 indicated strongly agree, agree, undecided, disagree and strongly disagree respectively for positive statement. And 1, 2, 3, 4 and 5 indicated strongly agree, agree, undecided, disagree and strongly disagree respectively for negative statement.

Below the Table 4.3, the highest mean 4.75 was the item ‘Manipulative materials is essential and important from the teaching geometry’ and its standard deviation 0.44. While the lowest mean was 3.28 which is obtained from the item ‘At the beginning, I did not like manipulative materials and its standard deviation 0.91. Other items mean were near about the highest mean. According to Denbel(2015) study and Shadaan and KwanEu(2013), a mean score of 3.0 or higher indicates a positive feedback or view about manipulative materials and the mean score lower than 3.0 indicates negative feedback or view about manipulative materials in learning geometry. The result from overall mean 4.39 shows that students generally gave positive feedback or view about the manipulative materials in learning parallelogram and circle of geometry at grade IX.

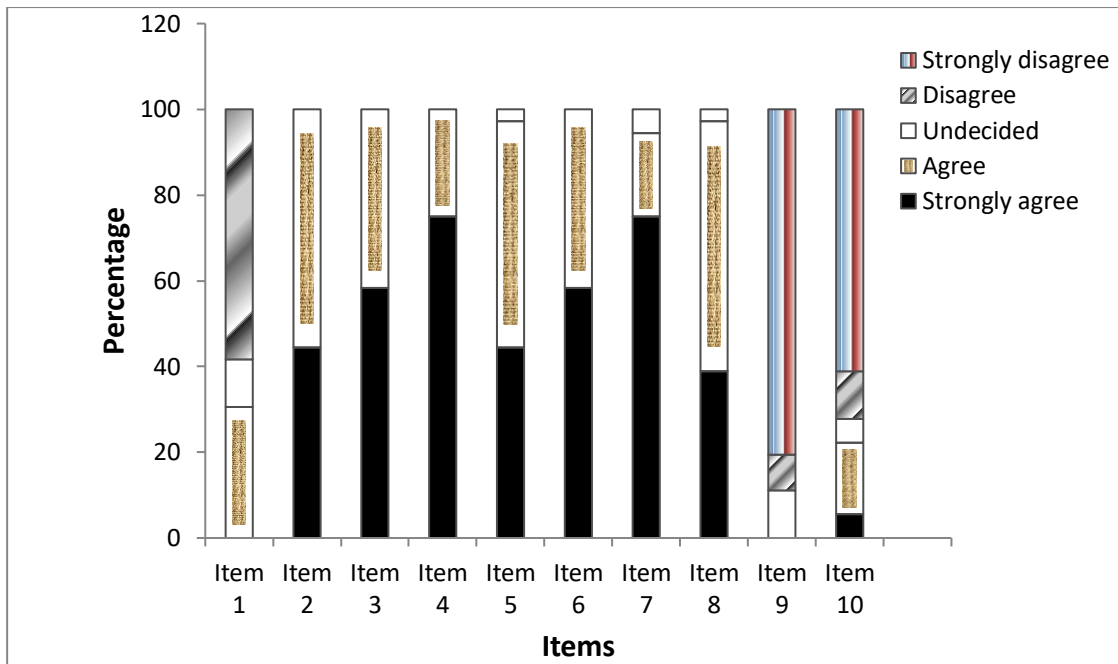


Figure 4.4: Percentage of Students View on Manipulative Materials

From Appendix 9 and Figure 4.4, about the item-1 ‘At the beginning, I did not like manipulative materials’ 30.56%, 11.11% and 58.33% of students gave agree, undecided and disagree respectively. Few students only agree and other students disagree and undecided about the item-1. Combination of strongly agree and agree was full percentage given by the students about the item-2 ‘I liked studying geometry lesson with using manipulative materials’. This means all students were liked the studying geometry with using manipulative materials. Also the full percentage of students gave positive response about the item-3 ‘Manipulative materials helped me a lot to learn the geometry concept’, item-4 ‘Manipulative materials is essential and important for the teaching geometry’ and item-6 ‘Manipulative materials helps visualizing the problem of geometry concept’. In item-5 ‘Manipulative materials helps easy to understand geometrical theorems and problems’, 44.44%, 52.78% and 2.78% of students gave the strongly agree, agree and undecided respectively. Its means students were positive about the item-5.

