

**THE EFFECTIVENESS OF MANIPULATIVE MATERIALS IN
TEACHING MATHEMATICS AT PRIMARY LEVEL**

BY

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Heartly Dedicated to My Parents,

Father: Mr. Narishwar Pande

Mother: Mrs. Til Kumari Pande

DECLARATION

I hereby declare that the thesis entitled *The Effectiveness of Manipulative Materials in Teaching Mathematics at Primary Level* is the result of my original work. No part of the thesis was earlier submitted for the research degree to any university and educational institution. This thesis is the result of my own research work conducted in the study area whatever; subject matter I have presented in this thesis is my original except some cited materials.

.....
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RECOMMENDATION LETTER

This is to certify that Mr. Megh Nath Pande, a student of Academic Year 2065/67 with Campus Roll No. 042, Exam Roll No. 2400342 (2067) and T.U. Registration No. 6-2-19-767-2002 has completed this thesis under my supervision, during the period prescribed by the rules and regulations of Tribhuvan University, Nepal. The thesis entitled *The Effectiveness of Manipulative Materials in Teaching Mathematics at Primary Level* embodies the result of his investigation conducted under the Department of Mathematics Education, Saptagandaki Multiple Campus, Bharatpur, Chitawan. I hereby recommend and forward this thesis to be submitted for the evaluation as the partial requirements to award the Degree of Master of Education.

.....

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.....

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LETTER OF APPROVAL

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ABSTRACT

This research, entitled “Effectiveness of Manipulative Materials in Teaching Mathematics at Primary Level”, is an experimental research in nature. The researcher evaluated the effectiveness of manipulative materials (algebraic tiles) in teaching mathematics (algebra) at primary level (grade V) selecting two comparable groups (experimental group & control group) of the students from a public school. The researcher chose 20/20 students in each group by random selection of tossing coin from the 40 sample students of grade V of the school. For this study, the pre-test, post-test & non-equivalent group design was adopted. Both groups were studied under the identical objectives, where experimental group was taught by using manipulative material and control group was taught by only drawing diagram on board in order to develop the concepts.

The main objective of this study was to find out the effectiveness of manipulative materials in teaching mathematics at primary level. For this, a pre-test was administered to both groups at the beginning of the study and found that both groups were comparable & had the same level of mathematics, i.e. no significant difference was identified between both group at 0.01 level of significance after applying two tailed t-test on their achieved scores.

After the experiment teaching which was conducted for 3 weeks by the researcher himself, the post-test was administered. The obtained data were arranged & statistically analyzed by using two tailed t-test at 0.01 level of significance and then it was come to know that there was significant difference between both groups. At last, it concluded that the mean achievement score of the students taught by using algebraic tiles are greater than that of the students taught only by traditional method.

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CHAPTER-I

INTRODUCTION

1.1 Background of the Study

The term 'Mathematics', derived from the Latin word 'Manthanein' which means 'to learn', has been interpreted and explained in various ways. According to Oxford Dictionary (Sixth Edition), "Mathematics is the science of number and space." A famous 20th century mathematician, Albert Einstein defined, 'Mathematics is a free investigating of the human intellect'. Mathematics is also known as the gate and key of science.

Mathematics education is defined as a science that deals mathematics from educational point of view. Mathematics education views mathematics from different aspects: philosophical, psychological and sociological. Mathematics education has also its own terms and terminologies but does not have axioms, postulates and theorems. Instead, it has its own theories and concern to problems of learning and teaching. Mathematics education is not obliged to create new mathematics or make new generalization.

Formally, mathematics education is a discipline which considers different environmental factors such as student's background and his/her surrounding, influences including scientific attitudes. Mathematics education also concerns about curriculum framing teaching and evaluation of mathematics learning. Mathematics education can be divided into four major areas (higher arithmetic, algebra, geometry and analysis) and algebra is one major area. Algebra is one of the most useful and important branch of mathematics education.

Manipulative materials are concrete models that involve mathematical concepts, appealing to several senses including the socio-cultural needs that can be touched and moved around by the learner (Heddens, 2005). Manipulative materials are physical objects, such as algebra tiles, base-ten blocks, geo-board, cuisenaire rods, fraction pieces,

pattern blocks and geometric solids that can make abstract ideas and symbols more meaningful and understandable to students. Working with manipulative materials improves performance on mathematical tasks. England, Japan, China and U.S. support the idea that mathematics instruction to students is effective if manipulative materials are used (Canny, 1984). The use of manipulative materials in classroom have long been recommended by educators (NCTM, 1989) and even mentioned in state legislations of Texas, Chapter-75, as new concepts should be introduced with appropriate manipulative at the elementary and secondary levels (Peaveler, 1987) and in California, the use of manipulative devices in all elementary classroom is recommended. In elementary level, students who use manipulative for extended periods of time perform better on achievement tests than those who don't (Envelyn J. Sowell, 1989).

Manipulative materials can be used as an intermediary between the real world and mathematical world. Using manipulative benefits students across grade level, ability level and topics which using manipulative makes sense but for that topic (Envelyn J. Sowell, 1989) emphasis using manipulative in order to provide a concrete reference for a concept, often at more than one level, instead of reference for a given abstract idea or procedure. According to Heddens (2005), manipulative materials help to students

- to relate real world situation to mathematical symbolism.
- to work together co-operatively in solving problem.
- to discuss mathematics idea and concepts.
- to verbalize their mathematical thinking.
- to symbolize mathematics problems in many different ways.
- to solve mathematics problems only on teacher's few directions and sometimes without teacher's directions too.

Algebra tiles are manipulative materials. Algebra tiles are geometric model that explore algebraic concepts. Algebra tiles have a variety of other names; Algetiles, Math tiles, Virtual tiles. Algebra tiles can help students to visualize algebraic expressions or equations. Many of the tiles have the positive and negative side. The virtual algebra tiles activities will use multi-colored positive tiles. The reverse (negative) side of each tile is black. It helps to understand that tiles have one positive and one negative dimension. Algebra tiles can easily and cheaply be constructed. The tiles are made from colored card, wood, stone, ... etc. Recently many of the commercial versions of algebra tiles are made from plastic.

The National Council of Teachers of Mathematics (NCTM, 1989) stresses the importance of uses of manipulative materials. Research indicates that lessons using manipulative materials have a higher achievement than doing lessons without such materials (Envelyn J. Sowell, 1989; Syudam and Higgins, 1977).

In the context of Nepal, the study of using manipulative materials in teaching algebraic concepts has not been studied yet. This study is a humble attempt to use algebra tiles in teaching algebraic notations and concepts at primary level.

1.2 Statement of the Problem

Mathematics plays an important role in our daily life. Because of this, the National Education System Plan (NESP, 1971-1976) has emphasized in making mathematics teaching life oriented and practical. Though, most of the primary schools of Nepal are still using the drill and lecture oriented traditional method with limited use of the teaching materials. In order to make the mathematics teaching practical and life oriented, the teacher is expected to follow learning by doing, learning by practical working and also to use the instructional materials properly and sufficiently. Without use of necessary teaching materials, the teacher remains unable to make the mathematics

teaching practical and effective. The students, particularly small children at primary level, find it difficult to understand mathematical concepts. Hence, the researcher has tried to find the answer of the following question.

