Chapter I

INTRODUCTION

Background of the Study

The word "Mathematics" is derived from ancient Greek word "Manthanein" which means "to learn". Mathematics is the science of numbers, quantity and space. It is also the logical study of shape, arrangement, quantity and other many related concepts. Mathematics is mirror of civilization and it is directly associated with society and human life. It is believed that the development of both mathematics and human civilization started together. So, the history of mathematics is the history of human civilization.

The term mathematics may be defined in a number of ways. It is an exact science which is related to measurement and calculation. According to New English Dictionary (1702), "Mathematics in a strict sense is the abstract science which investigates deductively the conclusion implicit in the elementary conception of spatial and numerical relationship". "Mathematics is way to settle in mind a habit of reasoning" (John Lock). "Mathematics is the logical study of space arrangement, quantity and other many related concepts" (James and James, 1986). "Mathematics is a way of thinking i.e. way of organizing, analyzing and synthesizing a body of data" (Howson, 1973).

On examining the history of educational development in Nepal, it is found that astrology, though not mathematics, used taught as a separate discipline under the Gurukul system during the Vedic period. Adopting Indian curriculum, Arithmetic and Algebra used to be taught at Darbar High School, the first government school established in Nepal. After having establishment of the School Leaving Certificate Board in Nepal in 1990 B.S., the Board managed to teach various subjects of 700 full marks. Among which mathematics was a separate subject with 100 marks in secondary and lower secondary schools.

National Education System Plan (2028 B.S.) contributed to a great extend by making mathematics more systematic. Mathematics education was made a compulsory subject from grade one to ten. Mathematics is also an extra optional subject at secondary level in the exiting curriculum shows the greater importance of teaching mathematics. The sound background of mathematics is necessary for the study of science and technology.

Although many efforts have been made to enhance the standard of mathematics, there exist many shortcomings in this field. The major drawback is the traditional teaching method. In algebra, 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 algebra. In this study, the researcher has made a humbly attempt to explore the effectiveness of manipulative materials while teaching algebra.

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 a 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, pre - operational, concrete operational and formal operational stage. The student in lower secondary level concern to concrete operational stage (6/7 - 11/12 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 using the traditional methods 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.

Mathematical teaching aids which are hundreds in number generally fall into three broad categories:

- Audio visual materials
- Manipulative materials
- Symbolic
- ICT, Computer, Computer software

In grade eight of lower secondary level curriculum, there are many areas, algebra is one of them. To teach Algebra, effectively and meaningfully as in other areas (Arithmetic and Geometry), manipulative materials play a vital role. So, this study was undertaken to use manipulative materials in teaching algebra of grade eight.

Statement of the Problem

Manipulatives are supposed to be good for students because they are concrete. The first question to consider might be, "What does *concrete* mean?" Does it mean something that students can grasp with their hands? Does this sensory character itself make manipulatives helpful? This view presents several problems. It cannot be assumed that when children mentally close their eyes and picture manipulative - based concepts, they "see" the same picture that the teacher sees.

Researchers in mathematics education are in the process of accumulating a persuasive body of evidence that supports the use of manipulative materials in the mathematics classroom. In view of this, it is perplexing that relatively few programs incorporate a substantive experimental component while so many others concentrate merely on completing the pages in the ubiquitous commercially produced textbooks and workbooks. However, students are provided well teaching environment in classroom. Guardian involvement is also active, extra classes are also provided to the students. The teachers are also trained also. But there is low achievement on mathematics. This is why? The question may arise. Thus the research has tried to highlight rationale for using manipulative materials in the classroom. This research also

tried to provide a summary of what is already known about the impact of manipulative materials on mathematics learning, discuss barriers to their use, and suggest directions for their use in future research.

This study was concerned with the use of manipulative materials in teaching algebra at lower secondary level. The statement of the problem were emerged as:

- Is the use of manipulative materials in teaching algebra effective than without using it?
- Is the use of manipulative materials in teaching algebra produce better performance?

Objectives of the Study

The following were the objectives of the study:

- To compare the achievement of the students in algebra taught by using manipulative materials and not using manipulative materials.
- To find the effectiveness of students in algebra taught by using manipulative materials.

Significance of the Study

The world is now running on a very exciting century. The development of technology has made tremendous impacts in all aspect of human life. Even the science of mathematics education could not stand separated from the impact of the development. The main problem of the challenging question to the mathematics educationists is how a teacher can teach and students learn mathematics effectively. The teacher can't keep contact with the students individually since there are large and crowd classes in the context of Nepal. Any traditional methods seldom use manipulative materials and techniques creativity in order to support imaginative power and reasoning power of the students in the classroom teaching. The students can learn any aspect of mathematics better. If the manipulative materials can be used in teaching

activities, all the students become active and learn more from themselves. Students' cognitive power is involved while learning through manipulative materials.

Realizing this fact, the researcher attempted to conduct this study to determine the effectiveness of the use of manipulative materials in teaching mathematics at lower secondary level in the context of Nepal.

- It is important that studies be conducted on instructional strategies. Research makes teachers aware of various techniques being tried and gives them an idea of their effectiveness.
- There have been very few studies conducted on the use of algebra manipulatives at the lower secondary level. Most studies deal with the use of mathematical manipulatives at the elementary level. This study will increase the body of knowledge on the use of manipulatives at the lower secondary level.
- This study will inform teachers of the effectiveness of manipulatives when used in Algebra in classes at the lower secondary level, and may help teachers decide whether to use them in their classrooms.

Hypothesis of the Study

Hypotheses are the assumptions or guesses about the populations involved. Such assumptions that may or may not be true are called hypothesis. In other words, hypotheses as used in research refer to predictions o results made before a study is made.

Research Hypothesis

The mean achievement score of the students taught by using manipulative materials is better than mean score of the achievement of the students taught by conventional ways.

Statistical Hypothesis

For the statistical test, the following hypothesis was formulated:

H_0: $\Uparrow_1 = \Uparrow_2$ (Null hypothesis)

H_1: $\Uparrow_1 | \Uparrow_2$ (Alternative hypothesis)

Where $\Uparrow_1$ and $\Uparrow_2$ are mean achievement scores of students taught by using manipulative materials and without using manipulative materials respectively in teaching mathematics.

Delimitations of the Study

This study was delimited in the following aspects:

- This study is done within Rukum district.
- Only the government schools included in the study.
- The study limited on the effectiveness of teaching algebra at grade eight students using instructional materials.
- The study covers only one unit "Algebraic expression" of the entire mathematics curriculum of the lower secondary level and the study will be based on experiment of only three weeks.

Definition of Related Terms

Terminology is the study of terms and their use. Terms are words and compound words or multi - word expressions that in specific contexts are given specific meanings—these may deviate from the meanings the same words have in other contexts and in everyday language. Some terminologies used in this research have been defined as below:

Effectiveness

In this research, effectiveness of the students is defined from two ways. Effectiveness from the point of cognitive view can be defined as the better achievement of the students. In the same way, effectiveness in this study from the non-cognitive point is active participation of the students, regular presence

on discussion and teaching-learning activities, interest on teaching-learning activities, motivation towards teaching-learning activities, self-control, self-regulation, self-discipline of the students and the students' commitment towards academic task.

Manipulative Materials

Manipulative materials are objects or things that the students are able to feel, touch, handle, and move. In this study, manipulative materials especially refer to the different models of factor kids which are used in teaching algebraic expressions. They are cardboard, geo-board, rubber band, piece of soap, pencil and materials available in daily life situation, etc.

Control Group

The students who are taught using the traditional method.

Experimental Group

The students who are taught using manipulative materials were considered as experimental group in this study.

Secondary Level

A lower secondary school, often referred to as junior high school, is a school which provides lower secondary education, between the ages of 11 and 14 depending on location, after primary school and before secondary education.

Chapter II

REVIEW OF RELATED LITERATURES

Review of literature means taking knowledge from different sources. In this chapter, the researcher has received various publications and unpublished materials. Similarly, past researchers' thesis were collected and also books, articles, newspaper as well. The previous study should be reviewed because they provide the foundation to the present study. The review of literature provides the foundation for developing a comprehensive theoretical framework from which hypothesis can be developed for testing. Review of literature is mainly divided into two sub - part: theoretical review and empirical review which are presented as follows:

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, algebraic 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 is 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 consideration 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 most 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 prove 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

Effective Use of Manipulative Materials

Manipulative materials are very important, in separable and inevitable for the teaching of mathematics in mathematics classroom. Particularly mathematical concepts, facts and activities are found to be abstract. A teacher can use manipulative materials to make his teaching easy, understandable, concrete and meaningful. Manipulative materials are useful to exchange the ideas with colleagues, to evaluate the effectiveness of the materials being used, to provide follow up activities, to allow the students to make errors, to ask the pupils questions, to encourage group interaction, to prepare the students to prepare themselves, to prepare the classroom, to prepare the students, to prepare in advance for the activity, to construct activities that provide multiple involvement of the concept and to consider pedagogical and physical criteria in selecting manipulative materials

Review of Empirical Studies

Five sensory organs play an important role on children's learning. When they touch, smell, hear and see, they can get new knowledge. So, instructional materials play a vital role in an educational programme as learning is based primarily on sensory experiences. They also provide visual and sensory experience for the students. Some of the researches are reviewed here to support the guidelines for use of instructional materials in teaching learning mathematics which are supported to full fill the objectives of this study.

Sharma (2000) did a research on "A study on the availability and use of instructional materials in teaching mathematics at the primary schools of Parbat

district Nepal" under the supervision of Prof. Dr. S.M. Maskey with the aim to investigate the availability and use of instructional materials in teaching mathematics at the primary level. Twenty - five schools of Parbat district were randomly selected. Twenty - five teachers teaching primary level mathematics were interviewed. Simple percentage reporting was applied to conclude. But the availability of the materials was not found very encouraging in most of the schools except the case of some materials such as meter scale, compass, clock model, and abacus etc.

Mitra (2001) did a research on "A study of teaching material and subjectwise classroom observation" with a view to investigate the availability and utilization of curriculum material in public primary schools with the research questions: how have these curriculum materials used in classroom? What have been instructional practice? The research team visited 50 classes of mathematics, social studies and Nepali. The study found that the lecture, question answer and illusion were the major approaches of teaching. The interests and ability with the emphasis shifting from teaching learning and from the teacher to one - who - makes - it possible for other to learn, it is essential that materials are available to pupil that in all appropriates sittings: in classroom, in library in resource center, in laboratories and at home. Not only must the material be available but opportunity to use them must be provided along with the necessary encouragement and advice, remember to teacher himself can be considered an audio - visual aids of the first order. Careful integration of all aids to learning into the main system of education will enables our schools to come closure to the need of children of today.

Bhushal (2000) did a research on "The effectiveness of teaching geometry using discovery model vs. expository model of teaching in secondary level" and his study showed that the mean achievement score of the students taught by discovery method was higher than the student taught by using expository method.

Karki (2006) in his study on "A comparative study of achievement in mathematics of lower secondary level students of Chhetri, Tamang and Damai caste of Lalitpur district" found that mean achievement of Chhetri students were higher than mean achievement of the students of Tamang and Damai. He also found that mean achievement of boys students were higher than mean achievement of girls students.

The review of the previous studies show that the most of the cases of comparative study of achievement of boys have left girls behind. This is also true in different topics.

Ghimire (2009) conducted his study entitled "A study on the effectiveness of experimental verification in teaching the deductive proofs of geometric theorem at secondary level". The researcher studied the effect of prior use of experimental verification in proving geometric theorems and the enhancement of understanding the facts, principles and concept of geometric ideas. Post-test equivalent group design was adopted. He taught both the groups on the same selected units of grade IX geometry. The experimental task was provided to experimental group only. The t-test and F-test were applied and the results supported the conjecture that the experimental verification did have significant of teaching of geometry.

Neupane (2010) did a research on "A study on the effectiveness of play way method in mathematics teaching at primary level" with the aims to explore the effectiveness of the play way method of teaching mathematics at primary level and to compare the achievement of the students taught by play way method Vs traditional method. Pre-test, post-test equivalent group design was adopted. The researcher taught both the group for four weeks in grade one. The researcher developed the achievement test. Two schools were sampled. The t-test was applied and concluded that the play way method resulted significantly better over traditional method of teaching at primary level.