The second highest 75% of students gave the strongly agree about the item-7 'Manipulative materials enhance my learning in geometry lesson' and 19.44% of students gave agree and 5.56% of students gave undecided. It means manipulative materials enhance students' achievement in geometry lesson. In item-8 'Manipulative materials help to make the learning more enjoyable', 38.89%, 58.33%, and 2.78% of students gave strongly agree, agree and undecided respectively. So, the class using manipulative materials in teaching geometry was more enjoyable. The highest 80.56% of students gave strongly disagree about the item-9 'Manipulative materials makes geometry class boring' and 8.33%, 11.11% of students gave disagree, undecided respectively. So, manipulative materials make the geometry class interesting and absorbing. In item-10 'Using manipulative materials makes geometry more difficult for me', 5.56%, 16.66%, 5.56%, 11.11% and 61.11% of students gave strongly agree, agree, undecided, disagree and strongly disagree respectively. So, manipulative materials make geometry not difficult that means easy for students. Thus, students gave the positive response about the above items.

Above review also showed that students in experimental group performs better when using manipulative materials than the control group without using manipulative materials. The result of this study indicates that there is significant difference between the average achievement score of experimental and control group in post-test. Based on their finding, this suggests that manipulative materials are very helpful for teaching and learning geometry. And the development of technology tools manipulative materials increases the students' achievement in their learning geometry. Overly the above result shows that, the teaching using manipulative materials more effective than without using manipulative materials in parallelogram and circle of geometry at grade IX. And students gave positive feedback or view about the manipulative materials.

CHAPTER V

SUMMARY, FINDING, CONCLUSION AND RECOMMENDATIONS

This chapter deals with summary, finding, conclusion and recommendations. The recommendations are intended for further study.

Summary of the Study

The research entitled “Effectiveness of manipulative materials in teaching mathematics at secondary level” was intended to investigate the using manipulative materials is more effective than without using manipulative materials and also analyse the students view on manipulative materials in parallelogram and circle of geometry at grade IX.

For the data collection of this study, pilot test was conducted on 25 students of the school Shree Kali Gandaki Secondary School, Waling-14, Syangja. The researcher developed and tested the reliability of achievement test and also find the difficult level (P%) and discrimination index (D) of items before their administration. The pilot test consisted of 20 objective (multiple choice) and 10 subjective type items on the area of parallelogram and circle of geometry from grade IX. The reliability coefficient of achievement test was found to be 0.94.

A pre-test and post-test design of quasi-experimental was adopted for the purpose of this study. Students of class IX of Syangja district have been considered as population. The sample schools were selected through the purposive and convenience method of sampling which were named as ‘Shree Bhanu Bhakta Acharya Secondary School’ and ‘Shree Janasewa Secondary School’, which was located on Syangja district.

After teaching one month in Shree Bhanu Bhakta Acharya Secondary School by using manipulative materials, researcher collects data from mathematics

achievement test and students view on manipulative materials by using questionnaire related to Likert scale of this experimental group. Also teaching one month in Shree Janasewa Secondary School without using manipulative materials, researcher collects the data from mathematics achievement test of this control group. The experimental group contained 36 students and control group contained 39 students.

Two hypotheses were analysed from the result of pre-test (show in Table 4.1) and post-test (show in Table 4.2). The score obtained by the students on pre-test was analysed using t-test at 0.05 level of significance, which shows that there was no significant difference the average achievement score of two groups. And the score obtained by post-test was also analysed using t-test at 0.05 level of significance, which shows that average achievement score of experimental group is higher than control group.

In this study teaching using manipulative materials more effective than without using manipulative materials in parallelogram and circle of geometry at grade IX. The result highlighted that students in the experimental group performed better using manipulative materials than the control group without using manipulative materials. In addition, students view about manipulative materials was analysed through a set questionnaire based on Likert scale consists of ten items. This questionnaire was distributed to only experimental group and result shows that students gave positive feedback or view about manipulative materials in learning parallelogram and circle of geometry.

Findings of the Study

Accepting or rejecting the significance of null hypotheses constructed for the study determined the effectiveness of manipulative materials as compared without using manipulative materials and questionnaire related to Likert scale constructed for the analysing students view on manipulative materials in teaching parallelogram and

circle of geometry at grade IX. The findings of the study were observed from the calculated and tabulated t-value recorded in table for hypotheses to achieve the objectives of the study. Also mean and standard deviation recorded in table for analyse students view on manipulative materials. Following were the findings of the study:

- There was no significant difference between the average achievement score of experimental and control groups on pre-test.
- There was significant difference between the average achievement score of these groups on post-test i.e. the average achievement score of experimental group was higher than that of control group.
- The teaching using manipulative materials was more effective than without using manipulative materials in parallelogram and circle of geometry.
- The results show that students gave positive feedback or view about the manipulative materials in learning parallelogram and circle.
- 75% of students of experimental group gave positive view on manipulative materials was enhanced students learning and understanding in geometry lesson. And manipulative materials were essential and important for the teaching geometry.