- Is the use of manipulative materials in teaching mathematics more effective?

1.3 Objective of the Study

The main objective of this study is to find out the effectiveness of the manipulative materials in teaching mathematics at primary level. This was accomplished by the following objectives:

- To compare the achievement of the students taught by using manipulative materials and without using manipulative materials.
- To find out the effectiveness of the manipulative materials in teaching mathematics at primary level.

1.4 Significance of the Study

Algebra is an integral part of mathematics in school curriculum. It gives the practical knowledge to everyone to live the life. But teachers are not found comfortable in teaching algebra due to the lack of sufficient trainings and awareness toward using teaching materials & appropriate teaching methods. That's why, students do not understand the concept properly which leads them to score poor mark or causes them unsuccessful in mathematics.

Manipulative materials are effective means to develop the concepts and principles; and also, their uses facilitate students to understand structures and principles of mathematics. Only the manipulative materials are not sufficient, the proper use of manipulative materials should be stressed.

Algebra provides opportunities to students to explore ideas, find ways of solving problems and various kinds of algebraic relationship. Algebra also provides opportunities

not only for the practicing and reinforcing skills learnt, but also for applying the concept and principles. Realizing this fact, the researcher attempted to study the effectiveness of the manipulative materials (algebraic tiles) in teaching mathematics (Algebra) at primary level.

1.5 Statement of Hypothesis

The following null hypothesis & alternative hypothesis were formulated for this study:

- a) Null Hypothesis (H_0): There is no significant difference between the achievement scores of experimental and control groups ($H_0: \mu_1 = \mu_2$).
- b) Alternative Hypothesis (H_1): There is significant difference between achievement scores of experimental and control groups ($H_1: \mu_2 \neq \mu_1$).

μ_1 , and μ_2 are mean achievement scores of students taught by using the manipulative materials and without using the manipulative materials respectively.

1.6 Limitations of the Study

The study was limited in the following aspects:

- The study was limited to the public school in the eastern part of Nawalpur district.
- The study was limited to the effectiveness of algebraic tiles of the teaching mathematics at grade V.
- The study was focused on Algebra Teaching.
- The teaching experiment period was set for 21 days (but taught 14 periods only, due to public holidays & Saturdays).
- This study was based on purposive sampling.
- The sample was selected from fifth grade students of Shree Janata Secondary School, Gaindakot-12, Nawalpur.

1.7 Definition of the Terms & Abbreviations

Effectiveness: Simply the meaning of the effectiveness is the degree to which something is successful in producing a desired result, i.e. effectiveness is the degree of success of the objective which is taken for the study.

Manipulative Materials: Manipulative materials are physical objects that are used as teaching tools to develop the concrete concept of the subject in the students. In mathematics education, the manipulative material is an object which is designed so that the learner perceives some mathematical concept by manipulating it, hence its name. Some examples of manipulative materials are: algebraic tiles, colour chips, pattern blocks, geo-boards... etc.

Algebra Tiles: The algebra tiles consist of small squares, large squares and rectangles. The number 1, the unit tiles, is represented by the small square; the large square represents X^2 , the rectangle represents X . the length of the X tile is not equal to the side length of the unit tile but the width of the X tile is equal to the side length of the unit tile (Appendix A).

Sample Students: The students taken as sample for the study are called sample students.

Experimental Group: It is a group of the students who are taught by using manipulative materials.

Control Group: It is a group of the students who are taught only by traditional method.

Non-equivalent Group: A non-equivalent group is the one where the assignment of participants to group is not controlled by the investigator.

Achievement: In reference to present study, the term “achievement” is defined in terms of the scores obtained by the students on an achievement test prepared by the researcher.

Public School: Public school is the school which receives the government grant for the salary of the teacher and other purpose.

SJSS: It is the name of the sample school, Shree Janata Secondary School, Gaidakot-12, Nawalpur.

CHAPTER-II

REVIEW OF RELATED LITERATURE, TEORITICAL FRAMEWORK AND CONCEPTUAL FRAMEWORK

2.1 Review of Related Literature

Review of related literature is an exacting task calling for a deep insight and prospective of the overall field. Scientific research must be based on past knowledge. The previous studies cannot be ignored because they provide the foundation to the present study. In other words, there has to be continuity in research. This continuity will be ensured by linking the present study with the past research study. The main purpose of review of related literature is to find out what works will be done in the area of the research problem under the study and what will have to be done in the field of the research study being undertaken. Therefore, the following reviews of the literatures will support the guideline for using manipulative material in teaching mathematics at primary level and fulfill the objective of this study.

Baral (2005), did a study on “*The effectiveness of the instructional materials in teaching geometry at primary level*”. The researcher studied primary level (class-5) students in Kaski district. Each class contained 20 students. Instructional materials were used with the experimental groups to teach geometry unit. The same unit was taught to control group using only the text and traditional instruction. The study was conducted over a period of 20 days. Using t-test, the researcher concluded that the experimental group scored significantly higher than the post-test than the control group.

Neupane (2002), conducted an experimental study on “*The effectiveness of play way method in mathematics teaching at primary level.*” The aim of research was to explore the effectiveness of play way method in mathematics teaching at primary level and to compare the achievements of the students taught by play way method versus

traditional method. The study showed that the play way method was resulted significantly better method over traditional method of teaching at primary level.

Upadhyaya (2001), conducted his study on “*Effect on constructivism on mathematics achievement of grade 5 students in Nepal*”. The aim of research was to adapt and advocate constructivism in class working on the sample size of 118 students from our schools involving two control and two experimental groups. The research found the possibility of constructivism, in Nepalese schools, with significant difference in achievement that of students in favour of teaching method based on constructivism approach than conventional method of teaching.

Nute (1997), did a study on “*The Impact Engagement Activity and Manipulative Presentation in Intermediate Mathematics Achievement, Time On-Task, Learning Efficiency and Attitude*”. This study examined on student math achievement. The participants were 241 students (from grades 4, 5 and 6) and they were randomly assigned to groups. One group had manipulative and another control group had no manipulative. Data was collected by three ways: students attempted an achievement test, completed a time-on-task measurement and filled out an attitude questionnaire. Then, the research concluded that the manipulative group showed higher level recognition and achievement performance than the control groups.

Ernest (1994), conducted on study on “*Evaluation of the effectiveness and implementation of math manipulative.*” The study consisted of 40 high school teachers from 26 schools. The teachers attended the weekly long training workshop in the use of manipulative implemented the teaching strategies discussed during the workshop in their classroom instruction on the following year, and then attended a fellow up session to discuss strategies and problems identified during the implementation phase of the study. Data was gathered to evaluate the weeklong teacher training workshop and the

implementation of manipulative in classroom instruction. Onsite observation were conducted to record utilization by course and manipulative, student participation, students attitudes towards the manipulative and interaction with the content. Evaluation of the workshop revealed that the teachers found the quality of instruction to be excellent to very good. Evaluation of the math manipulative and that “on task” involvement were very high. The researcher reported that the students enjoyed and were more interested in assignment when manipulative were used.