Thapa (2013) conducted a study on "Impact of instructional materials in teaching mathematics at primary level school of Lamjung district" with the main of the investigating impact of instructional materials in teaching mathematics at primary level. He selected the ten secondary school randomly for Lamjung district. Researcher compared the result of class five between the school using instructional materials and school not using instructional materials. He used mean, standard deviation and variance to compare their results. Finally, researcher found that achievement of school teaching with instructional materials was higher than the achievement of school teaching without instructional materials.

The above studies have been done to explore whether the achievement in mathematics is affected by the variables such as class size, in structural materials, play way methods, ethnic group and gender. The present study deals with the effectiveness of teaching mathematics by using manipulative instructional materials at lower secondary level.

Chapter III

METHODS AND PROCEDURES

The present study "Effectiveness of Manipulative Instructional materials in teaching algebra" is an experimental in nature. Researcher collected quantitative data to fulfill the objective of the study. Design of the study, population and sample of the study, controlled exercise during the experiment, instruments used for data collection, validity and reliability, item analysis of the test paper, procedure of experiment are described.

Design of the Study

The pre-test, post-test, non - equivalent control group design was adopted to draw the conclusion of the study. The study involved pre-test, post-test equivalent group design. There are many natural social (classroom) setting in which the research person can introduce something like experimental design into his scheduling of data collection procedure (e.g. when and whom of measurement). Even though he lacks the full control over the scheduling of experimental stimuli (when and whom of exposure and the ability to randomize exposures) which makes a true experimental possible. Collectively, such situation can be required as quasi experimental design. But just because full experimental control is lacking, it becomes imperative that the researcher is thoroughly aware of which specific variables his particular design fails to control (Upadhyay, 2001, P. 40 - 41).

Table No. 1

The Design of the Study

Groups	Pre-test	Treatment	Post-test
Experimental	T_1	X	T_2
Control	T_3	-	T_4

Where,

T_1, T_3= Pre-tests given to the students.

X= The treatment given to the experimental group.

T_2, T_4= Post-tests given to the students.

The design of this study consists of two groups. One is experimental and other is the control group. Both schools are within the Khalanga Resource Centre. Before selecting the experimental and control groups, researcher visited the resource person and analyzed the final exam result of year 2073 of both groups at grade VII and these two groups were matched to equivalent on the basis of pre-test. Before the treatment was given, these two groups were given an achievement tests T_1 and T_3. In this test, sixteen questions were asked, in which 8 were of 1 mark, 5 were of 2 marks and 3 were of 4 marks (see Appendix A_3). In this design, the experimental group received the experimental treatment till 1 month period. But the controlled group was taught by traditional method. Finally both groups were given achievement tests T_2 and T_4. After taking pilot study, researcher refined the achievement test papers. The achievement test paper consists of objective and subjective questions according as the specification grid of grade VII published from curriculum development center, Sanothimi Bhaktapur. By using achievement test paper II, the mean, variance and standard deviation of the scores were found for both experimental and control group. These mean difference and standard deviation were compared with the help of the test statistics formula. For this, the significance of the difference in mean and standard deviation was determined with the use of t-test for the correlated data.

Field of the Study

Both sampled schools were taken from Khalanga Municipality. Tribhuvan Janata H.S. School is the oldest schools of the district. Similarly, Yamunananda Namuna H.S. School is also a model school of Rukum district. In both schools, different castes and ethnics group students are studying. The

economic status of the students on both schools is also similar. The distance between two schools is about 10 minutes on foot. From the point of infrastructure is also found similar. The field of the study was grade - VIII of higher secondary schools of Khalanga municipality, Rukum.

Population of the Study

All the students of grade - VIII in public higher secondary schools of Rukum district were the population of the study.

Sample of the Study

Simply put, purposive sampling is when a researcher chooses specific people within the population to use for a particular study or research project. Unlike random studies, which deliberately include heterogeneous characteristics of sample. The idea behind purposive sampling is to concentrate on the students with particular characteristics who are better be able to assist with the relevant research. For example, if we select the students using probability sampling, there is the chance of selecting heterogeneous characteristics. If such types of students selected, then the achievement test cannot provide actual results. To get actual results, we have tried to select the students who have similar characteristics and homogeneity in teaching - learning capacity. Hence, the researcher has selected the students by using purposive sampling.

The researcher selected only two public schools of Rukum district. Both the schools were the sample of the study. There were only 28 students in Tribhuvan Janata H.S. Schools and 26 students in Yamuna Nanda H.S. School. Out of them, 20 students from both schools were selected because other students were found taking tuition classes, irregular and class bunker. Hence, 20 students from each school were selected as experimental and control group by using purposive sampling technique.

Variables of the Study

A variable is defined as anything that has a quantity or quality that varies. The dependent variable is the variable a researcher is interested in. An

independent variable is a variable believed to affect the dependent variable. Confounding variables are defined as interference caused by another variable. In this study, mainly two types of variables are used i.e. dependent and independent variables. Achievement of the students is dependent variable in the study. Since achievement is depended upon teaching methods used, teacher's qualification, teacher's behavior, students' learning relationship with teachers etc. are called independent variables. Similarly, age group of the students is the confounding variable which interrupts both independent variables and dependent variable. Some independent variables have been presented below:

Independent Variables, Controlled in the Experiment

Different extraneous variables can affect the validity of the research activity. This was the reason to control some variables such as maturation, history, time interval, testing effect and statistical mortality through this design of experiment. And other different variables were controlled by the following ways.

Teacher Variable

Researcher himself taught both experimental and control group. He taught them for the same duration of time and same unit which controls certain extraneous variables such as teacher's behaviour, teacher's qualification and other activities.

Equivalence of Experimental and Control Group

Both the schools were conducted from the same resource center and students of both schools were come from same level of society/culture. Also experimental and control group were equated with respect to the school grading. Researcher also visited the resource person of the resource center and analyzed the final exam result 2073B.S. of the both schools and it was found both could be taken as equivalent groups. By using pre-test scores, researcher found correlation coefficient r_{xy}=0.73. Also, he calculated t-test to check the

homogeneity of the variances of both groups and found that there was no significance difference between variances. And by using t-test for correlated samples and found that there is no difference between two means of two groups. By these conditions, researcher found two groups equivalent. Finally, by tossing a coin, he selected one group as experimental and other group as control group.

Teaching Methods

Researcher used same teaching methods for both groups. He used instructional materials only for experimental group but not for control group.

Subject Matter

Same content was taught to both the experimental and control group from the same curriculum, same textbook prescribed by GON.

Length of the Experiment

Researcher devoted equal time duration to teach both experimental and control group. He taught 1 month duration in both groups by using two different techniques i.e. with using different instructional materials for experimental group and without using instructional material in control group. Both groups were taught for 1 month.

Students

Both schools were situated near to each other and lie on same resource center. Both schools are similar in case of socio - economic status. There were twenty - two and twenty students on Tribhuvan Janata H.S. School and Yamuna Nanda Namuna H.S. School, Rukum respectively. Twenty students were selected for each school for experiment.

Dependent Variable: Students' Achievement

All the independent variables like teachers quality, student - teacher relation in teaching, teacher's behavior, qualification of teacher affects on the achievement of students; achievement of students is dependent variable in this study.

Tools for Research

The instrument of this study was achievement test, class observation, which is given below:

Achievement Test

An achievement test paper was the main instrument for data collection for the study. Some questions were developed by researcher himself, some questions were taken from teacher's guide and specification grid of grade VIII which were published from CDC, Sanothimi Bhaktapur, pilot study was adopted to establish the validity and reliability of the test item (see Appendix – B). For the pilot study twenty - one items were kept. Among them eleven were objective type and thirteen items were subjective type questions. After analysis of the pilot study, sixteen items were accepted and five items were rejected.

Achievement Test Paper – I

An achievement test paper - I contained sixteen items. Among them eight were objective item and eight were subjective items. All the questions were selected from the unit algebraic expression of grade – VIII from curriculum of lower secondary level. Eight questions were of one mark and five were of two marks and three were of four marks.

Achievement Test Paper - II

The achievement test paper – II was used for both the experimental and control group. This paper consists of only sixteen items, eight were of one

mark, five were of two marks and three were of four marks. Length of the post-test was equal as the pre-test. The test was administrated on the experimental and control group at the final stage of the instruction (experiment). Obtained mark of the post-test was described in Appendix (see Appendix - F).

Observation Note

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 algebra) and teachers response towards manipulative materials were used. Based on these mentioned tools, qualitative data have been collected and analyzed.

Estimation of Validity and Reliability of the Test

The school's subject teacher established the content validity of the test. To establish the reliability of the test, pilot study was administrated to 22 students of grade - VIII of Balkalyan H.S. School, Jhulkhet of Rukum district. Before administering the test paper, the researcher gave instructions about how to answer the given questions. Mean time was devoted two minutes per mark. The test consisted 21 items, 11 were objective and 10 were subjective. To finalize the suitable questions of the test, the researcher used achievement score to carry out the item analysis (See Appendix - B). For item analysis, 27% of upper and 27% of lower sources were identified. Also the split half reliability of the test was found 0.96. It indicates that the test was reliable (see Appendix - C)

Item Analysis of the Test

For the item analysis of the test paper, the researcher made twenty - four items in which eleven were objective and thirteen were subjective type

questions. To analyze these items researcher selected 27% upper level scores' students and 27% lower level scores' students. Out of 21 questions, each correct response was denoted by '1' and incorrect response was denoted by '0'.

The difficulty level and discriminating index of two and four marks questions were separated by step wise with one mark and the average difficulty - level and discriminate index was calculated. The item analysis table is given in Appendix (See Appendix - B) Ja.Ba.Ra. (2058, B.S.) writes: the items having (30 - 70%) and discriminate index above 0.20 were accepted. So the item numbers 4,6,11 of one marks, item numbers 13, 16 and 19 were rejected after pilot study and item no. 12 was modified. The pre-test contained only eight items of one mark, five items of two marks and three items of four marks. The questions accepted and rejected are in appendix - A_2).

Specification Chart of the Test

The refined test after pilot study had only 16 items. Among them six were knowledge level, 4 were comprehensive level, four were application level and two were skill level questions described in Table 2. The refined test is put in Appendix (See Appendix A_2) where an item no. (1 - 8) were one mark, item no (9 - 13) were of two marks and item no. (13 - 16) were of four marks.

Table No. 2

Level / Unit	Knowledge	Skill	Comprehensive	Application
Algebra	1,3,4,5,7,9,12	15,17	2,10,14,20	8,18,21
Total	7	2	4	3

Module

To conduct experiment the researcher developed a teaching module for the unit "Algebraic expression" at grade - VIII mathematics curriculum. This module was developed on the basis of theoretical framework of the

demonstrative approach. Detail information of the module is described in Appendix (See Appendix - D2).

Process of Experiment

For the experiment purpose, the researcher identified two equivalent groups of students such that both the groups were assumed to have homogeneity in variance with respect to abilities in mathematics. The researcher selected two schools as the sample of the study. Twenty students from each school were selected. The experimental group and control group were decided by tossing a coin.

The achievement test paper - I (pre-test) was administrated to the students of grade – VIII of both schools before giving treatment. The time allocated to complete the test was given two minutes per mark i.e. one hour (The test was consisted 16 items. 8 items were objective items each of one marks other items were subjective on which 5 items were of two marks and three items were of four marks). The scores of these students were tabulated and their mean and variance were calculated by using statistical formulae. The calculation process was given in the Appendix (See Appendix - E).

After making both groups equivalent in abilities in mathematics, researcher himself taught both experimental and control group. But the control group didn't get any treatment, this group was taught traditionally by researcher himself. The researcher taught experimental group in the first period (10:15 to 11:00) and control group in the third period (11:45 to 12:30). The experiment was carried out for 1 month period.

After 1 month, a post-test was administrated on the both groups. The achievement test paper - II (post test) consisted eight items of one mark, five items of two marks, three items of four marks. The duration of test was same as the pre-test. The answer sheets were marked by researcher himself. The scores

of these students were tabulated and their mean and variance were calculated by using statistical formulae (see Appendix – G).

Threats to Validity of the Study

Validity are classified into two categories viz. internal and external validity. Internal validity is most concerned with strength and control of research design and its ability to determine casual relationship between dependent and independent variables (Campbell and Stanley, 2012). In this study the researcher control the different factors that affect the treatment of experimental and control group. Researcher controlled those students whose parental education and financial status are very high and also controlled those students who took tuition class regularly.