Conclusions

In this study, the teaching and learning of parallelogram and circle of geometry using manipulative materials has been effective. This was shown through the improved scored of the students in experimental group. The finding highlighted that students in experimental group performed better using the manipulative materials than the control group without using manipulative materials. Students in the experimental group performed better in the post-test compared to the control group.

Students generally gave positive feedback or view about the manipulative materials in learning geometry. In addition, the manipulative materials enhanced students learning and understanding of the parallelogram and circle of geometry. Also manipulative materials was essential and important for the teaching geometry.

Recommendations

The results of this study show that teaching and learning geometry using manipulative materials has been effective but the following recommendations are forwarded for the further research:

- If manipulative materials is going to become an established part of the curriculum it is important to continue to address the following issues: the general impact of manipulative materials activity on mathematics learning, gender differences while using manipulative materials, the use and developing understanding of mathematical ideas and the role of the teacher in manipulative materials environments.
- Longitudinal studies need to be carried out to examine the long-term effect of the use of manipulative materials in students' mathematical achievement.
- To study on 'How does using manipulative materials affect students' achievement towards mathematics learning?'
- Analysing the teachers' view on manipulative materials in teaching and learning geometry.
- It is recommended that to do the similar study on other level of school and also on private school.

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Appendix - 1

Teaching Episode 1

Class: IX

Subject: C. Mathematics

Topic: Parallelogram

Objectives: At the end of the teaching of these lesson students should be able to :

- Verify experimentally that the opposite sides of a parallelogram are equal.
- Verify experimentally that the opposite angles of a parallelogram are equal.

Teaching Materials: Geo Board, Rubber, geometry box and daily uses materials.

Teaching Learning Activities:

Review the concept:

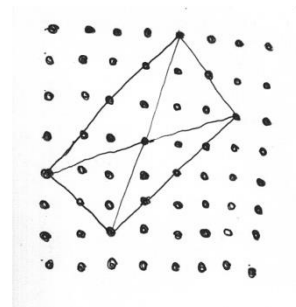
- Teacher ask the students about properties of parallelogram.

Relate the pre-concept with new concept:

- Teacher and students both interaction each other then conclude the properties of parallelogram.
- Opposite sides are parallel.
- Opposite sides are equal.
- Opposite angles are equal.
- The diagonals are equal.

Then teacher shows this properties in white

board and shows the parallelogram on-board.



- After that teacher and students both interaction each other about figure and statement of theorem. Then after teacher asked the questions to students about statement of theorem and sometime teacher discuss students answer. And verify this theorem by teacher.
- To verify the properties of parallelogram teacher introduced geo-board as a materials.
- To prove experimentally, teacher shows steps of construction on geo-board as well as drawing the same concept on white board.
- To show, opposite side's equal of geo-board can be observed usually.
- After visualizing the figure using geo-board, teacher discussed with students for the concept understanding.
- Then finally teacher, instructed students to draw and relate the necessary concept with logic.
- After that one, statement of next theorem the opposite angles of parallelogram are equal should be given to students to verify themselves. For five minutes by receiving students, teacher and student both discuss about this theorem. Then teacher would show the figure with the help of geo- board and theorem would be verified on white board.

Evaluation:

- I. Verify experimentally that the opposite sides of rectangle are equal.
- II. Verify experimentally that the opposite angles of parallelogram PQRS are equal.

Teaching Episode 2

Class: IX

Subject: C. Mathematics

Topic: Parallelogram

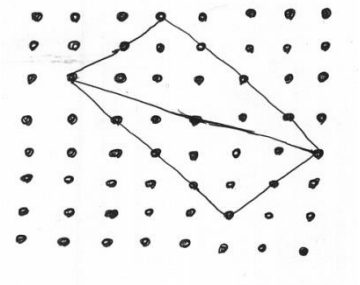
Objectives: At the end of the teaching of these lesson students should be able to:

Prove the theorem a diagonals of a parallelogram divides it into two equal areas.

Teaching Materials: Geo board ,rubber and daily uses materials.