Lackey and Reglin (1991), conducted a study entitled “*Manipulative and Achievement of Subtraction Basic facts for Rural Second grade student.*” This study investigated the effect of manipulative, instructional approach and traditional instrument on the achievement of subtraction facts for 4 African American and 26 white second grades in a rural North Carolina Public School. There was no correlation between the race and ability of the subject. The 30 students were broken down into two groups. Control group used a traditional approach and experimental group used manipulative approach. The data was collected through tests and the ability to communicate their understanding of subtraction. It was concluded that greater gains in achievement were of subtraction basic facts occurred with the manipulative instruction approach.

Pandey (1985), conducted an experimental study entitled “*Use of visual aids in teaching fraction development of teaching models for teaching fraction in grade VI*” with the aim to develop teaching models for teaching fraction in grade VI selecting proper visual aids and to see how effective the prepared model was. A teaching model with visual aids and a plain verbal exposition model were prepared. Sixty students were randomly chosen for teaching for twenty days. A pre-test and post-test research design was chosen and t-test was applied to conclude that the teaching made with visual aids was found to be more effective than the verbal exposition model.

In Nepal, some studies have been done to explore whether the achievement in mathematics is affected by class size or sex factor, teacher qualification or ethnic groups or use of instructional materials. Some studies concerning scholastic achievement and child development in primary level or any particular grade have also been made. The present study will be different from those of the existing researchers in the sense that it deals with the effectiveness of particular materials in teaching mathematics.

2.2 Theoretical Framework

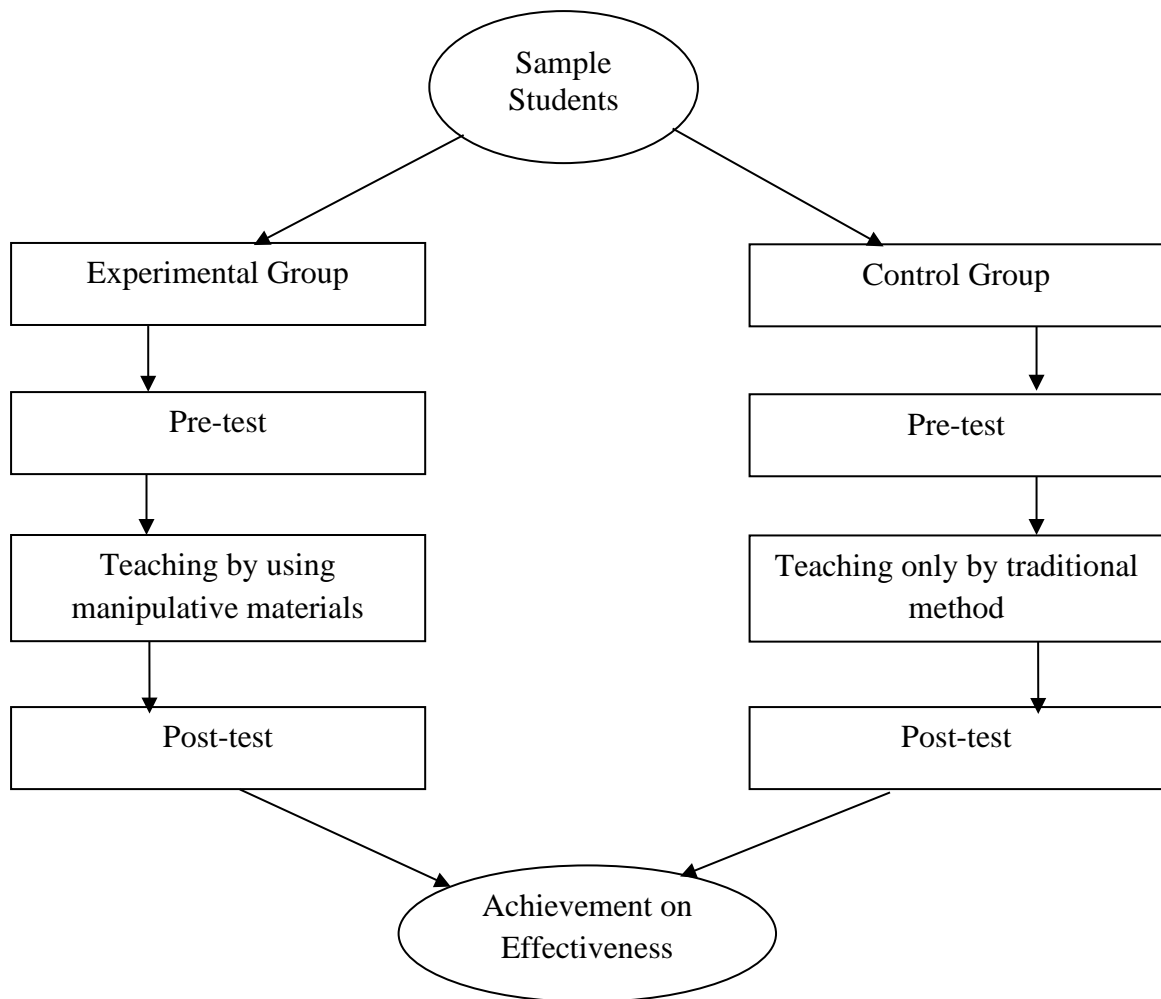
This study, entitled “The Effectiveness of Manipulative Materials in Teaching Mathematics at Primary Level”, was guided by the learning theory based on the constructivist model. This learning theory indicates that mathematical understanding in young children is closely associated with sensory perception and concrete experience.

Manipulatives are effective tools in mathematics education by helping children move from a concrete to an abstract level of understanding. Students who see, touch, take part and manipulate physical objects begin to develop clearer mental images and can represent abstract idea more completely than those whose concrete experiences are limited (Heddens and Howden, 1986). Furthermore, constructivism advances the idea that the individual begins to develop understanding through personal experiences and personal connections.

2.3 Conceptual Framework

Conceptual Framework is a map of actions required in the course of the study which guides how the research is going to be conducted. It is also called like a blue print of all actions of the researcher throughout the study.

The researcher himself drew the following paradigm to clarify the conceptual framework of this study:



CHAPTER-III

METHODOLOGY

Research methodology is a science, which determines how the research becomes complete and systematic. This chapter deals with how the methodology of the study was determined. It presents how the sampling was done, how the data collection instruments were developed, how the instruments were administered to the target group. It also presents how the collected information was translated into meaningful statistics.