Similarly, external validity consists of a determination whether the result of the experiment and generalized to an entire population from which the sample was drawn in the study. Threats to external validity can create significant result during the experiment. In this study researcher brought those school which has almost same socio-economic status. On the case of teacher qualification, researcher himself had taught the both school. In the case of socio-economic status all students were likely from farmer and poor financial background. Textbook may be the intervening variable for the student achievement but the researcher use the same book and same content for both groups. So, it did not impact the achievement. Hence, the researcher keeps all these variable as silent except using manipulative materials.

Data Analysis Procedure

The researcher analyzed and interpreted the collected statistics by using different statistical tools and techniques. Mean, standard deviation and variance were calculated for both groups with their secured marks in the test. t-test for independent samples were used at 0.05 level of significance to find whether the difference between means is statistically significant by using the method of

pooled variances formulae as given in Appendix - G. When the samples are small and their variance are equal nearly we can use method of pooled variance to test the significance difference between two independent means, the critical value of t-test is found for $N_1 + N_2 - 2$ degree of freedom. Homogeneity of variance was tested by using the statistical formula of F-test given in Appendix- G.

The researcher has analyzed qualitative data based on the observation note. During research period, the researcher has noted down the students participation, their regularity, their interest towards manipulative teaching-learning, students motivation, students commitment on their learning activities. The researcher had also taken the feelings of teachers, their opinions towards manipulative teaching-learning in mathematics. These all collected information have been systematically analyzed and presented in the study.

Chapter - IV

ANALYSIS AND INTERPRETATION OF DATA

This is an experimental research related to find the effectiveness of manipulative materials in teaching mathematics at lower secondary level. The objective of this study were to compare the achievement of mathematics of grade VIII students taught by using manipulative materials and without using manipulative materials and to explore the feelings of student and their activeness in the class while teaching them by using manipulative materials in teaching mathematics at lower secondary level. For this purpose, pre-test, post-test, non-equivalent control and experimental group was adopted. The population of the study was selected all students of Khalanga municipality, Rukum. Then the researcher selected only two public school Tribhuvan Janata H.S. School and Yamunananda Namuna H.S. School. Tools of the study was achievement test and observation note. Required data collected from achievement test, class observation and class teaching. For this data collection of the study period for both group was one month. Then the collected data were analyzed and interpreted by using statistical techniques. To obtain numerical data, the researcher used the statistical tools like mean, standard deviation, variance and t-test. T-test was used to compare the achievement score of the student of experimental group and control group. For the qualitative part, the researcher described the noted information form the basis of student participation, interaction, performance, homework, regularity and interest on subject matter. The data score on achievement tests were analyzed by using quantitative techniques.

The us, the obtained data were analyzed and interpretation under the following headings.

- Comparison of Achievement between the Experimental and Control Group

- Analysis of the Responses Given by Teacher and Students about Manipulative Materials in Teaching Mathematics

Comparison of Achievement between the Experimental and Control Group

The research was experimental in nature. The achievement test was the basic tool for data collection to achieve the result for the objectives. Twenty students from each school were selected. Research was intended to explore the effectiveness of the instructional materials in teaching mathematics. In this study, obtained data were analyzed and interpreted under the following headings:

Analysis of Pre-test Result

Score of the pre-test of the students of the experimental and control group are presented in Appendix E and the statistical calculation of the pre-test of both the groups is presented in table 3.

Table No. 3

Comparison of Pre-test Results

Groups	N	$\overline{X}$	∃	ℑ	F. value	t-value
Experimental	20	8.55	5.14	0.05	1.57	0.13
Control	20	7.65	4.10			

$t_{0.025,\ 38=\ 1.96}$ at ℑ = 0.05

The means, variances and the standard deviation of the scores in pre-test of experimental and control group are 8.55, 26.24, 5.14 and 7.65, 16.8, 4.10 respectively as shown in above table.

Homogeneity of the Experimental and Control Group

In order to test the null hypothesis of this study, the researcher established two equivalent groups of students on the basis of coin tossing. Pre-test was taken as the purpose to find out the gap between the experiment and

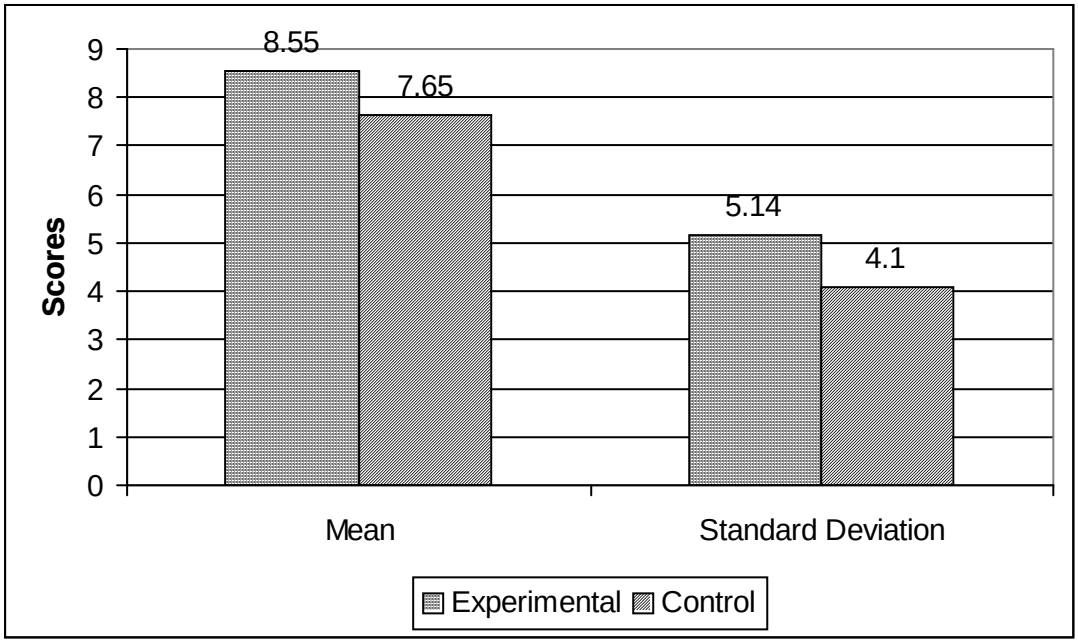
control group, if it was present. The other purpose of pre-test was to check out whether these groups were equivalent. The researcher found the correlation coefficient between these two groups by using Pearson's method. The researcher found the correlation coefficient r_{xy}= 0.73. The correlation between the experimental and the control group is substantial.

Whether initial difference existed between two groups, the t-test for correlated samples were used to find out the value of t. The t-value (t - 0.13) in above table no.3, which was less than the tabulated value, 2.57. So the null hypothesis is accepted. Therefore there is no significance difference between the means of two groups and thus both groups are taken as equivalent.

To test the homogeneity of the variances, researcher calculated the value of F. The calculated value F = 1.57 is less than the tabulated value of F (F = 2.12) which indicates that the groups are homogeneous to each other.

Figure no. 1

Comparative Bar Graph Showing Achievement of Experimental and Control Group in Pre-test in Mathematics



The figure 1 shows the mean and standard deviation scores obtained from both experimental and control group in pre-test. The diagram indicates that there is no significance difference between mean and standard deviation obtained from achievement scores in mathematics of both groups.

Analysis of Post-test Result

The post-test was administrated to both experimental and control group after the treatment was given. The post-test scores of students of experimental and control group are presented in Appendix - 'F' and the summary of the statistical calculation for both groups is presented in the table 4.

Table No. 4

Comparison of Post-test Scores

Groups	N	$\overline{X}$	∃	t-value	ℑ
Experimental	20	16.50	6.86	2.86	0.05
Control	20	10.75	5.79		

$t_{0.025, 38}$= 1.96

The table no. 4 indicates that both mean and standard deviation of both groups are different. The score of experimental group ranged from seven to twenty eight with mean score 16.50 and scores of control group ranged from five to twenty five with mean score 10.75 and standard deviation are 6.86 and 5.79 respectively.

In order to see whether initial difference is existed between two groups; t-test was employed with 0.05 level of significance. On table 4 the calculated value 2.86 is greater than the critical value i.e. tabulated value 1.96 at 0.05 level of significance. Therefore, the null hypothesis that there is no significance difference between two means of experimental and control group students, is rejected and the alternative hypothesis is accepted. This indicates that the students of experimental group are significantly benefited in the achievement

of mathematics than the achievement of the students of control group. Thus, the researcher concluded that the achievement of the grade VIII students who were taught mathematics by using instructional materials achieved better achievement than the students who were taught without using instructional materials.

Figure No. 2

Comparative Bar Diagram Showing Achievement of Experimental and Control Group on Post-test in Mathematics

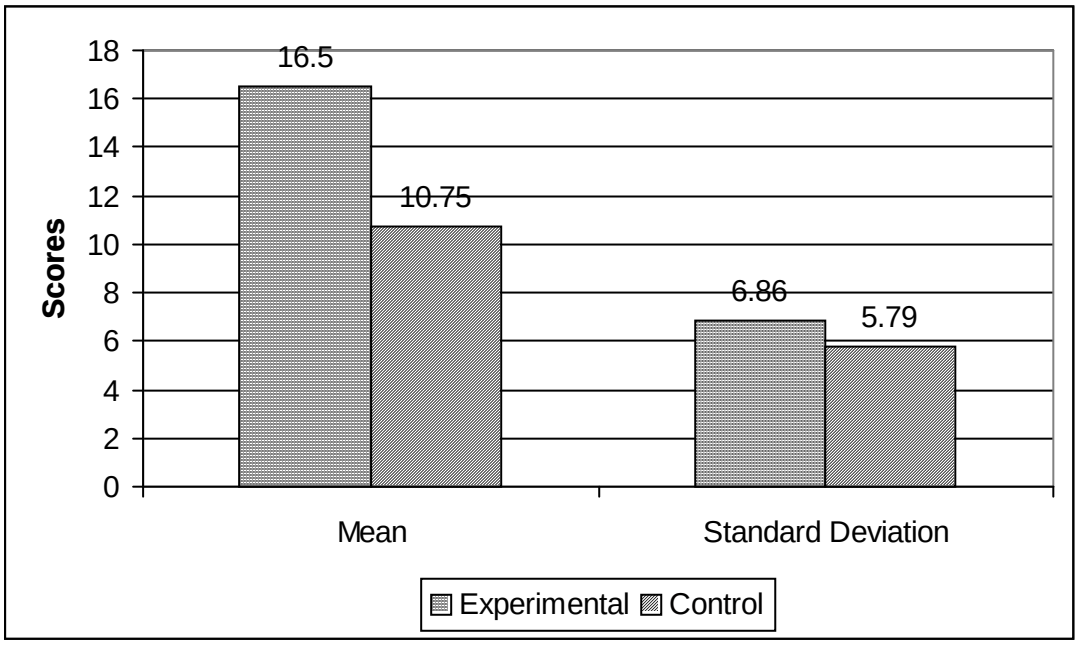


Figure 2 shows that the mean and standard deviation scores obtained by the students of experimental and control group. In the post-test, the mean score of experimental group is 16.50 and control group is 10.75. Therefore, the mean score of experimental group is greater than the control group and the standard deviation of experimental group is also greater than the control group. This result indicates that the experimental group has better result than the control group. Hence the achievement of the students taught by using instructional materials is better than the achievement of the students taught without using instructional materials.

Analysis of the Responses Given by Teacher and Students about Manipulative Materials in Teaching Mathematics

Non-Cognitive Skills

The term 'non-cognitive skill' is used to contrast a variety of behaviours, personality characteristics, and attitudes with academic skills, aptitudes, and attainment. It highlighted the role of attitudes, motivation and personality traits, rather than academic skills, as determinants of labour market success. Their findings have been reinforced by more recent studies, which have demonstrated the significant role of non - cognitive skills (i.e., attitudes, motivation and personal characteristics) over and above cognitive skills in shaping labour market outcomes, social behavior and health.

It is important to note that discussion of non - cognitive skills is complicated and contested. There is little agreement even on whether 'non - cognitive skills' is the right way to describe the set of issues under discussion, and terms such as 'character skills', 'competencies', 'personality traits' and 'life skills' are also widely used. The term 'non - cognitive', further, highlights an erroneous distinction between cognitive and on - cognitive factors.