Teaching Learning Activities

- Teacher and students discuss about the area of triangle and parallelogram.
- The teacher asked the students about parallelogram. Then he asked some students to make parallelogram on a geo-board with the help of rubber. Then he asked them to said about the properties of a parallelogram.
- Teacher asked to the students about congruency of triangles. And teacher writes the axiom of congruency on white board.
- To prove experimentally, the teacher showed every step of construction on geo-board as well as drawing the same concept on white board.
- To show, the two triangles equal, we can show every square are equal of geo-board can be observed visually.
- Teacher showed the areas of two triangles are equal using geo-board.
- Then finally teacher instructed students to draw and relate the necessary



concept with logic.

Evaluation:

The teacher asked the students to show all the same proof by altering the diagonal, i.e. drawing another diagonal bisect the rectangle.

Teaching Episode-3

Class: IX

Subject: C. Mathematics

Topic: Circle

Objectives: At the end of teaching of these lesson students should be able to:

- Verify experimentally that the perpendicular line drawn from the centre of the circle to the chord bisect the chord.

Teaching Materials: circle board, rubber, and daily uses materials.

Teaching learning activities:

-Researcher should ask to students about circle, centre, circumference, and chord.

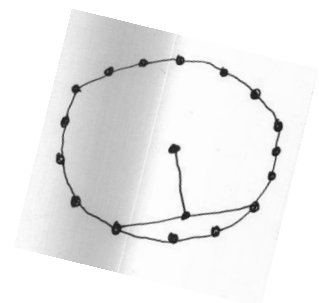
After students answer researcher used to circle board with the help of rubber and demonstrates the figure of circle, centre, circumference and chord on circle board.

After that researcher and students both interaction each other than conclude about the circle, centre, circumference and chord.

-Researcher writes the statements of theorem the perpendicular drawn from the centre of the circle to the chord bisect the chord on white board.

-Researcher used to circle board and rubber for figure.

Hedemonstrates the figure of this theorem on circle board with the help of rubber. Researcher shows the chord on circle board.



-Researcher draws the line from the centre to the chord on circle board with the help of rubber.

-After that, researcher and students both interaction each other about figure and statements of theorem. Then after researcher asks some questions to students about statements of theorem and some time researcher discuss student's answer. And to verify this theorem by researcher on white board.

-Evaluation:

Experimentally verify that the perpendicular drawn to a chord of a circle through the centre bisects the chord.

Teaching Episode-4

Class: IX

Subject : C. Mathematics

Topic: Circle

Objectives: At the end of teaching of these lesson students should be able to:

Verify experimentally that the equal chords of a circle are equidistant from the centre.

Teaching Materials: circle board, rubber, and daily uses materials.

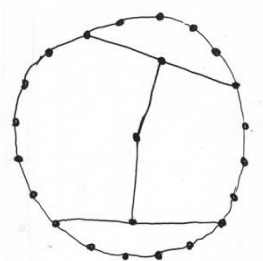
Teaching Learning Activities:

-Researcher should ask to students about chords. After students answer, researcher used to circle board with the help of rubber. And demonstrates the figure of the circle and chords view of circle board. After that researcher and students both interaction each other about chords and relation between chords and centre.

-Researcher write the statements of theorem the equal chords of a circle are equidistance from the centre on a circle board with the help of rubber.

-Researcher used to circle board for figure. She demonstrates the figure of this theorem in circle board. After that researcher and students both interaction each other about figure and statement of theorem. Then after researcher asks some questions to students about statements of theorem and some time researcher discuss students answer. And to verify this

theorem by researcher, figure should be drawn and write steps and conclusion with tables on white board and to teach the students.



-After that one, researcher writes some problems related to previous theorems on white board. Then researcher and students both interaction each other about this problems and find out the answer of this problems.

-Researcher and students discuss about the statement of the theorem the chords which are equidistance from the centre of a circle are equal. Researcher used to circle board and rubber for figure. He discuss the figure of this statement on circle board. After that researcher and students both interaction each other about figure and statements of this theorem then conclude the chords are equidistance from the centre of a circle are equal.

Evaluation:

In the given figure, O is the centre of the circle and PQ and RS are two chords. If $PQ=RS$, OX is perpendicular to RS, show that $OX=OY$.

Appendix - 2

Mathematics Achievement Test in Pre-test and Post-test

Class: IX

Full marks: 10

Subject: C. Mathematics

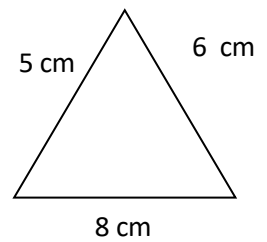
Time: 10 min.