3.1 Design of the Study

This study is an experimental research in nature. The pre-test, post-test & non-equivalent group design was adopted for the purpose of this study. The paradigm of the study is as follow:

Table No. 1

Group	Pre-test	Treatment	Post-test
E	O ₁	New Treatment	O ₂
C	O ₃	Conventional Treatment	O ₄

where E = Experimental Group, C = Control Group,

O₁ and O₃ = Pre-test given to the students &

O₂ and O₄ = Post-test given to the students.

The experimental group was taught by using algebraic tiles while teaching algebra, whereas the control group was taught by conventional (traditional) method. This design is the most effective in minimizing the threats to experimental validity

3.2 Population and Sample of the Study

The population of the study consisted of all the students of grade V in public schools of Nawalpur district. The researcher selected Shree Janata Secondary School (SJSS), Gaidakot-12, Nawalpur, as a sample school. After selecting the school, the grade V was chosen for the research. According to the school attendance register, there were 45 students in grade V of SJSS. Two groups (Experimental Group & Control Group) were made including 20/20 sample students in each from the students of grade V and they were chosen randomly by tossing a coin. Since 5 students were irregular in class, so they were skipped for the groups but kept together with the sample students during the experiment class when they were present. That's why, only 20/20 students were chosen as sample students in each group to equate the group in size. Name of the students in Experimental Group & Control Group are mentioned in Appendix – B.

3.3 Instruments/Tools

Achievement test is the main tool for the data collection of the study. Before and after the treatment class teaching, the researcher also used the same tool to collect the data to analyze the achievement of this study.

3.3.1 Construction of Achievement Test

In this study, the researcher considered some topics from algebra of grade V for the experimental units. Those topics were 'Algebraic Terms/Expressions & their values, Addition & Subtraction of Algebraic Expressions and Solution of Equations'. Focusing these topics, the researcher himself constructed a test paper of 18 questions (with full marks 30) for the achievement test, arranging the questions in groups according to their natures. Out of 18 questions, 12 were objective questions of 1 mark each (with multiple choices) and 6 were subjective questions of 3 marks each (See Appendix – G). All the

questions were based on the topic of algebra of grade V and also based on Curriculum Specification Chart.

Table No. 2

Specification Chart of Achievement Test

Level	Knowledge	Skill	Comprehensive	Application	Total
Unit Algebra	(1, 2, 3, 4, 5, 12)	(6, 8, 14, 15, 16)	(7, 9, 13)	(10,11,17,18)	18
Total	28%	33%	17%	22%	100%
Item numbers 1 to 12 are objective items and 13 to 18 are subjective items.					

3.3.2 Piloting of the Instrument

It is very important to ensure that the instrument used in the study is of good quality, by both technically and administratively. In other words, it is necessary that the test should be standardized one. So, for the Standardization, the researcher piloted the test in Shree Ratna Rajya Laxmi Secondary School (SRRLSS), Gaidakot-10, Nawalpur, involving only 22 students of grade V which is different from the sample school but it has almost the same status compared to the sample school in all aspects. Before administrating the test, the researcher took the permission for the test from the school and then explained the class how to respond the test paper. The headmaster and subject teacher of the school also supervised the administration of the test. For the pilot test, the test paper consisted of 24 questions (with full marks 40) where 16 were objective questions of 1 mark each (with multiple choices) and 8 were subjective questions of 3 marks each (See Appendix – D). The time taken by students to complete the test was found 1 hour 30 minutes.

3.3.3 Item Analysis of the Test for Validity and Reliability

In item analysis, the difficulty index (P-value) and discrimination index (D-value) of the test were computed to check the quality of the test items. These were done by calculating the response of the top 27% students and bottom 27% students. So, the researcher took 6 upper and 6 lower scored students out of 22 involved students of grade V of Shree Ratna Rajya Laxmi Secondary School, Gaindakot-10, Nawalpur. The calculation of discrimination index (D-value) of the test item was done on the basis of this kind of analysis. The table of item analysis is given in Appendix - E. Taking into account of the obtained level of difficulty (P-value) and index of discrimination (D-value) of each item, only those items were selected whose P-value was ranging between 30% to 70% and D-value was ranging between 0.20 to 0.80. Though the researcher prepared the test paper consisting of 24 questions at first where 16 were objective questions of mark 1 each (with multiple choices) and 8 were subjective questions of mark 3 each, the six items (3, 5, 12, 14, 18 and 24) were rejected with the help of P-value & D-value and discussing with mathematics teacher. The remaining items were accepted as the final form for the achievement tests. Also, the reliability of the test was found 0.96 (See Appendix – F).

3.4 Procedures of Data Collection

The procedure of data collection describes how the relevant information was gathered. The study is mainly based on quantitative data obtained from the achievement test. After the standardization of the test, the collection of data from achievement test was done by the following processes:

- The researcher met the headmaster & subject teacher and took permission for the test in the school.
- The students were informed how to respond the items before the test.

- The test was administered on the students of grade V of Shree Janata Secondary School, Gaindakot-12, Nawalpur.
- After collecting and scoring all the answer sheets, the scores were tabulated & arranged in descending order for analysis.
- The time allocated for the test was 1 hour 30 minutes which was determined from the pilot test.

3.5 Procedure of Data Analysis

The researcher analyzed and interpreted the collected data by using the following procedures and statistical devices/tools:

- Mean, standard deviation and variance were calculated for both the groups with their secured marks in the tests.
- T-test for independent samples was used at 0.01 level of signification to find whether the difference of mean is statistically significant or not.

CHAPTER-IV

ANALYSIS AND INTREPRETATION OF DATA

The most important part of any study is the analysis of its collected data. This chapter deals with the analysis and interpretation of data obtained from the achievement tests of the sample students. Those data were analyzed by using two tailed t-test for the difference between two means.

This study, entitled “*The Effectiveness of Manipulative Materials in Teaching Mathematics at Primary Level*”, is an experimental study in nature involving pretest, post-test & non- equivalent group design. The researcher established two groups (Experimental Group & Control Group) of 40 sample students for the study by the help of random selection from the students of grade V of SJSS. Experimental Group (A group to teach by using algebraic tiles) and Control Group (A group to teach by traditional method) were constructed with 20/20 students in each by tossing coin.

4.1 Analysis of Pre-Test Result

Scores of the pre-test of students of the experimental and control groups are given in Appendix - H together with the statistical calculation of mean, standard deviation and variance. The t-test analysis for the comparison of the mean achievement scores of pre-test has been summarized below in table-3.

Table No. 3

Comparison of Experimental & Control Groups on Pre-Test Scores:

Groups	N	Mean	Standard Deviation	Variance	t- Value	R
Experimental	20	8.65	4.96	24.63	0.67	0.96
Control	20	7.70	3.98	15.81		

Degree of Freedom = $N_1 + N_2 - 2 = 38$

Mean, standard deviation and variance of the scores in pre-test were respectively found 8.65, 4.96 and 24.63 for the experimental group and 7.7, 3.98 and 15.81 for the control group. The mean achievement scores of both groups were compared statistically using two tailed t-test at 0.01 level of significance. The table showed that the calculated value of t-test 0.67 was less than the tabulated value 2.58 at 0.01 level of significance with degree of freedom 38. So, the null hypothesis was accepted and supported that there is no significant difference between the experimental and control groups on pre-test scores.