Since this review aims to identify key competencies that can be modified, I have focused on more flexible, malleable characteristics which have been linked to positive outcomes for children. Researcher found some non-cognitive skills of students on both group in the period of experiment, which are as follows:

Participation: The participation of students were excited and regular. They were positive towards the participation in teaching - learning activities with manipulative materials. But it was not found in control group.

Regularity: The participant students were regularly participated in the classroom. They were participated in discussion and control group students were found high.

Interest: Manipulative teaching materials made students happy and interest. They were eager to know the use of manipulative materials and interest activities. But control group were not seemed so.

Motivation: Manipulative materials made the students highly motivated towards teaching-learning activities. They were found concentrated on problem solving of subject matter.

Self-control: Self - control is the capacity for altering one's own response, self-discipline, self - regulation and impulses control. In the class of experimental group there was peace and silent. They were self - controlled and active in class work.

Perseverance: Generally it refers to the engagement involves how students behave, feel, and think regarding their commitment to academic task and activities. The students were found committed towards their teaching - learning activities because of manipulative materials. But, it was not found on control group students.

Qualitative Information

From the survey, teachers said that instructional materials are essential elements in teaching learning process. They opined that without use of these teaching materials, teaching learning process becomes incomplete and handicapped. When a teacher teaches mathematics by using materials then he can achieve the objectives. Without applying instructional materials, teaching learning process cannot be effective. Teacher should have knowledge of using teaching material in the classroom. Many materials are available in our locality. Most of our lower secondary mathematics teachers have no knowledge of using these materials. So it is necessary to train lower secondary teacher to provide the knowledge of collecting, constructing and using instructional materials.

From the survey, the teachers are highly positive that implementation of manipulative materials provides children with opportunities to explore ideas

and to find the ways for solving problems. In the process of manipulation, they may well find various kinds of mathematical relationships. Manipulative materials, in the form of games provide opportunities not only for practicing and reinforcing skills learnt, but also for applying the concept and principles.

The mathematics teachers were agreed that teaching is a specialized skill that's why it requires various sorts of instruments and skills to handle it. Similarly, materials are required for effective teaching. Local materials can also be used for constructing the instructional materials that can be used for teaching mathematics. There are various types of instructional materials; some of them are readymade, expensive and wonderful. Instead of these, use of local materials are very important because they are well known for student and teacher and these are constructing locally, using all local things. They pointed out that the main problem of learning mathematics is, it is generally accepted as a complex subject. Due to the cause of feeling hardness, most of the students fail in exam at any level of many times. We can see the result of SLC exam. It is not occurred as we think. Many pupil drooped from the education due to failure in exam, which is caused by mathematics. They opined "We cannot minimize the fail percentage in mathematics; such types of series questions are in mathematics education." On other hand, the important of mathematics education is universal. We can't underestimate of its importance in daily life situation of this reality.

From the above mentioned problem, it can be realized that the value and significance of manipulative material, various kinds of researches can be conducted how the children acquire the mathematical concept.

The teachers said that there are many abstract mathematical concepts, which cannot be thought meaningfully without use of instructional materials. We should relate these mathematical concepts, skills and facts to enhance mental power of child with the help of the instructional materials. Lower secondary level mathematics is the base for further level of mathematics so it is

necessary to built up true knowledge and concept on the topic related to this level.

Finally, the teachers pointed out that the importance of instructional materials are as follows:

- It reduces the teaching load of teacher.
- It makes teaching learning activities lively
- It helps to understand the abstract concept of mathematics.
- It increased the amount of student understanding.
- It helps to involve the students directly in teaching learning activities.
- It arouses the interest of the student to the teaching learning activities.

Improving Mathematics Teaching by Using Manipulative Materials

During survey period, teachers are seemed always interested in looking for ways to improve their teaching and to help students to understand mathematics. Teaching materials support the idea that mathematics instruction and student mathematics understanding was found more effective. From this it can be said that mathematics manipulative is defined as any material or object from the real world that children move around to show a mathematics concept.

Teachers were agreed on manipulative materials in teaching mathematics to students hold the promise that manipulative helps students understand mathematics. At the same time as with any "cure", manipulative hold potential for harm if they are used poorly. They said that manipulative are improperly used will convince students that two mathematical worlds exists - manipulative and symbolic. All mathematics comes from the real world. Then the real situation must be translated into the symbolism of mathematics for calculating. For example, putting three goats to get eight goats in the real world situation but on the mathematics level we say 3 + 5=8 (Read three add five equals eight). They said that these are not two different worlds but they are in same world expressing the concept in different ways.

The teachers suggested that the manipulative materials should relate to the students' real world. They had also give an example that the use of an abacus is not something that is used in Malawian daily life; instead stones, eating utensils, tins, beans, apples, peanuts, sticks, etc. would be more appropriate.

Teachers focused that each student needs material to manipulate independently. Demonstration by the teacher or by one student is not sufficient. With students actively involved in manipulating material, interest in mathematics will be aroused. Manipulative materials must be selected that are appropriate for the concept being developed and appropriate for the developmental level of the students. For example, one stick may be placed on a place value chart in the ones place. However, one stick shouldn't be placed in the tens place. Instead a package of ten sticks bundled together with string or an elastic should be placed in the tens place.

The teachers gave the example that the same is true for the concept of the hundreds place; a bundle of 100 identical things should be used. As the students' concept of place value develops, then singles sticks can be used for place value of numbers with greater value.

Teachers said that good mathematics manipulative materials are durable, simplistic (easily manipulated), attractive (to create interest), and manageable. A systematic method should be developed for storage and distribution purposes.

They pointed out that using manipulative materials in teaching mathematics will help students learn:

- to relate real world situation to mathematics symbolism.
- to work together co - operatively in solving problems.
- to discuss mathematical ideas and concepts.
- to verbalize their mathematical thinking.
- that there are many different ways to solve problems.
- that mathematics problems can be symbolized in many different ways.

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

Mathematics teachers from the selected schools taught using manipulative materials, then the methods of evaluating mathematical achievement must also change. Just calculating correct solutions to mathematics problem is not sufficient. Concept development and understandings should be valued more highly. Effective use of mathematics manipulative contributes to conceptualize and understanding. Evaluation of students' mathematics is changing from tests and testing to assessment. Assessment is much broader than testing or evaluation. For teachers to asses' students' understanding of concepts, different techniques of evaluation is needed. Mathematics teachers said that they received more insight into students' mathematics understanding by:

- Listening to students' talk about their mathematics thinking.
- Observing students working individually and in co - operative groups.
- Asking why and how questions rather than asking:

a. Yes or no questions.
b. For results of calculating activities.
c. For answers.

- having students write a solution to a problem rather than by only responding with correct or incorrect values.

From the survey, paper - and - pencil method of assessment limits the scope of student's evaluation. Requiring students to defend their mathematical reasoning provides insight into the development of the student's functioning within a group provided data for assessment. The teachers moved around the classroom observing how students are working and interacting.

Chapter V

SUMMARY, FINDINGS, CONCLUSION AND RECOMMENDATIONS

After the analysis and interpretation of the collected data, an attempt has been made to summarize to enlist the findings and some recommendations for further study. The first section of this chapter presents the summary of the study, the second section presents its findings and the last section presents recommendations based on the findings of the study.

Summary

This study was concerned with the study of effectiveness of teaching mathematics by using instructional materials at lower secondary level. For this study, the researcher developed test items with the help of prescribed curriculum and the textbook of mathematics of grade eight. He administrated the test in Janajagriti Secondary School for the purpose of piloting. Test paper was the main instrument used for the study.

For this study, the researcher selected Shree Khalanga Lower Secondary School and Shree Janajagriti Secondary School for experimental and control group by tossing a coin. Each group had contained 20 students. At first pre-test was administered on the both groups. Then the experimental group was taught by using instructional materials and the control group was taught without using materials. The scores of 40 students were analyzed by using the mean, variance and t-test for independent samples under comparison of achievement scores of experimental and control group on pre-test and comparison of achievement score of experimental and control group on post-test.

Findings

The existing statistical analysis of the data leads towards the following results as the major findings of this study:

- The achievement of the grade VIII students who were taught mathematics using manipulative instructional materials achieved better achievement than the students who were taught without using manipulative instructional materials.
- The mean achievement scores of students taught with using manipulative materials is higher than mean achievement score of the students taught without using manipulative materials on post-test.
- The students of experimental group were found curious and highly interested in teaching - learning activities than that of control group.
- Students felt pleasure while teaching mathematics using manipulative materials.

Conclusion

Results showed that mathematics achievement is increased through the use of concrete instructional materials and that students' attitudes toward mathematics are improved when they have instruction with manipulative materials provided by teachers knowledgeable about their use. The researcher found that the mean achievement score of pre-test was as nearly some on both group without using manipulative materials but the mean achievement scores of students taught with using different manipulative materials was higher than the achievement scores of the students taught without using manipulative materials in post-test. The students of control group felt bored and lazy to learn mathematics without manipulative materials. But the students of experimental group were so curious and interested in learning mathematics with using manipulative materials. It was concluded that the manipulative materials affected with the teaching and learning. This shows that the students who were taught manipulative materials are more active, regular, participating in all activities of classroom than the students who were taught without using manipulative materials. So the manipulative material helps the students to understand the problems in mathematics. Hence, the use of manipulative materials in teaching - learning activities in mathematics is found effective.

Recommendations

From the findings and conclusions drawn from this study, the researcher suggested the following recommendations:

- Each teacher should give the basic concept of mathematics with the help of manipulative teaching materials.
- Teachers should be confident that which materials to be used while teaching mathematics because all students have not their equal teaching - learning capacity.
- When a person writes a textbook and teacher guide, he/she has to show the pictorial method as a problem solving method.
- Teachers should be able to construct well manipulative materials.
- The teachers, students, textbook writers, syllabus designers and methodologists can modify their views or approach in the light of the information provided.

Suggestions for Further Researcher

- A similar study can be carried out in other branches of school mathematics.
- Similar studies including the opinions and attitudes of parents', teachers' and students' should be carried out.

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Appendix – A_1

Achievement Test (For Pilot test)

विद्यार्थीको नाम : कक्षा :

विद्यालय रोल नं.:

समय: पूर्णाङ्क

विषय: उत्तीर्णाङ्क

1. $a^2 - b^2$ को विस्तारित रुप कुन हो ?

a) (a - b) (a - b) b) (a + b) (a - b) c. (a + b) (b - a) d) (a + b) (a + b)

2. $(a - b)^3$ को विस्तारित रुप कति हुन्छ ?

a. $a^3 + a^2b + ab^2 + b^3$

b. $(a - b)^3 + 3ab$

c. $a^3 - 3a^2b + 3ab^2 - b^3$

d. $a^3 + 3ab + 3ab^2 + b^2$

3. $x^6 - 8$ को खण्डीकरण गर्न कुन शुत्रको प्रयोग गर्न सकिन्छ ?

a. $(a^2 - b^2)$ b. $(a^3 - b^3)$ c. $(a - b)^2$ d. $(a - b)^3$

4. $(x + 2)^2$ को मान कति हुन्छ ?

a. $x^2 + 2x + 4$ b. $x^2 + 4x + 4$ c. $x^2 + x + 2$ d. $x^2 + 2x + 2$

5. a एकाई भुजा भएको घनको आयतन कति हन्छ?

a. a b. a^2 c. a^3 d. a^4

6. 3cm भुजा भएको घनको आयतन कति हुन्छ ?

a. $9cm^3$ b. $3cm^3$ c. $27cm^3$ d. $18cm^3$

7. $3x^4y^2 - x^2y^2 + xy$ कति डिग्रिको अभिव्यञ्जक हो ?

a. 2 b. 4 c. 6 d. 8

8. $(a + b)^2$ र $(a^2 - b^2)$ को म.स. कति हुन्छ ?

a a + b b. a - b c. $(a + b)^2$ d. $a^2 - b^2$

9. $2x^2 - 6x$ र $x^2 - 3x$ को म.स. कति हुन्छ ?

a $(x - 3)$ b. $x^3 - 3$ c. $x^2 - 3x$ d. $x + 3$

10. $(a - b)^2$ को मान कति हुन्छ ?

a. $a^2 + 2ab + b^2$ b. $a^2 - 2ab + b^2$ c. $a^2 + 2ab - b^2$ d. $b^2 - 2ab - a^2$

11. आयतको क्षेत्रफल निकाल्ने शूत्र कुन हो ?

a. $l + b$ b. $l \times b$ c. $2(l + b)$ d. l^2

12. गुणन गर : $(5x + 3y)(5x - 3y)$

13 सरल गर $(3x + 4y)^3$

14. $a^2 - b^2 = (a + b)(a - b)$ चित्रद्वारा देखाऊ

15. गुणन गरः $(ab + b^2)$ $(2a + 2b)$

16. सरल गरः $\frac{m^2 \text{ Z} 4m}{m^2 \text{ Z} 6m}$

17. सरल गर $3x^2 + 5x(x - 2) - 8x^2 = 5$

18. $(x - y)^2$ लाई बिस्तार गरी, $x=5$ र $y = 7$ हुँदा $(x - y)^2$ को मान निकाल ।

Long Questions

19 चित्रद्वारा $(a + b)^2 = a^2 + 2ab + b^2$ हुन्छ भनी देखाऊ ।

20. यदि $x - y = 2$ र $xy=15$ भए $x^3 - y^3$ को मान निकाल ।

21. यदि $a - \frac{1}{a} \text{X} 5$ भए प्रमाणित गर : $a^3 - \frac{1}{a^3} = 140$

Appendix – A_2

Achievement test (for Final test)

विद्यार्थीको नाम: कक्षा: ८

विद्यालय: रोल न ं .