Tick (✓) the best answer.

[10×1=10]

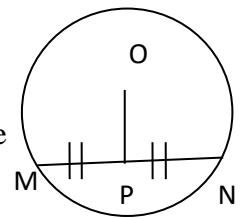
1. In the adjoining $\triangle ABC$, which is the greatest angle.

a. $\angle ABC$ b. $\angle ABC$ and c. $\angle BAC$.



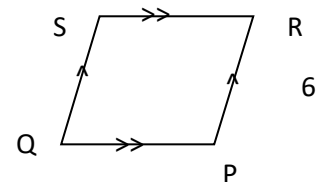
2. O is the centre of circle. If p is the midpoint of chord MN, state the relation of OP and MN.

a. $OP=MN$ b. $OP \parallel MN$ c. $OP \perp MN$ d. None of the above



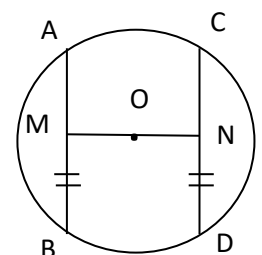
3. In a parallelogram PQRS, write the measurement of PS.

a. 12cm b. 6cm c. 3cm d. none of the above.



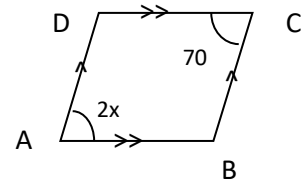
4. In the adjoining figure, $OM=2\text{cm}$, find ON.

a. 2cm b. 4cm c. 1cm d. 5 cm



5. In a parallelogram ABCD, $\angle A = 2x^\circ$ and $\angle C = 70^\circ$, find x° .

- a. 70° b. 140° c. 35° d. 180°

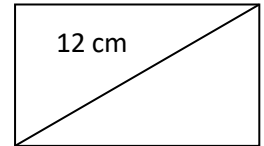


6. In a parallelogram ABCD, $AC = BD$, what is it?

- a. Rectangle b. rhombus c. parallelogram d. quadrilateral

7. Find the area of given square alongside.

- a. 144cm^2 b. 36cm^2 c. 72cm^2 d. 18cm^2

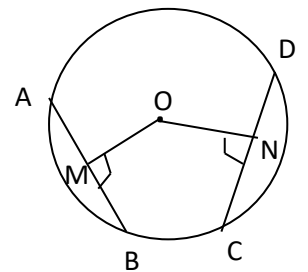


8. O is the centre of a circle. If $OP \perp MN$, $PN = 2.5\text{cm}$, what is the length of PM?

- a. 2.5 cm b. 5 cm c. 3.5 cm d. 2 cm

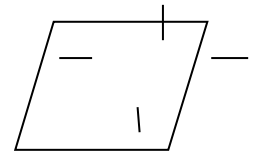
9. In the figure, O is the centre of the circle $OM = ON$. Write the relation between AB and CD.

- a. Parallel b. Perpendicular c. Equal d. Double



10. What kind of quadrilateral is it ?

- a. Rectangle b. Rhombus c. Square d. Parallelogram



Appendix - 3**Mathematics Achievement Test in Pre-test and Post-test**

Class: IX

Full marks: 20

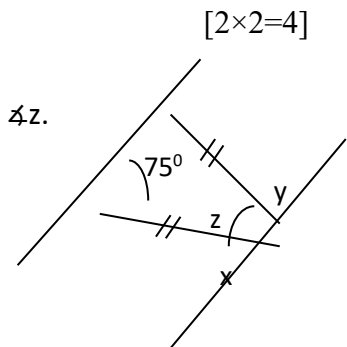
Subject: C. Mathematics

Time: 36 min.

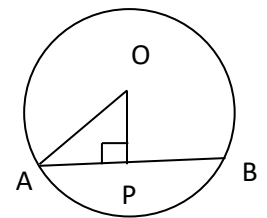
Attempt all Question

Group 'A'

1. In the given figure, find the sizes of angles $\angle x$, $\angle y$ and $\angle z$.



2. In the adjoining figure, O is the centre of a circle with radius 5 cm .If $OP=3$ cm, find the length of the chord.



Group 'B'

[4×4=16]

1. Prove that the diagonals of a parallelogram bisect each other.
2. Prove that the opposite angles and sides of a parallelogram are equal.
3. Prove that the line joining the mid-point of a chord and the centre of a circle is perpendicular to the chord.
4. Verify experimentally that the equals chords of a circle are equidistance from the centre.