4.2 Analysis of Post-Test Result

The post-test was administered to both experimental and control groups after the treatment was given. The post-test scores of students of experimental and control group are given in Appendix - I together with the statistical calculation of mean, standard deviation and variance. The t-test analysis for the comparison of the mean achievement scores of post-test has been summarized below in table-4.

Table No. 4

Comparison of Experimental & Control Groups on Post-Test Scores

Groups	N	Mean	Standard Deviation	Variance	t- Value	R
Experimental	20	19.35	5.37	28.83	3.65	0.96
Control	20	13.25	5.19	26.98		

$$\text{Degree of Freedom} = N_1 + N_2 - 2 = 38$$

The scores of experimental group ranged from 10 to 29 with mean 19.35, standard deviation 5.37 and variance 28.83, whereas the scores of control group ranged from 7 to 23 with mean 13.25, standard deviation 5.19 and variance 26.98. Here, the mean difference of scores of both groups was found of 6.10. Also, the mean of achievement scores of both groups were compared statistically using two tailed t-test at 0.01 level of

significance. As shown in the above table, the calculated value of t-test 3.65 is greater than its tabulated value 2.58 at 0.01 level of significance with degree of freedom 38. Since the calculated value of t-test is greater than its tabulated value, it rejects the null hypothesis saying that there is significant difference in mean achievement scores between experimental group & control group on post test scores. Thus, the result was in favor of experimental group, i.e. the group taught algebra (mathematics) by using algebraic tiles (manipulative materials) performed better than the group taught only by traditional method.

When researcher divided the students to experimental group & control group and administered pre-test examination, no difference was found in mean scores between them. After the experiment teaching of 3 weeks (14 periods only, due to public holidays & Saturdays), again post-test was administered and then there was found quite difference in mean scores from the result of both the groups. Experimental group scored higher marks than the control group. They solved more problems than earlier but control group students remained almost same. It was also noticed that the students seemed very active and interested in algebra while teaching them by using algebraic tiles. Therefore, it showed that teaching students using teaching materials is quite fruitful and effective.

CHAPTER-V

FINDINGS, SUMMARY AND IMPLICATIONS

5.1 Findings

The result of pre-test indicated that there was no significant difference between the groups after testing by two tailed t-test at specified level 0.01 with the degree of freedom 38, but the result of the post-test indicated that there was significant difference after testing by two tailed t-test at specified level 0.01 with the degree of freedom 38 which was in favor of experimental group, i.e. the null hypothesis for the post test was not accepted. So, the better performance of experimental group over control group explained the positive effect of using algebraic tiles (manipulative materials) in teaching algebra (mathematics) at primary level.

It was also noticed that the students deeply enjoyed and were found more interested in algebraic tiles to learn the algebraic concepts. The use of manipulative materials was found more flexible in presenting mathematical figures and identifying properties in comparison to the use of only board & markers.

5.2 Summary / Conclusion

The present study is concerned with the study of effectiveness of manipulative materials in teaching mathematics at primary level. This study, therefore, was intended to answer the question whether the use of Algebra tiles yields better achievement of students than without using it while teaching algebra at primary level.

A pre-test, post-test and non-equivalent group design was adopted as the design of the study and the sample students were taken from grade V students of Shree Janata Secondary School, Gaindakot-12, Nawalpur, for study. There were 20/20 students randomly selected in experimental group & control group from sample students by tossing coin. These two groups were found comparable on the basis of pre-test results and

with respect to the physical condition, academic achievement, ethnicity, mathematical condition and other educational facilities. The researcher himself taught both experimental and control groups on the same selected unit “Algebra: Algebraic Terms, Algebraic Expression, Values of Algebraic Express, Their Addition & Subtraction and Solution of Equation”. The instruction period was for 3 weeks (14 periods only, due to public holidays & Saturdays).

The data obtained from the pre-test & post-test were analyzed and interpreted statistically to find the conclusion. T-test was applied along with other statistical measures in order to compare the significant difference of the mean scores between the two groups in both tests. The statistical analysis and interpretation of the data showed that the students taught by using algebraic tiles performed better than the students taught by only traditional method. Hence it concludes that the use of manipulative materials in teaching mathematics at primary level is more effective than without using them.

5.3 Implications / Recommendations

Mathematics plays an important role for everyone’s daily life because of its needs, usefulness & significance. That’s why, mathematics is being considered as a compulsory subject through primary level to secondary level in Nepal.

On the basis of this study, the following recommendations are drawn from which Ministry of Education, the syllabus designers, textbook writers, subject experts and trainers might be benefited:

- Concrete manipulative materials such as tiles, geo-board should be used while teaching mathematics at primary level.
- Students should be encouraged to get involved in active participation in the classroom activities.

- The teacher should be encouraged to use manipulative materials in teaching mathematics.
- The teacher should be trained for, how to handle & use manipulative materials in teaching mathematics.
- Workshops, seminars and conference for the teachers should be organized to improve the teaching activities and to promote the appropriate teaching techniques with instruction materials
- Sufficient teaching materials should be available in the school.
- Education plan, syllabus and textbooks should be designed for the mathematics emphasizing to use the manipulative materials (specially at primary level).

5.4 Suggestions for Further Research

The following suggested points could be very useful if any researcher is going to study in the same kind of topics in future:

- This study was limited to a school of eastern part of Nawalpur district with the small number of sample students, but the study can be designed and carried out in large samples and various schools of different parts of Nepal in order to investigate the effectiveness of the use of manipulative materials in teaching mathematics.
- These kinds of studies should be conduct at different level and in other subjects as well.
- It would also be worthwhile to study the opinions and attitude of teachers and pupils towards manipulative materials such as tiles, geo-boards, colour chips, patterns, tan grams etc.