समय १ घण्टा पूर्णाङ्क : ३०

विषय: गणित उत्तीर्णाङ्क : १०

Object Question

1. $a^2 - b^2$ को विस्तरित रुप कुन हो ?

a. (a - b) (a - b) b. (a + b)(a - b) c. (a + b) (b - a) d. (a + b) (a + b)

2. $(a - b)^3$ को विस्तारित रुप कति हुन्छ ?

a. $a^3 + a^2b + ab^2 + b^3$

b. $(a - b)^3 + 3ab$

c. $a^3 - 3a^2b + 3ab^2 - b^2$

d. $a^3 + 3a^3b + 3ab^2 + b^3$

3. $x^6 - 8$ को खण्डकीकरण गर्न कुन शुत्रको प्रयोग गर्न सकिन्छ ?

a. $(a^2 - b^2)$ b. $(a^3 - b^3)$ c. $(a - b)^2$ d. $(a - b)^3$

4.a एकाइ भुजा भएको घनको आयतन कति हन्छ ?

a. a b. a^2 c. a^3 d. a^4

5. $3x^4y^2 - x^2y^2 + xy$ कति डिग्रीको अभिव्यञ्जक हो ?

a. 2 b. 4 c .6 d. 8

6. $(a + b)^2$ र $(a^2 - b^2)$ को म.स. कति हुन्छ ?

a. (a + b) b. a - b c. $(a + b)^2$ d. $a^2 - b^2$

7. $2x^2 - 6x$ र $x^2 - 3x$ को म.स. कति हुन्छ ?

a. x - 3 b. $x^3 - 3$ c. $x^2 - 3x$ d. x + 3

8. $(a - b)^2$ को मान कति हुन्छ ?

a. $a^2 + 2ab + b^2$ b. $a^2 - 2ab + b^2$

c. $a^2 + 2ab - b^2$ d. $b^2 - 2ab + a^2$

9. गुणन गर: (5x + 3y) (5x - 3y)

10. $a^2 - b^2$=(a + b)(a - b) चित्रद्वारा देखाऊ ।

11. गुणन गर, $(ab + b^2)(2a + 2b)$

12. सरल गरः $3x^2 + 5x(x - 2) - 8x^2 + 5$

13. $(x - y)^2$ लाई बिस्तार गरी, x=5 र y = 7 हुँदा $(x - y)^2$ को मान निकाल ।

14. चित्रद्वारा $(a + b)^2 = a^2 + 2ab + b^2$ हुन्छ भनी देखाऊ ।

15. x - y=2 र xy=15 भए प्रमाणित गरः $x^3 - y^3$ को मान निकाल ।

16. यदि $a - \frac{1}{a} = 5$ भए $a^3 - \frac{1}{a^3} = 140$ हुन्छ भनी प्रमाणित गर ।

Rejected Questions After Item Analysis

1. $(x + 2)^2$ को मान कति हुन्छ ?

a. $x^2 + 2x + 4$ b. $x^2 + 4x + 4$ c. $x^2 + x + 2$ d. $x^2 + 2x + 2$

2. 3cm भुजा भएको घनको आयतन कति हुन्छ ?

a. $9cm^3$ b. $3cm^3$ c. $27cm^3$ d. $18cm^3$

3. आयतको क्षेत्रफल निकाल्ने शुत्र के हो ?

a. l + b b. lxb c. 2(l + b) d. l^2

4. सरल गरः $(3x + 4y)^3$

5. सरल गरः $\frac{m^2 Z 4m}{m^2 Z 6m}$

Appendix A_3
Achievement test (for Pre - Test)

विद्यार्थीको नाम: कक्षा: ८

विद्यालय: रोल न ं .

समय १ घण्टा पूर्णाङ्क : ३०

विषय: गणित उत्तीर्णाङ्क : १०

1. $5x^2 - 7x - 2x + 3$ कति डिग्रिको समिकरण हेा ?

a. 3 b. 2 c. 1 d. 0

2. यदि $x=4$ भए $5x^2 + 6x - 3$ को मान कित हुन्छ ?

a. 101 b. 205 c. 110 d. 200

3. $(a + b)^2$ बरावर कति हुन्छ ?

a. $a^2 + 2ab + b^2$ b. $a^2 - 2ab + b^2$ c. $b^2 - 2ab - a^2$ d. $a^2 + 2ab - b^2$

4. $(x - 2)(x + 2)$ को गुणनफल कति हुन्छ ?

a. $x^2 - 4$ b. $x^2 + 4$ c. $x^2 - 4x + 4$ d. $x^2 + 4x + 4$

5. $6x^2 - 12x|\rceil 3x$ को मान कति हुन्छ ?

a. $2x + 4$ b. $2x + 5$ c. $2x - 4$ d. $2x - 1$

6. $a^2 x a^3$ को मान कति हुन्छ ?

a. a^4 b. a^4 c. a^7 d. a^5

7. 20 र 15 को म.स. कति हुन्छ ?

a. 5 b. 6 c. 7 d. 4

8. $5x + 10$ को खण्डीकरण कति हुन्छ ?

a. $5(x + 2)$ b. $8(x + 5)$ d. $x(3x + 5)$ d. $x(2x - 5)$

9. खण्डीकरण गर: $x^2 + 7x + 10$

10. यदि $ab= - 18, a + b= - 7$ भए a र b को मान निकाल ।

11. हल गर: $x - y=9$

$x + y=1$

12. ल.स. निकाल: $5xy$ र $10x^2$

13. गुणन गर : $(a + b)(2a - b - 3c)$

14. सरल गर : $(2x3x + 5) + (2x + 4)(2x - 4)$

15. यदि एउटा आयातको क्षेत्रफल $(x^3 + x^2y + x + 3x^2y + 3xy^2 + 3y)$ वर्ग एकाइ, त्यसको लम्बाइ $(x^2 + xy + 1)$ छ भने त्यसको चौडाई कति होला ?

16. $x\Gamma\frac{1}{x}$ X3 भए $x^3\Gamma\frac{1}{x^3}$ को मान निकाल ।

Appendix – B
Item analysis of the Test

Student	Upper 27% student giving correct response							Lower 27% student giving correct response									Rem.
Item	1	2	3	4	5	6	Total	1	2	3	4	5	6	Total	P%	D	
1	1	1	1	0	0	1	4	1	0	0	0	0	0	1	42	0.50	
2	1	1	0	1	1	1	5	1	0	1	0	0	0	2	58	0.50	
3	1	0	0	1	1	1	4	0	1	0	1	0	0	2	50	0.33	
4	1	1	1	1	1	0	5	1	1	1	0	0	1	4	72	0.16	Rejected
5	0	1	1	1	1	0	4	1	0	0	0	0	0	1	2	0.50	
6	1	0	0	0	0	0	1	0	0	0	0	0	0	0	16	0.16	Rejected
7	1	1	1	1	0	1	5	0	1	0	0	0	0	1	50	0.66	
8	1	1	1	1	1	1	6	1	0	0	0	0	0	1	42	0.83	
9	1	0	0	1	1	1	4	0	0	0	0	1	0	1	42	0.50	
10	1	1	0	1	0	1	4	0	1	1	0	0	0	2	50	0.33	
11	0	0	0	1	0	0	1	0	0	0	1	0	0	1	16	0	Rejected
12	1	1	1	1	1	1	6	1	1	1	1	0	1	5	92	0.17	
	0	1	1	1	1	1	5	1	1	1	0	0	0	3	67	0.33	
															80	0.25	Modified
13	1	1	1	1	1	1	6	1	1	1	1	1	0	5	91	0.17	
	1	1	1	1	0	1	5	1	1	1	0	1	0	4	75	0.17	
															83	0.17	Rejected
14	1	1	1	1	1	1	6	1	0	0	0	0	0	1	58	0.83	
	1	1	0	1	1	1	5	0	0	0	1	0	0	1	50	0.66	
															54	0.74	
15	1	1	1	1	1	0	5	1	0	1	0	0	0	2	82	0.17	
	1	0	0	1	1	1	4	0	1	0	0	0	0	1	59	0.17	
															76	0.17	
16	1	1	1	1	1	1	6	1	1	1	0	1	1	5	92	0.17	
	1	0	1	1	1	0	4	0	1	0	0	1	1	3	59	0.17	
															76	0.17	Rejected
17	1	1	1	0	1	0	4	0	0	0	0	0	0	0	33	0.66	
	0	1	1	1	0	0	3	0	0	1	0	0	0	1	33	0.33	
															33	0.50	
18	1	1	1	1	0	1	5	1	0	0	0	0	1	2	58	0.50	
	1	0	1	1	0	0	3	0	1	0	0	0	0	1	33	0.33	
															46	0.42	
19	1	1	1	0	0	0	3	1	0	0	0	0	1	2	42	0.17	
	0	1	0	0	0	0	1	0	1	0	0	0	0	1	17	0	
															30	0.08	Rejected
20	1	1	0	1	1	1	5	0	1	0	0	0	0	1	50	0.67	
	1	1	1	1	1	0	5	0	0	0	1	0	0	1	50	0.67	
	1	0	0	0	1	1	3	0	0	0	0	0	0	0	25	0.50	
	1	1	0	0	0	0	2	0	0	0	0	0	0	0	17	0.33	
															36	0.54	

21		1	1	1	1	1	1	6	1	1	0	0	0	0	2	67	0.67	
		1	1	0	1	1	0	4	0	0	1	0	0	0	1	42	0.50	
		0	0	1	0	1	1	3	0	0	0	0	0	0	0	25	0.50	
		0	1	0	1	0	0	2	0	0	0	0	0	0	0	27	0.33	
																38	0.50	
Sum	Odd	15	16	13	16	12	11		9	7	6	4	4	1				
	Even	22	19	14	19	16	16		10	9	8	6	6	8				
	Total	37	35	27	35	28	27		19	16	14	10	10	9				

Appendix – C

(Split half reliability of the test)

Students	Odd (x)	Even (y)	x.y.	X^2	y^2
1	15	22	330	225	484
2	16	19	304	256	361
3	13	14	182	169	196
4	16	19	304	256	361
5	12	16	192	144	256
6	11	16	176	121	256
7	9	10	90	81	100
8	7	9	63	49	81
9	6	8	48	36	64
10	4	6	24	16	36
11	4	6	24	16	36
12	1	8	8	1	64
N= 12					

Reliability of split half test, $r_{xy} = \frac{N\phi xy \; Z\phi x.\phi y}{\sqrt{\phi x^2 \; Z(\phi x)^2}.\sqrt{\phi y^2 \; Z(\phi y)^2}}$

$= 0.93$

Therefore, reliability of whole test $(r_{tt}) = \frac{2r_{xy}}{1 \Gamma r_{xy}} X \frac{2 \mid 0.93}{1.93} = 0.96.$

Appendix - D_1

Model of Lesson Plan Based on Conventional Method

For Control Group

School: Date:

Subject: Mathematics Time : 45 Mins

Unit : Algebraic expression Class: 8

Topic: Squares of Polynomials

1. Specific objective

After the completion of this lesson the students will be able to:

a. Derive $(a + b)^2 = a^2 + 2ab + b^2$

b. Apply the formula to solve related problem.

1. Teaching Aids.

Daily used materials.