Appendix - 4

Item Analysis of Objective Questions of the Test

S.N.→ Q.N.↓	Upper 27%								Lower 27%								P% Value	D Value	Remark
	1	2	3	4	5	6	7	Total	1	2	3	4	5	6	7	Total			
1	1	1	1	1	1	1	0	6	1	1	1	0	0	1	0	4	71.43%	0.29	Accept
2	1	1	1	1	0	1	1	6	1	1	1	0	1	0	1	5	78.57%	0.14	Reject
3	1	0	1	1	1	1	1	6	1	1	1	1	0	1	1	6	85.71%	0	Reject
4	1	1	1	1	1	1	1	7	1	1	0	0	1	1	0	4	78.57%	0.43	Reject
5	1	1	1	1	1	1	1	7	0	0	0	0	0	0	0	0	50%	1	Accept
6	1	1	1	0	1	1	1	6	1	1	1	1	0	1	0	5	78.57%	0.14	Reject
7	1	1	1	1	1	1	0	6	0	1	1	0	1	0	0	3	64.29%	0.43	Accept
8	1	1	0	1	1	0	1	5	0	0	0	1	1	1	1	4	64.29%	0.14	Reject
9	1	1	1	1	1	1	1	7	1	0	0	0	1	0	0	2	64.29%	0.71	Accept
10	1	1	1	1	1	1	1	7	0	1	1	0	0	1	0	3	71.43%	0.57	Accept
11	1	1	1	1	1	1	1	7	1	0	0	0	0	0	0	1	57.14%	0.86	Accept

12	1	1	1	1	1	1	1	7	1	1	0	1	1	0	1	5	85.71%	0.29	Reject
13	1	1	1	1	1	1	1	7	0	0	1	0	0	0	0	1	57.14%	0.86	Accept
14	1	1	1	1	0	0	1	5	1	1	1	1	0	0	0	4	64.29%	0.14	Reject
15	1	1	1	1	1	1	1	7	0	0	0	1	0	1	1	3	64.29%	0.57	Accept
16	1	1	1	1	1	1	1	7	0	0	0	0	1	0	0	1	57.14%	0.86	Accept
17	1	1	1	1	1	1	0	6	0	0	1	0	0	0	1	2	57.14%	0.57	Accept
18	1	1	1	1	1	1	1	7	0	0	0	1	0	0	0	1	57.14%	0.86	Accept
19	1	1	1	1	1	1	1	7	1	0	0	1	1	1	0	4	78.57%	0.42	Reject
20	1	1	1	1	1	1	1	7	1	1	1	1	1	1	0	6	92.86%	0.14	Reject
Total	20	19	19	19	18	18	17		11	10	10	9	9	9	6				

Appendix - 5

Item Analysis of Subjective Questions of the Test

S.N.→ Q.N↓	Upper 27%								Lower 27%								P% Value	D Value	Remark
	1	2	3	4	5	6	7	Total	1	2	3	4	5	6	7	Total			
1	1	1	1	1	1	1	1	7	1	1	1	0	0	1	1	5	85.71%	0.29	Reject
	1	1	1	1	1	1	1	7	1	1	1	0	0	1	1	5	85.71%	0.29	
																	85.71%	0.29	
2	1	1	1	1	1	1	0	6	1	0	0	0	0	1	0	2	57.14%	0.57	Accept
	1	1	1	1	1	1	0	6	1	0	0	0	0	1	0	2	57.14%	0.57	
																	57.14%	0.57	
3	1	1	1	1	1	1	0	6	1	1	0	0	1	1	0	4	71.43%	0.29	Accept
	1	1	1	1	1	1	0	6	1	1	0	0	1	1	0	4	71.43%	0.29	
																	71.43%	0.29	
4	1	1	1	0	0	0	1	4	0	0	1	0	1	0	1	3	50%	0.14	
	1	1	1	0	0	0	1	4	0	0	1	0	1	0	1	3	50%	0.14	