REFERENCES

- Baral, B.R. (2005), "*Effectiveness of Instructional Materials in Teaching Geometry at Primary Level.*" Master thesis submitted to central Department of Education, Tribhuvan University, Kathmandu.
- Canny, M.E. (1984), "*The relationship of manipulative materials to achievement in three areas of Fourth-Grade mathematics: Computation, Concept Development and Problem Solving.*"
- Ernest (1994), "*Evaluation of the effectiveness and implementation of math manipulative.*"
- Envelyn J. Sowell (1989), "*Effects os manipulative materials in mathematics instruction.*"
- Garity (1988), "*Does the use of Hands-on-learning with manipulative improve the test scores of secondary geometry students?.*"
- Hedden, J.W. (2005), "*Improving mathematics teaching by using manipulatives.*"
- Heddens, J. (1986), "*Bridging the gap between the concrete and the abstract.*"
- Howden, H. (1986), "*The role of manipulatives in learning mathematics.*"
- Lackey and Reglin (1991), "*Manipulative and Achievement of Subtraction Basic Facts for Rular Second Grade Student.*"
- MOES (Ministry of Education 2056), "*Teachers Guide of Mathematics of Grade- V.*" Curriculum Development Centre, Ministry of Education.
- National Council of Teacher of Mathematics (NCTM, 1989), "*Curriculum and Evaluation Standard for School Mathematics.*"
- Neupane (2002), "*The effectiveness of play way method in mathematics teaching at primary level.*"

- Nute (1997), *"The impact engagement activity and manipulative presentation in intermediate mathematics achievement, time-on-task, learning efficiency and attitude."*
- Pandey, H.B. (1985). *"Use of Visual Aids in Teaching Fraction: Development of Teaching Models for Teaching Fraction in Grade-VI"*. Master thesis submitted to Central Department of Education, Tribhuvan University. Kathmandu.
- Peaveler (1987), *"The mathematics program: An overview and explanation, Focus on learning problems in mathematics."*
- Pokhrel, S. (2004). *"Effectiveness of Teaching Mathematics with and without Use of Constructivism."* Unpublished master thesis submitted to Central Department of Education, Tribhuvan University.
- Sharma, S.N. (2002). *"A Study of Availability and Use of Instructional Materials in Teaching Mathematics at Primary School of Parbat District of Nepal."* Master thesis submitted to Central Department of Education, Tribhuvan University Kathmandu.
- Sharp, J.N. (1995). *"Result of Using Algebra Tiles as Meaning Representation of Algebra Concept."* America: Paper Presented at the Annual Meeting of the Mid-Western Research Association, Chicago.
- Suydam and Higgings (1976), *"The uses and effects of manipulatives on achievement."*
- Upaddhya, H.P. (2001). *"Effect of Construction of Mathematics Achievement of Grade V Students in Nepal. Doctoral Diss."* Punjab University.
- <http://mathforum.org/trscavo/geoboards/dotpaper.html>.
- <http://standards.nctm.org/document/examples/chap4/402/index.htm>
- <http://www.illuminations.nctm.org.lessonplan/3-5/paperquiltsindex>
- <http://www.pde.estate.pa.us/k12/lib/k12kMATH.pdf>

<https://www.ericdigests.org/pre-9217/math.htm>

<http://www.google.com>

<http://www.wikipedia.com>

<http://www.youtube.com>

APPENDICES

APPENDIX - A

Algebraic tiles are manipulative materials widely used in teaching algebra. Algebra tiles are geometric models that explore algebraic concepts. Algebra tiles are used to solve the problems of addition & subtraction of algebraic expressions and equation of mathematics.

Algebraic tiles have two sides; one is positive (white) side and another is negative (black) side. Algebra tiles are made of wood and other materials.

For example:



Fig. 1

Types of Tiles

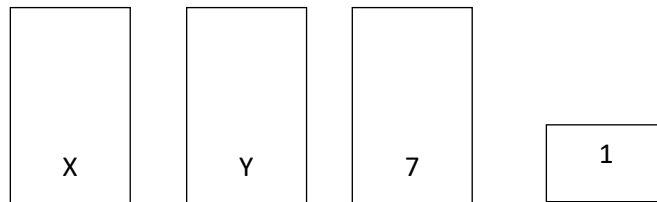


Fig. 2

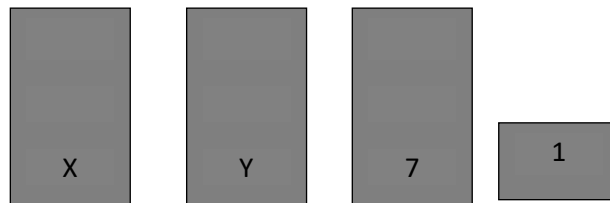


Fig. 3

APPENDIX – B

The name of the students selected for the Experimental Group and Control Group are mentioned below:

<u>Experimental Group</u>	<u>Control Group</u>
1. Bimala Sugarpak	Dibina Pulami
2. Durga Maya Pulami	Anish Pariyar
3. Richan Chhetri	Motiraj Sugarpak
4. Kabita Gautam	Sunita Saru
5. Safal Baniya	Shree Ram Thapa
6. Puja Rana	Priya Ale
7. Tesara Ale	Sambidhan Ghimire
8. Smriti Gurung	Sandhya Hamal
9. Barsha Gurung	Kismat Regmi
10. Teksan Ale	Sanij Mahato
11. Sabina Thapa	Melina Harmel
12. Gita Poudel	Suraj Baruwal
13. Aarati Bhusal	Deep Shahi
14. Susan Gautam	Kushal Sadashankar
15. Punam Mahato	Khagendra Sunari
16. Kritika Thanet	Pujan Sugarpak
17. Samar Pandey	Prashant Mahato
18. Sargam Kafle	Rakshya Parajuli
19. Kiran Rasaili	Deepak Bhatta
20. Praju Bhusal	Suraj Thakuri

And names of the irregular students are: Yojit Paudel, Krish Mahato, Harish Chapagain, Nabin B. K. and Bishal Lamichhane.

APPENDIX - C

Teaching Episodes in Teaching Algebra by Using Tiles

Teaching Episodes 1

Unit: Algebra

Class: V

Lesson: Algebraic expressions and their values

Time: 45 min.

Name of School:

Date:

1. Specific Objectives:

At the end of lesson students will be able to define algebraic terms and expressions.

2. Teaching Materials: Different types of tiles

3. Teaching Procedure and Activities:

The teacher writes different types of algebraic terms on the blackboard and let the students to discuss on it.

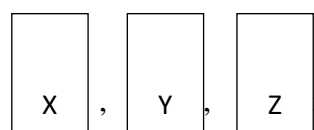
For example, $5a$, $2b$, $4x$, $3ab$, $3y$, $6xy$.

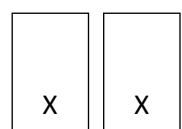
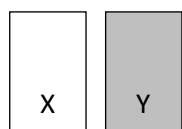
After discussion, they comprehend the following:

(a) $5a$, $2b$, $4x$ etc. are called algebraic terms in algebra.

(b) The letters which are used in algebra are called variables.

For example:

 are tiles.

 = $X+X = 2X$  = $X-Y$

(c) The number which comes before variable is called coefficient.

E.g. $5X$, $2Y$, $4Z$ etc.

(d) The value of algebraic terms depends upon the value of variables.

(e) A collection of letters or numbers and letters connected by the signs +, - , ÷, x is called algebraic expressions. E.g. $2X + 4$, $10Y - 5$, $3X - 5$.

4. Evaluation: Find the variables and coefficients of the following terms:

$9XY$, $5X$, $12Y$, AX

5. Homework: Solve questions 1, 2 and 3 of Exercise 16.1 of Mero Ganit.

Teaching Episodes 2

Unit: Algebra

Class: V

Lesson: Algebraic expressions and their values

Time: 45 min.