2. Teaching Learning Activities:

Reviewing the previous lesson, today's lesson follows the following activities:

Reviewing the previous lesson, the teacher will clarify the expansion of $(a + b)^2=a^2 + 2ab + b^2$, $(a - b)^2= a^2 - 2ab + b^2$ by using the different teaching methods: problem solving, discussion, demonstration respectively.

4. Evaluation :

a. What is the extension of $(a + b)^2$?
b. Simplify $(2x + 3)^2$ applying the formula, $(a + b)^2$.

5. Homework:

Do the followings

a. $(a + b)^2$ b. If $x + \frac{1}{x} X3$ find the value of $x^2 + \frac{1}{x^2} X$?

c. $(a^2b + b^2c)^2$ d. Simplify: $(2x + 5)^2 + (6x + 3)^2$

Appendix D_2

Lesson Based on the Used of Models (For Experiment Group)

Lesson Plan No. 1

School: Date:

Subject: Mathematics Time : 45 Mins

Unit : Algebraic expression Class: 8

Topic: Different of Two Squares

1. Specific objective:

After the completion of this lesson the students will be able to

a. Define $a^2 - b^2=(a + b)(a - b)$
b. Apply the formula to solve related problem.

2. Teaching materials:

Daily used materials and different models having area of a^2 & b^2.

3. Teaching learning activities:

During the class period the teacher will do the following activities.

a. To show the extensive form of $(a^2 - b^2)$ showing pieces of a^2 & b^2 the teacher will conduct the following activities using the different teaching methods: problem solving, discussion and demonstration respectively.

Activity No. 1

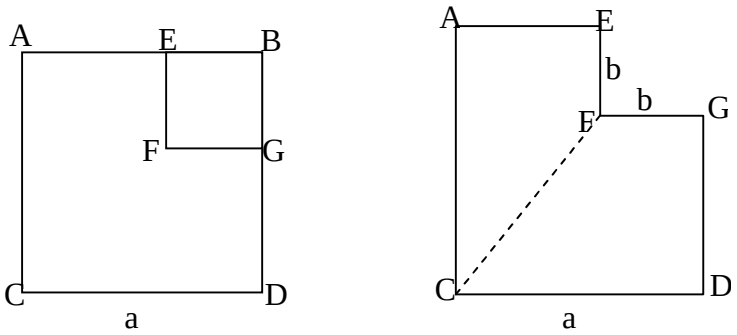


Fig. No. 1

Area of ABCD = a^2

Area of EFGB = b^2

Activity No. 2

Area of ADGE = (a + b) (a - b)

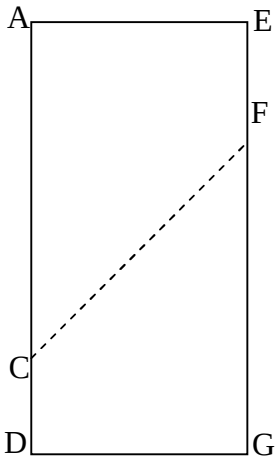


Fig. No. 2

4. Evaluation

a. What is the extension of $(a + b)^2$

b. Simplify: $(2x)^2 - 9$

5. Homework

Do the following

a) $a^2 - \frac{1}{a^2}$ b) $p^2 - 25q^2$ c. $25x^2 - (3x + 1)^2$

Lesson Plan No. 2

School: Date:

Subject: Mathematics Time : 45 Mins

Unit : Algebraic expression Class: 8

Topic: Different of Two Squares

1. Specific objective:

After the completion of this lesson the students will be able to

a. Show $a^2 - b^2 = (a + b)(a - b)$

b. Apply the formula to solve related problem.

2. Teaching materials:

Daily used materials and different models having area of $a^2 - b^2$ and ab.

3. Teaching learning Activities:

Reminding the previous lesson to the students, the teacher completes the new lesson conducting the following different activities:

a. to show the extensive form of $(a + b)^2$ showing the different pieces of wood having areas of a^2, b^2 and ab, the teacher will conduct the following activities using different teaching methods: Problem solving, discussion and demonstration respectively.

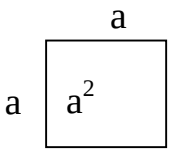


Fig.1

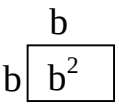


Fig.2

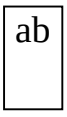


Fig.3

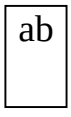
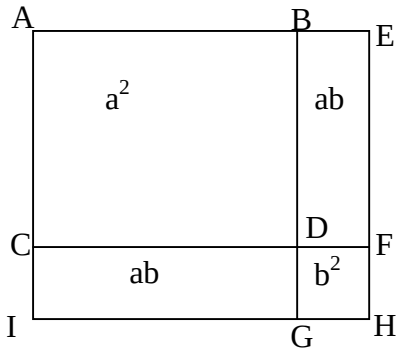


Fig.4

Area of figure no. 1,2,3,4 are a^2, b^2 ab, ab



Area of AEHI = Ar. ABDC + Ar. CDGI + Ar. DGHF + AR. BDFE

$(a + b)^2 = a^2 + ab + ab + b^2$

$= (a^2 + 2ab + b^2)$

b. To make clear the students, makes different models of other expression having $(a + b)^2$

$(3x)^2$	3x x 2y
3x x 2y	$(2y)^2$

In this figure $9x^2 + 6xy + 6xy + 4y^2$

$= 9x^2 + 12xy + 4y^2$

4. Evaluation:

a. What is the extension of $(a + b)^2$?

b. Simplify: $(2x + 3)^2$ applying the formula, $(a + b)^2$.

5. Homework:

Do the following

a. $(a + b)^2$ b. If $x + \frac{1}{x} = 3$ find the value of $x^2 - \frac{1}{x^2}$ X?

c. $(a^2b + b^2c)^2$ d. Simplify : $(2x + 5)^2 + (6x + 3)^2$

Lesson Plan No. 3

School: Date:

Subject: Mathematics Time : 45 Mins

Unit : Algebraic expression Class: 8

Topic: Different of Two Squares

1. Specific objective:

After the completion of this lesson the students will be able to

a. Derive $(a - b)^2 = a^2 - 2ab + b^2$
b. Apply the formula to solve related problem.

2. Teaching materials:

Daily used materials and different models having area of a^2, b^2 and ab.

3. Teaching learning activities:

Reminding the previous lesson to the students the teacher. Complete the new lesson conducting the following different activities.

a. To show the extensive from of $(a - b)^2$, showing the different pieces of wood having area a^2, b^2 and ab the teacher will conduct the following activities using different teaching methods: problem solving, discussion and demonstration respectively.

Activity No. 1

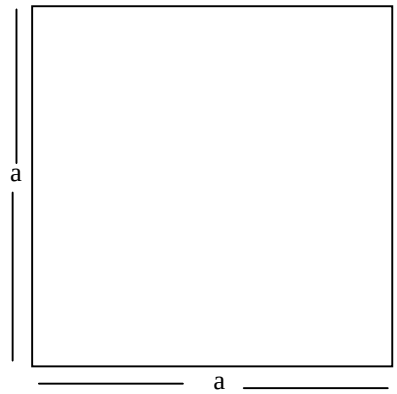


Figure No. 1

Activity No. 2

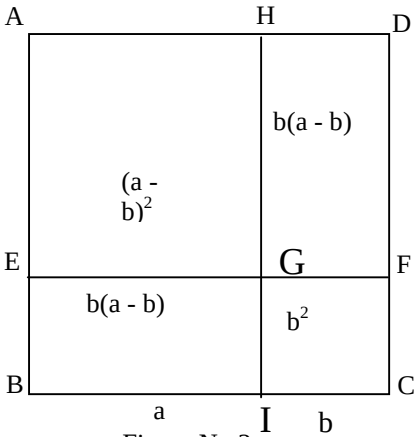


Figure No.2

Area of Figure no. 1 = a^2

Area of figure no. 2 ABCD = Area of (AEGH + GHDF + BEGI + GICF)

$a^2 = (a - b)^2 + b(a - b) + b(a - b) + b^2$

$\ldots(a - b)^2 = a^2 - 2ab + b^2$

b. To make clear the students make different models of other expression having $(a - b)^2$.

4. Evaluation

a. What is the extension of $(a - b)^2$.

b. Simplify $(2y - 1)^2$ applying the formula $(a - b)^2$.

5. Homework:

a. Simplify: $(2a - 1)^2$ b. If $x - \frac{1}{x} X3$, find $x^2 + \frac{1}{x^2} X?$

c. Expand: $(a^2b - c^2c)^2$ d. Simplify: $(2x - 5)^2 + (6x - 3)^2$

Lesson Plan No. 4

School: Date:

Subject: Mathematics Time : 45 Mins

Unit : Algebraic expression Class: 8

Topic: Factorization of trinomials of the type $px^2 + qx + r$.

1. Specific objective

After the completion of this lesson the students will be able to:

a. Factorization of trinomials forms $px^2 + qx + r$

2. Teaching materials

Dairy used materials and different models having x^2, x and unit.

3. Teaching learning activities

During the class period the teacher will do the following activities.

a. To show the extensive form $px^2 + qx + r$, showing the different pieces of wood having area x^2, x and unit, the teacher will conduct the following activities using different teaching methods: Problem solving, discussion and demonstration respectively.

Ex: $x^2 + 5x + 6$

Activity No. 1

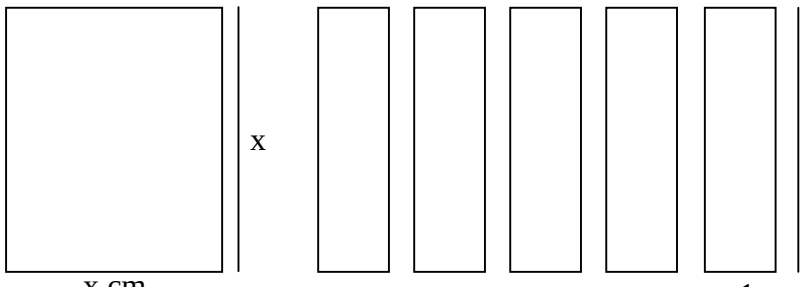


Figure No. 1 Figure No. 2

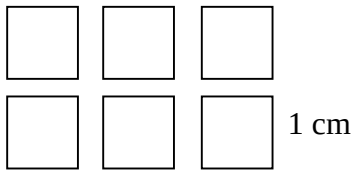


Figure No. 3

Here, Area of figure no. 1=x^2

Area of figure no. 2= x x 1=X

Area of figure no. 3= 1x1=1

In the above pieces of wood construct the rectangle.

Activity No. 2:

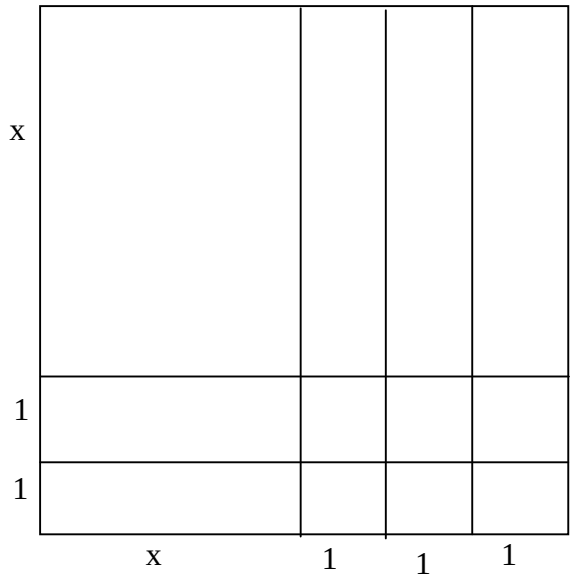


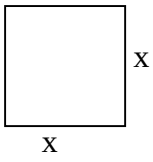
Figure No. 4

Are of above figure no. 4 = (x + 2) x (x + 3)

…We conclude that $x^2 + 5x + 6 = (x + 2) x (x + 3)$

b. To make clear the students make different models of another factorization.

4. Evaluation:



What is the area of this figure?

Evaluation is embedded within the activities.

5. Homework:

Do the following:

a. $x^2 + 7x + 12$ b. $x^2 + 4x - 3$

c. $5p^2 + 18pq + 9q^2$ d. $4x^2 + 5x - 1$

Lesson Plan No. 5

School: Date:

Subject: Mathematics Time : 45 Mins

Unit : Algebraic expression Class: 8

Topic: Factorization of trinomials of the type $px^2 + qx + r$.