																	50%	0.14	Reject
5	0	1	1	1	1	1	1	6	1	0	0	0	1	0	0	2	57.14%	0.57	
	0	1	1	1	1	1	1	6	1	0	0	0	1	0	0	2	57.14%	0.57	
	0	1	1	1	1	0	1	5	0	0	0	1	0	0	0	1	42.86%	0.57	
	0	1	1	1	1	0	1	5	0	0	0	0	1	0	0	1	42.86%	0.57	
																50%	0.57	Accept	
6	1	1	0	1	1	0	1	5	0	1	1	0	0	0	0	2	50%	0.43	
	1	1	0	1	1	0	1	5	0	1	1	0	0	0	0	2	50%	0.43	
	1	1	0	1	1	0	1	5	0	1	1	0	0	0	0	2	50%	0.43	
	1	1	0	1	1	0	1	5	0	1	1	0	0	0	0	2	50%	0.43	
																50%	0.43	Accept	
7	1	1	1	0	0	0	1	4	1	1	1	1	1	0	0	5	64.29%	-0.14	
	1	1	1	0	0	0	1	4	1	1	1	1	1	0	0	5	64.29%	-0.14	
	1	1	1	0	0	0	1	4	1	1	1	1	1	0	0	5	64.29%	-0.14	
	1	1	1	0	0	0	1	4	1	1	1	1	1	0	0	5	64.29%	-0.14	
																64.29%	-0.14	Reject	

8	0	1	1	1	1	1	1	6	0	0	0	1	0	0	1	2	57.14%	0.57	
	0	1	1	0	1	1	1	5	0	0	0	1	0	0	1	2	50%	0.43	
	0	1	1	0	1	1	0	4	0	0	0	0	0	0	1	1	71.43%	0.43	
	0	1	1	0	1	0	0	3	0	0	0	0	0	0	1	1	28.57%	0.29	
																		51.79%	
9	1	0	1	1	1	1	0	5	0	0	0	0	0	1	0	1	42.86%	0.57	
	1	0	1	1	1	1	0	5	0	0	0	0	0	1	0	1	42.86%	0.57	
	1	0	1	1	1	1	0	5	0	0	0	0	0	1	0	1	42.86%	0.57	
	1	0	1	1	1	1	0	5	0	0	0	0	0	1	0	1	42.86%	0.57	
																		42.86%	
10	1	0	0	1	0	1	0	3	0	0	0	1	0	0	0	1	28.57%	0.29	
	1	0	0	1	0	1	0	3	0	0	0	1	0	0	0	1	28.57%	0.29	
	1	0	0	1	0	1	0	3	0	0	0	1	0	0	0	1	28.57%	0.29	
	1	0	0	1	0	1	0	3	0	0	0	1	0	0	0	1	28.57%	0.29	
																		28.57%	
Total	24	24	24	23	22	19	18		12	12	12	11	11	10	8				

Appendix - 6

Reliability of the Test

S.N.	Scores on odd items (X)	Scores on even items (Y)	X ²	Y ²	XY
1	10	11	100	121	110
2	12	11	144	121	132
3	7	11	49	121	77
4	9	9	81	81	81
5	9	10	81	100	90
6	8	12	64	144	96
7	8	9	64	81	72
8	10	8	100	64	80
9	8	8	64	64	64
10	11	13	121	169	143
11	24	16	576	256	384
12	20	14	400	196	280
13	28	28	784	784	784
14	36	24	1296	576	864
15	24	16	576	256	384
N = 15	ΣX = 224	ΣY = 200	ΣX² = 4500	ΣY² = 3134	ΣXY = 3641

$$\text{Correlation Coefficient (r}_{xy}) = \frac{N \sum XY - \sum X \cdot \sum Y}{\sqrt{N \sum X^2 - (\sum X)^2} \sqrt{N \sum Y^2 - (\sum Y)^2}}$$

$$= \frac{15 \times 3641 - 224 \times 200}{\sqrt{15 \times 4500 - (224)^2} \sqrt{15 \times 3134 - (200)^2}}$$

$$= 0.89$$

$$\text{Reliability Coefficient (r)} = \frac{2 r_{xy}}{1 + r_{xy}} = \frac{2 \times 0.89}{1 + 0.89} = 0.94$$

Appendix - 7**Score of Pre-test**

S.N.	Score of Students in Experimental Group	Score of Students in Control Group
1	24	19
2	11	17
3	17	9
4	12	10
5	10	18
6	6	8
7	6	10
8	13	7
9	10	8
10	8	3
11	7	5
12	7	5
13	8	4
14	9	8
15	5	3
16	3	4
17	3	5
18	5	5
19	3	3
20	5	7