Name of School:

Date:

1. Specific Objectives:

At the end of lesson students will be able:

- a. To express the statement in algebraic terms.
- b. To express the algebraic expressions in statement.

2. Teaching Materials: Different types of tiles.

3. Teaching Procedure and Activities:

After the general review of previous lesson, the following expressions and statements are discussed among the students and make them to express.

E.g., To express in algebraic expression,

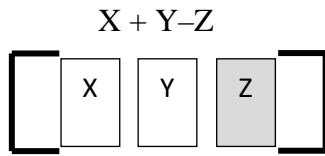
- a) Multiply by 3 the subtraction of X and 3.

$$= 3(X - 3)$$

$$= \begin{array}{c} \boxed{1} \quad \boxed{1} \quad \boxed{1} \quad \boxed{X} \quad \boxed{1} \quad \boxed{1} \quad \boxed{1} \end{array}$$

The difference of three black 1 x 1 tiles from one white X tile is to be multiplied by three white 1 x 1 tiles.

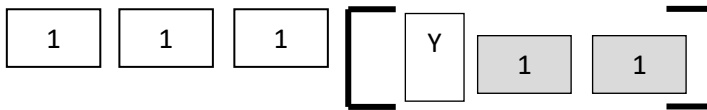
c) Difference of Z in addition of X and Y.



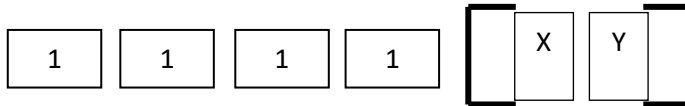
To express in statement.

1) $3(Y-2)$

Statement = multiply by 3 to the difference of Y and 2.



b) $4(X + Y)$



Statement = the sum of X and Y is multiplied by 4.

4. Evaluation: Write down the statement in algebraic expression and algebraic expression in statement.

- a) The addition of X and triple of Y. b) $8X - 5Y$

5. Homework: Solve questions 4 and 5 of Exercise 16.1 of Mero Ganit.

Teaching Episodes 3

Unit: Algebra

Class: V

Lesson: Algebraic expressions and their values

Time: 45 min.

Name of School:

Date:

1. Specific Objectives:

At the end of lesson students will be able:

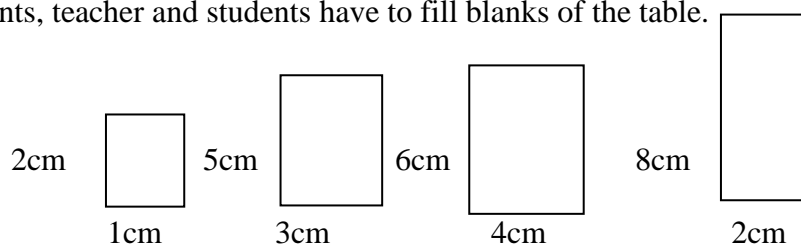
- a. To find the area of rectangle.
- b. To find the perimeter of rectangle.

2. Teaching Materials: Different types of tiles.

3. Teaching Procedure and Activities:

First of all, review the last class & start to recall the students about the formulae of the area and perimeter of rectangle.

Following table is written in the blackboard by showing the tiles and discussing with the students, teacher and students have to fill blanks of the table.



Length (l)	2cm	5cm	6cm	8cm
Breadth (b)	1cm	3cm	4cm	2cm
Area (A) = l x b				
Perimeter (P) = 2(l+b)				

4. Evaluation: Find the area and perimeter of the rectangle whose length is 7cm and breadth is 2cm.

5. Homework: Solve the questions 6, 7 & 8 of Exercise 16.1 of Mero Ganit.

Teaching Episodes 4

Unit: Algebra

Class: V

Date:

Lesson: Addition & subtraction of Algebraic expressions & their values.

Name of School:

Time: 45 min.

1. Specific Objectives: At the end of lesson students will be able to add or subtract terms; only the coefficients are added or subtracted.

2. Teaching Materials: Different types of tiles

3. Teaching Procedure and Activities:

First of all by giving examples of like and unlike terms to the students, discuss about them.

E.g. a) $3X$ and $7X$ contain like/same variable X . So, they are like terms.

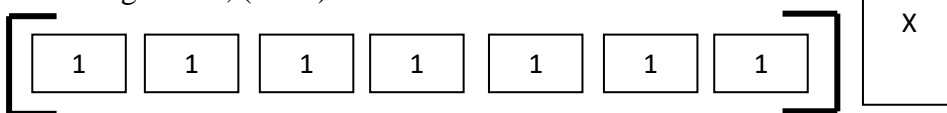
b) $5a$ and $7b$ contain different variables. So, they are unlike terms.

After the discussion, start to add or subtract like terms only adding or subtracting their coefficients.

E.g. i) Add: $2X + 5X$

First method: $2X + 5X = (2 + 5) X = 7X$.

Through Tiles, $(2 + 5) X$

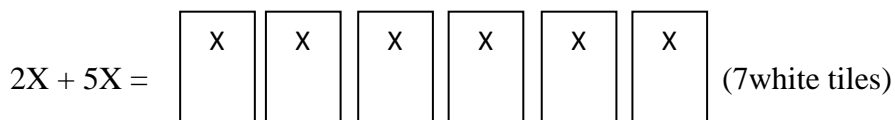
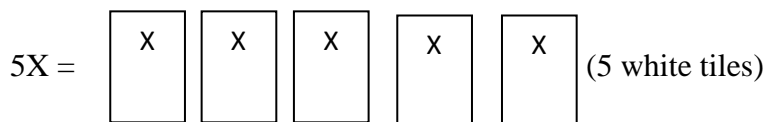
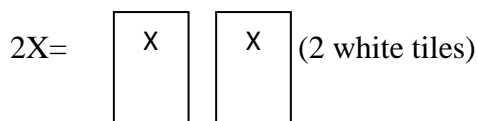


Second Method:

$2X$ means that $X + X$ and $5X$ means that $X + X + X + X + X$

$\Rightarrow 2X + 5X = X + X + X + X + X + X + X = 7X$

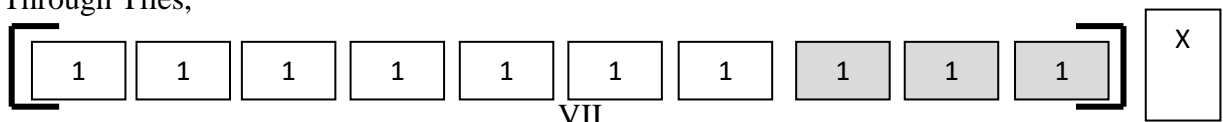
Through Tiles,



ii) Subtract:

$7X - 4X = (7 - 4) X = 3X$

Through Tiles,



4. Evaluation:

a) Add: $7X + 8X$

b) Subtract: $9Y - 5Y$

5. Homework:

Solve the questions 1, 2 and 3 of Exercise 16.2 of Mero Ganit.