1. Specific objective

After the completion of this lesson the students will be able to:

a. Factorize of trinomial forms of $px^2 - qx - r$

2. Teaching materials:

Daily used materials and different models having x^2, $-x$, $+x$ & unit .

3. Teaching learning activities:

During the class period the teacher will do the following activities.

a. To show the extensive form $px^2 - qx - r$, showing the different pieces of wood having area x^2, x, $-x$ & unit the teacher will conduct the following activities using different teaching methods: questionnaire, discussion and demonstration respectively.

Ex: Factorized $x^2 - x - 6$

Activity No. 1

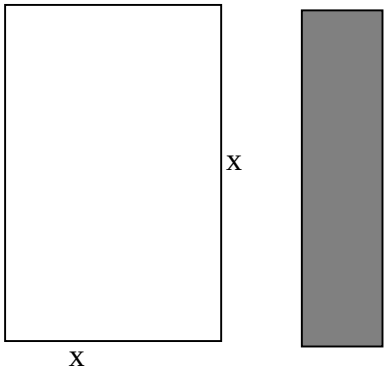


Figure No. 1

Figure No. 2

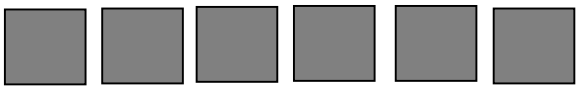


Figure No. 3

Area of figure no. 1 = x^2

Area of Figure no. 2 = $-x$

Area of figure no. 3 = -1

Activity no. 2

An attempt was made to construct the rectangle using above pieces.

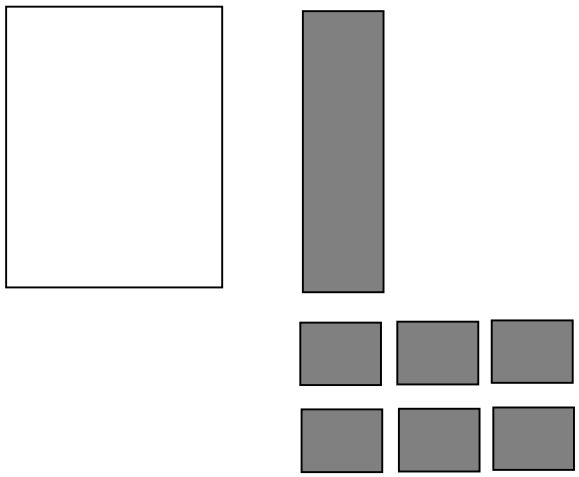


Figure No. 4

Activity no. 3

Here, above figure complete the rectangle add + 2x & - 2x

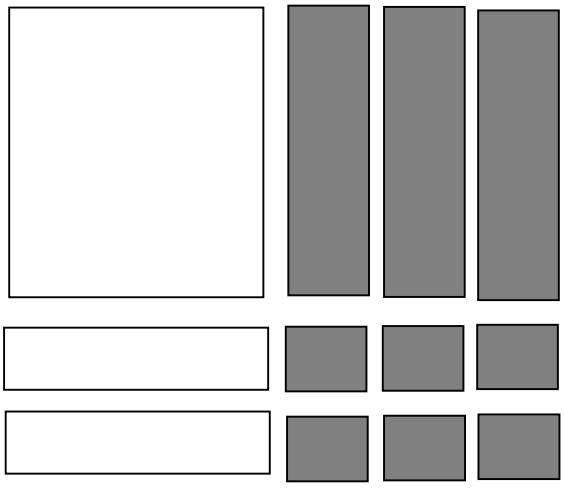


Figure No. 5

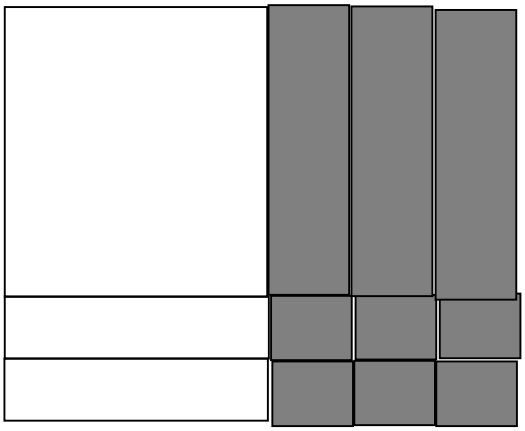


Figure No.6

Area of Figure No. 6 = (x + 2) (x - 3)

…x^2 - x - 6 = (x - 3)(x + 2)

4. Evaluation:

Evaluation is embedded within the activities.

5. Homework:

Do the following:

a. $6x^2$ - x - 15 b. $8x^2$ - 6x - 9

c. x^2 - x - 72 d. p^2 - 3p - 4

Lesson Plan No. 6

School: Date:

Subject: Mathematics Time : 45 Mins

Unit : Algebraic expression Class: 8

Topic: Cube of Polynomials.

1. Specific objective

After the completion of this lesson the students will be able to:

a. Derive $(a + b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$

2. Teaching materials:

a. To show the extensive form of $(a + b)^3$, showing pieces of a^3, b^3, a^2b, ab^2 the teacher will conduct the following activities using the different teaching methods problem solving, discussion and demonstration respectively.

Activity No. 1:

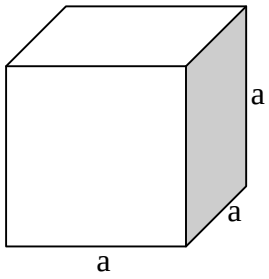


Figure No.1

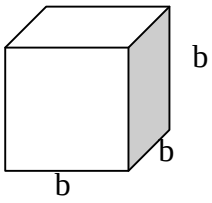


Figure No.2

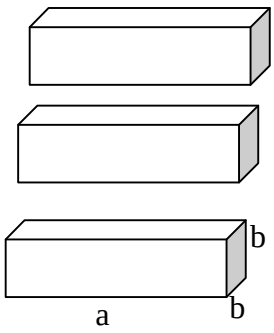


Figure No.3

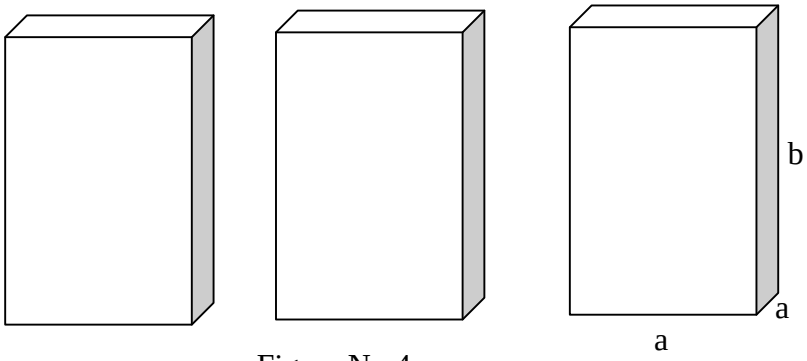


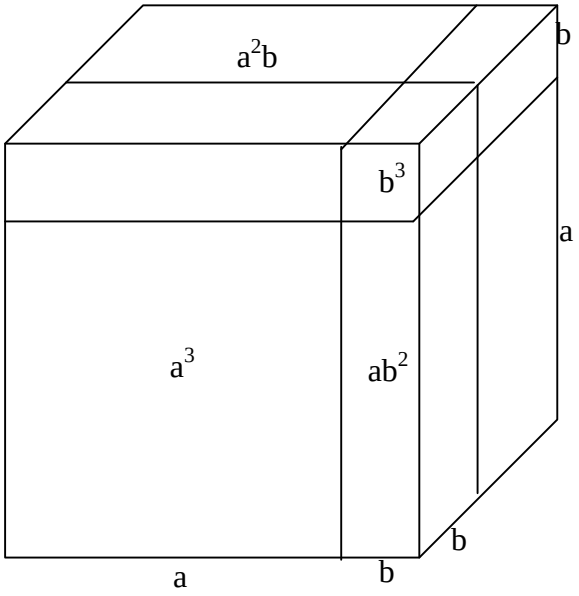
Figure No.4

Here, Volume of Figure no. 1 is a^3 Volume of figure no 2 is b^3

Volume of figure no. 3 is ab^2 Volume of figure no. 4 is a^2b

Activity No. 2

On the basis of above shown pieces of wood, to construct the cube.



We can demonstrate this result using a cube having the length of (a - b) units as in following

We can see using the actual physical model that

$(a + b)^3 = a^3 + a^2b + a^2b + a^2b + ab^2 + ab^2 + ab^2 + b^3$

$= a^3 + 3a^2b + 3ab^2 + b^3$

3. Evaluation

a. What is the expression of $(a + b)^3$

b. What is the volume of cube.

5. Homework

Do the following

a. $(2x + 3y)^3$

b. $(a^2 + b)^3$

c. $3x\Gamma\frac{1}{3x}^{3}$

d. $\frac{2}{p}\Gamma p^{3}$

Lesson Plan No. 7

School: Date:

Subject: Mathematics Time : 45 Mins

Unit : Algebraic expression Class: 8

Topic: Cube of Polynomials.

1. Specific objective

After the completion of this lesson the students will be able to:

a. Derive $(a - b)^3 = a^3 - 3a^2b + 3ab^2 - b^3$

2. Teaching materials:

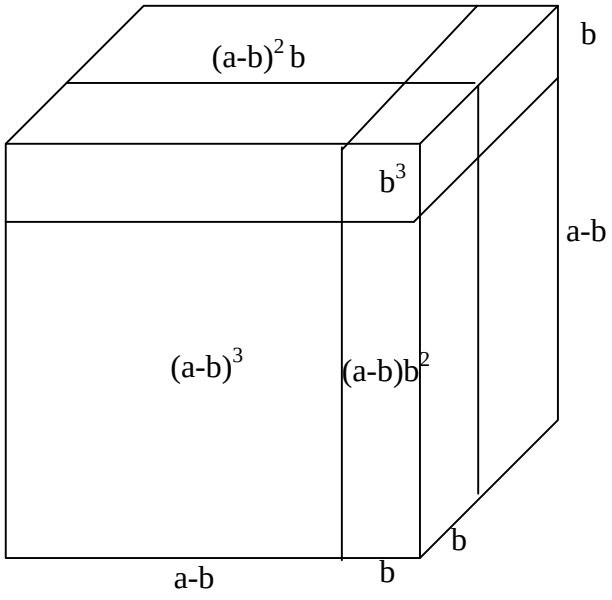
Daily used materials and different models having value of a^3, b^3, $(a - b)^3$.

$(a - b)b^2$ & $(a - b)^2xb$

3. Teaching learning activities:

a. To show the extensive form of $(a - b)^3$. Showing pieces of a^3 the teacher conducts the following activities using the different teaching methods. Problem solving, discussion and demonstration respectively.

Activity No. 1:



Volume of this cube = a^3

Now from the solid a^3 let's take out in all sides: height, length and breath. It is shown in figure No. 2.

Activity No. 2

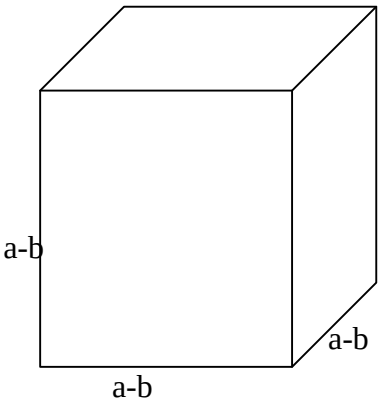


Figure No. 2

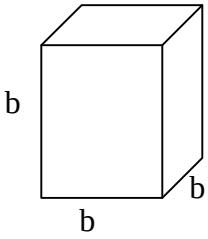


Figure No. 3

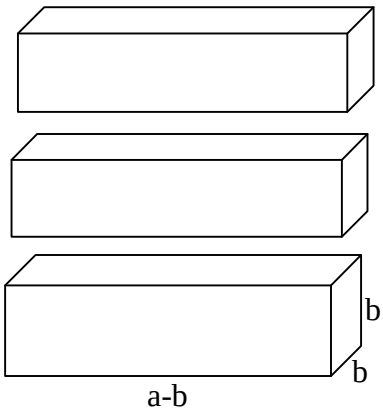


Figure No. 4

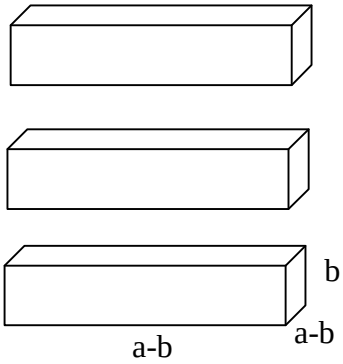


Figure No.5

Here, this cube is divided into eight pieces, whose volume are $(a + b)^3$, $3 \times b^2(a - b)$, $3 \times (a - b)^2$ & b^3

… $a^3=(a - b)^3 + 3b^2(a - b) + 3b(a - b)^2 + b^3$

or $a^3 = (a - b)^3 + 3a^2b - 3b^3 + 3a^2b - 6ab^2 + 3b^3 + b^3$.

or, $a^3 = (a - b)^3 + 3a^2b - 3ab^2 + b^3$

or, $a^3 - 3a^2b + 3ab^2 - b^2 = (a - b)^3$.