21	3	2
22	3	4
23	3	3
24	4	5
25	3	4
26	3	2
27	7	8
28	6	4
29	5	2
30	6	4
31	3	2
32	6	3
33	6	2
34	7	3
35	9	4
36	4	4
37		3
38		6
39		7
	$N_1 = 36, \bar{x}_1 = 6.94, s_1^2 = 19.37,$ $s_1 = 4.40$	$N_2 = 39, \bar{x}_2 = 5.9, s_2^2 = 17.73,$ $s_2 = 4.21$

Appendix - 8**Score of Post-test**

S.N.	Score of Students in Experimental Group	Score of Students in Control Group
1	28	24
2	26	22
3	28	20
4	25	15
5	18	21
6	21	16
7	26	13
8	18	17
9	22	20
10	24	14
11	26	16
12	15	17
13	23	13
14	12	10
15	15	17
16	15	10
17	10	13
18	12	12
19	19	13
20	11	15

21	11	3
22	15	9
23	17	7
24	16	9
25	17	15
26	15	12
27	21	16
28	15	10
29	20	10
30	23	14
31	10	9
32	20	9
33	22	9
34	22	9
35	18	10
36	13	11
37		6
38		10
39		13
	$N_1 = 36, \bar{x}_1 = 18.58, s_1^2 = 27.79,$ $s_1 = 5.27$	$N_2 = 39, \bar{x}_2 = 13.05, s_2^2 = 20.89,$ $s_2 = 4.57$

Appendix - 9

Scale of Students View on Manipulative Materials

Name:	Class: IX
Roll No.:	Subject: C. Mathematics
School:	

S.N.	Items		Strongly agree	Agree	Undecided	Disagree	Strongly disagree	Total	Mean	Standard Deviation
1	At the beginning, I did not like manipulative materials	fre.	0	11	4	21	0	36	3.2	0.9
		%	0	30.56	11.11	58.33	0	100	8	1
2	I liked studying geometry lessons with using manipulative materials	fre.	16	20	0	0	0	36	4.4	0.5
		%	44.44	55.56	0	0	0	100	4	0
3	Manipulative materials helped me a lot to learn the geometry concept	fre.	21	15	0	0	0	36	4.5	0.5
		%	58.33	41.67	0	0	0	100	8	0
4	Manipulative materials is essential and important for the teaching geometry	fre.	27	9	0	0	0	36	4.7	0.4
		%	75	25	0	0	0	100	5	4
5	Manipulative materials helps easy to understand geometrical theorems and problems	fre.	16	19	1	0	0	36	4.4	0.5
		%	44.44	52.78	2.78	0	0	100	2	5
6	Manipulative materials helps visualizing the problems of geometry concept	fre.	21	15	0	0	0	36	4.5	0.5
		%	58.33	41.67	0	0	0	100	8	0
7	Manipulative materials enhance my learning in geometry lessons	fre.	27	7	2	0	0	36	4.6	0.5
		%	75	19.44	5.56	0	0	100	9	8
8	Manipulative materials help to make the learning more enjoyable	fre.	14	21	1	0	0	36	4.3	0.4
		%	38.89	58.33	2.78	0	0	100	6	3
9	Manipulative materials makes geometry class boring	fre.	0	0	4	3	29	36	4.6	0.6
		%	0	0	11.11	8.33	80.56	100	9	7
10	Using manipulative materials makes geometry more difficult for me	fre.	2	6	2	4	22	36	4.0	1.3
		%	5.56	16.66	5.56	11.11	61.11	100	6	7
Overall Mean = 4.39										

Appendix - 10

Statistical Formula Used in Data Collection and Analysis Procedure

S.N.	Subject	Notation	Formula
1	Pooled Variance	S_P^2	$\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$
2	t - distribution	t	$\frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{S_P \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$
3	F-distribution	F	$\frac{S_1^2}{S_2^2}$
4	Degree of freedom	d.f.	$n_1 + n_2 - 2$
5	Pearsons's Correlation Coefficient	r_{xy}	$\frac{N \sum XY - \sum X \cdot \sum Y}{\sqrt{N \sum X^2 - (\sum X)^2} \sqrt{N \sum Y^2 - (\sum Y)^2}}$
6	Reliability Coefficient	r	$\frac{2 r_{xy}}{1 + r_{xy}}$
7	Difficulty Level of Item	P%	$\left(\frac{R_u + R_l}{N} \times 100 \right) \%$
	Discrimination Index of Item	D	$\left(\frac{R_u - R_l}{\frac{N}{2}} \right)$
			Where R_u and R_l are the number of correct response given by upper 27% and lower 27% students respectively. N is the total number of lower 27% students plus total number of upper 27% students.