4. Evaluation

a. What is the extension of $(a - b)^3$.

b. Simplify: $(2y - 1)^3$.

5. Homework:

Do the following:

a) $(2x - 1)^3$ b) $x Z\frac{1}{x}^3$ c. $(a^2b - c^2)^3$

Lesson Plan No. 8

School: Date:

Subject: Mathematics Time : 45 Mins

Unit : Algebraic expression Class: 8

Topic: Cube of Polynomials.

1. Specific objective

After the completion of this lesson the students will be able to:

a. Derive $a^3 + b^3 = (a + b)(a^2 - ab + b^2)$

2. Teaching materials:

Daily used materials and different models having volume of a^3, b^3, a^2b, ab^2.

3. Teaching learning activities:

During the class period the teacher will do the following activities.

a. To show the extensive form of $a^3 + b^3$, showing pieces of a^3, b^3, a^2b, ab^2, the teacher will conduct the following activities using the different teaching methods: problem solving, discussion and demonstration respectively.

Activity No. 1

Here, a^3, b^3 be two pieces of wood and make a cube in this figure.

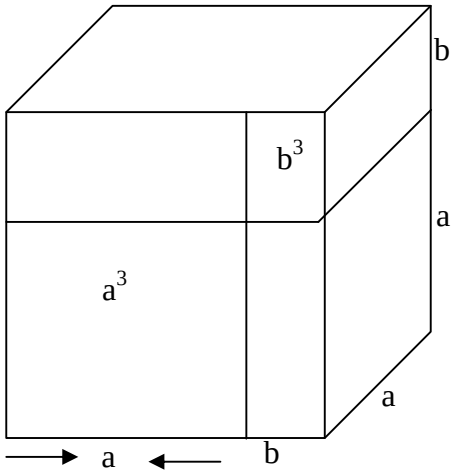


Figure No. 1

Activity No. 2

From above figure, there are eight pieces of cube.

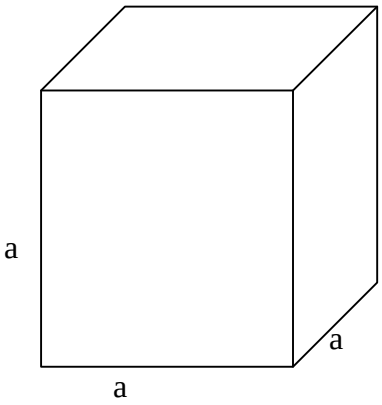


Figure No. 2

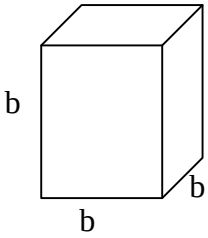


Figure No. 3

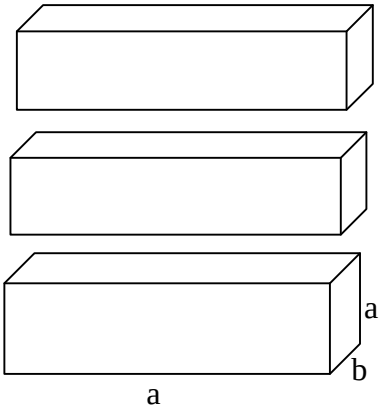


Figure No. 4

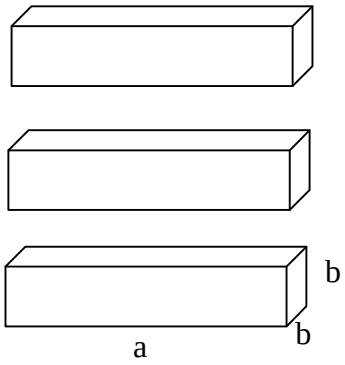


Figure No.5

Volume of Figure No. 1 = Volume of (Fig. No. 2 + Fig. No. 3 + Fig. No. 4 + Fig No. 5)

$$(a + b)^3 = a^3 + b^3 + 3a^2b + 3ab^2$$

$$\ldots(a + b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$$

$$(a + b)^3 = a^3 + 3ab(a + b) + b^3$$

$$(a + b)^3 - 3ab(a + b) = a^3 + b^3$$

$$a^3 + b^3 = (a + b)(a^2 - ab + b^2)$$

5. Evaluation:

What is the extension of $a^3 + b^3$=?

6. Homework

a. $x^3 + 27$ b. $a^3 + \frac{1}{a^3}$ c. $x^3 + (a + b)^3$ d. $8x^3 + 125$

Lesson Plan No. 9

School: Date:

Subject: Mathematics Time : 45 Mins

Unit : Algebraic expression Class: 8

Topic: Different two cube.

1. Specific objective

After the completion of this lesson the students will be able to:

a. Derive $a^3 - b^3 = (a - b)(a^2 + ab + b^2)$

2. Teaching materials:

Daily used materials and different models having volume of a^3, b^3, $a^2(a - b)$. $ab(a - b)$, $b^2(a - b)$.

3. Teaching learning activities:

During the class period the teacher will do the following activities.

a. To show the extensive from of $a^3 - b^3$ showing pieces of a^3, b^3, $a^2(a - b)$. $ab(a - b)$, $b^3(a - b)$, the teacher will conduct the following activities using the different teaching methods: problem solving , discussion and demonstration respectively.

Activity No. 1

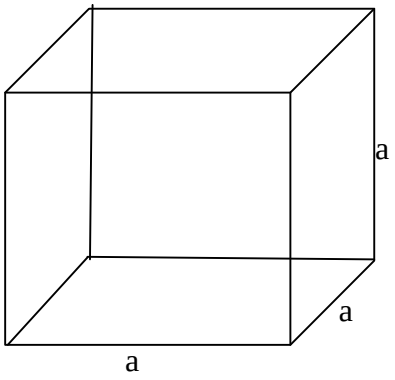


Figure No. 1

Volume of Solid (Figure NO. 1) = a^3

Activity No. 2

Now from the solid a^3, let's cut off b^3. It will be more convenient to take out b^3 from a^3.

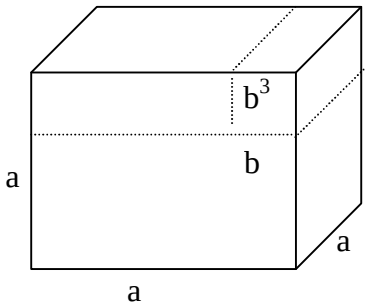


Figure No. 2

Now, we have to calculate the volume of this solid. We can split it into three different cubes.

Activity No. 3

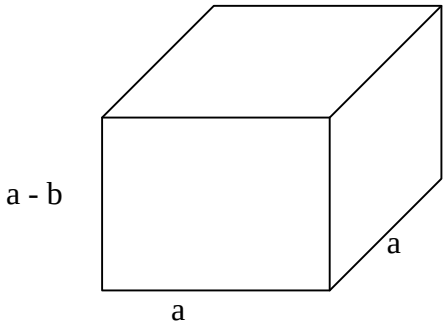


Figure No. 3

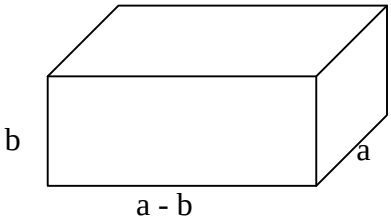


Figure No. 4

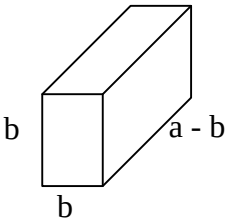


Figure No. 5

The total volume of Figure No 2 = Volume of (fig. No. 3 + fig. No. 4 + fig. 5)

$a^3 - b^3 = a^2(a - b) + ab(a - b) + b^2(a - b)$

$= (a - b)(a^2 + ab + b^2)$

4. Evaluation

Evaluation provided the activities.

5. Homework:

a. $(2x)^3 - \left(\frac{1}{4}\right)^3$ b. $a^3 - \frac{1}{a^3}$ c. $a^3 - 27$

Appendix –E

Pretest result of experimental and control group

S.N.	Experimental group	Control group
1	19	18
2	19	19
3	17	9
4	17	7
5	7	8
6	15	7
7	10	7
8	6	9
9	4	8
10	5	3
11	9	3
12	5	9
13	7	6
14	3	6
15	3	6
16	5	4
17	4	8
18	9	8
19	4	3
20	13	5
N=20	Mean = 8.55 Variance = 26.4 Standard deviation – 5.14	Mean = 7.65 Variance = 16.8 Standard deviation = 4.10

Therefore, correlation between E - Group and C – Group $r_{xy} = 0.73$.

Appendix – F

(Post - test result of Experimental and control group)

In descending order

S.N.	Experimental group	Control group
1	28	25
2	27	23
3	25	20
4	25	15
5	23	13
6	22	11
7	22	10
8	18	10
9	18	10
10	16	9
11	14	9
12	13	8
13	13	8
14	12	8
15	12	7
16	9	7
17	9	6
18	9	5
19	8	5
20	7	5
N=20	Mean = 16.5 Variance = 47.10 Standard deviation =5.14	Mean = 10.75 Variance = 33.56 Standard deviation = 5.79

Value of t - distribution = 2.86, and $t_{0.005,\ 38}$ = 2.57 at ℑ0.01.

Appendix – G

Statistical Formula used in Data Collection and Analysis procedure

S.N.	Subject	Notation	Formula
1	Mean	($\overline{X}$)	$\frac{\phi fx}{N}$ where, x= random variable f= Frequency
2	Variance	(S^2)	$\frac{\phi fd^2}{N} - \left(\frac{\phi fd}{N}\right)^2$
3	Pooled variance	(S_P2)	$\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$
4	Standard deviation	(S)	$\sqrt{\frac{\phi fd^2}{N} - \left(\frac{\phi fd}{N}\right)^2}$
5	Parson's correlation coefficient	(R_{xy})	$\frac{N\phi x.y - \phi x \phi y}{\sqrt{N\phi x^2 - (\phi x)^2}\sqrt{N\phi y^2 - (\phi y)^2}}$ Where x and y are paired scores. N = number of paired scores
6	Difficulty level of item	(P%)	$\frac{R_U + R_L}{N} \times 100\ \%$
7	Discrimination index of item	(D)	$\frac{R_U - R_L}{N/2}$ Where, R_u=Number of correct response given by upper 27% students. R_L = Number of correct response given by lower 27% students N = Total students lies on 27%
8	Spearman Brown split half reliability of the test	(r_{tt})	$\frac{2r_{xy}}{1 + r_{xy}}$
9	F - distribution	(f)	$\frac{S_1^2(large\ variance)}{S_2^2(small\ variance)}$

10	t - test of correlated group	(t)	$\frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2} - 2r \frac{S_1}{\sqrt{n_1}} \frac{S_1}{\sqrt{n_2}}}}$
11	t - statistics	(t)	$\frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{1}{n_1} + \frac{1}{n_2}} \sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S^2_2}{n_1 + n_2 - 2}}}$ Where $\bar{x}_1$, and $\bar{x}_2$ are mean of experimental and control groups respectively. S_1^2 and S_2^2 are variance of exp. And control group respectively. n_1 and n_2 are number of student lies on experimental and control groups. r= coefficient correlation between pair of score

Appendix - H

Observation Note

1. Participation of the students

2. Regularity of the students

3. Interest of students towards manipulative teaching - learning activities

4. Motivation of students on manipulative teaching - learning activities

5. Self - control of students while teaching using manipulative materials

6. Perseverance (how students behave and feel while using manipulative materials in teaching algebra)

7. Teachers response towards manipulative materials used.