Teaching Episodes 5

Unit: Algebra

Class: V

Date:

Lesson: Addition & subtraction of Algebraic expression & their values.

Name of School:

Time: 45min

1. Specific Objectives:

At the end of lesson students will be able to get the value of expression if the variable is given in expression.

2. Teaching Materials: Different types of tiles

3. Teaching Procedure and Activities:

First of all, questions are given to the students and given them to solve the problem by using tiles.

E.g.

a) If $X = 2$ then find the value of the expression $X + 8$

Solⁿ: $X + 8 =$

1	1
1	1

1	1	1	1	1	1
---	---	---	---	---	---

$= 10$

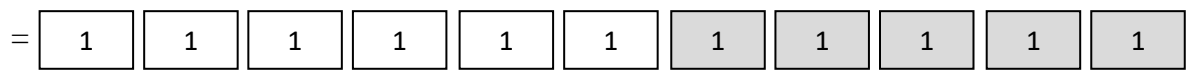
[$X = 2$, so we take two white tiles 1×1 tiles then altogether there are ten white 1×1 tiles]

Therefore, the value of $X + 8 = 10$

b) If $a = 1$, $b = 3$ and $c = 5$, find the value of $3a + b - c$.

Solⁿ: $3a + b - c$

$$= 3 + 3 - 5$$



$= \boxed{1}$ [There are six 1 x 1 white tiles and five 1 x 1 black tiles. Five 1 x 1 white tiles and five 1 x 1 black tiles are cancelled with each other, then there is remaining 1 white 1 x 1 tiles.]

4. Evaluation: If $X = 4$, find the value of $7X - 8$.

5. Homework: Solve question number 7 of Exercise 16.2 of Mero Ganit.

Teaching Episodes 6

Unit: Algebra

Class: V

Date:

Lesson: Addition & subtraction of Algebraic expressions & their values.

Name of School:

Time: 45 min.

1. Specific Objectives: At the end of lesson students will be able:

- a) To distinguish like and unlike terms.
- b) To solve the addition and subtraction of like and unlike terms.

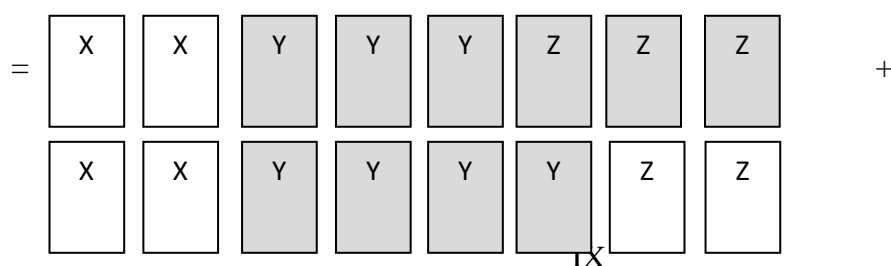
2. Teaching Materials: Different types of tiles

3. Teaching Procedure and Activities:

First of all, review the last lesson and make the students to discuss on the like and unlike terms giving the examples as: $8a$, $6ab$, $5X$, $4ab$, $2a$, $8aX$.

By giving the problem of like and unlike terms, start to solve the problem using tiles through discussion.

E. g. $(2X - 3Y - 3Z) + (2X - 4Y + 2z)$



$$= \begin{array}{ccccccccc} \boxed{X} & \boxed{X} & \boxed{X} & \boxed{X} & \boxed{Y} & \boxed{Y} & \boxed{Y} & \boxed{Y} & \boxed{Y} \\ \boxed{Y} & \boxed{Y} & \boxed{Z} & & & & & & \end{array}$$

$$= 4X - 7Y - Z$$

[Here two white X tiles and two white X tiles are added. Three black Y tiles and four black Y tiles are also added. Three black Z tiles and two white Z tiles are subtracted, then there remains one black Z tile.]

4. Evaluation:

- a) Add: $5X + 7Y - 6Z$ and $8X - 9Y + 2Z$.
- b) Subtract: $9Y - 5Y$

5. Homework: Solve the question number 8 of Exercise 16.2 of Mero Ganit.

Teaching Episodes 7

Unit: Algebra Class: V Date:

Lesson: Addition & subtraction of Algebraic expressions & their values.

Name of School: Time: 45 min.

1. Specific Objectives:

At the end of lesson students will be able to change the sign of all the terms in expression which is to be subtracted and then processed as in addition.

2. Teaching Materials: Different types of tiles.

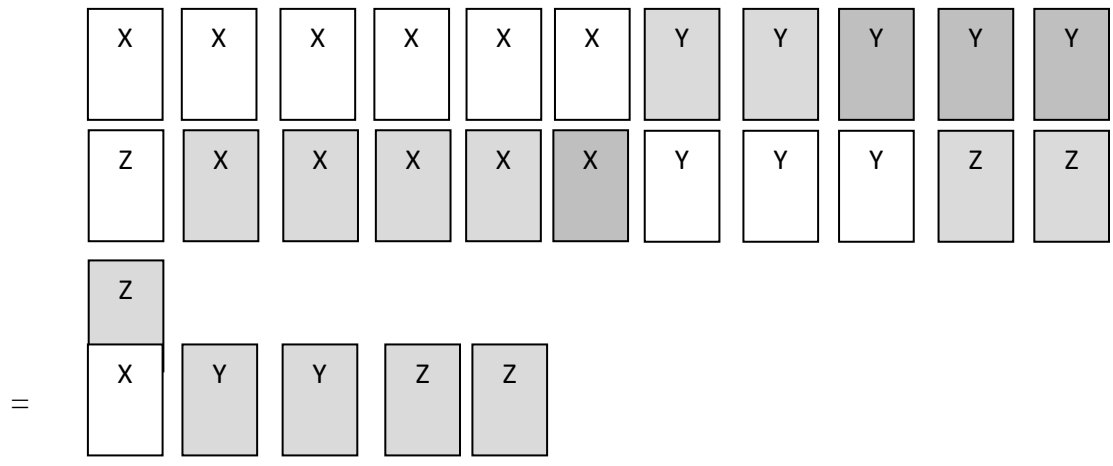
3. Teaching Procedure and Activities:

Firstly, review the last lesson and write problem of subtraction and then solve the problem by using tiles along with discussion.

E. g. i. Subtract $5X - 3Y + 3Z$ from $6X - 5Y + Z$

Solution: $6X - 5Y + Z - 5X + 3Y - 3Z = X - 2Y - 2Z$

Through tiles,



$= X - 2Y - 2Z$.

4. Evaluation: Subtract: $6a - 5b - 8c$ from $a - 2b + 4c$.

5. Homework: Solve the rest of the problems of Exercise 16.2 of Mero Ganit.

Teaching Episodes 8

Unit: Algebra

Class: V

Lesson: Solution of Equation

Time: 45 min. Name of

School:

Date:

1. Specific Objectives:

By understanding the concept of axioms of equality, they are able to solve the given equation.

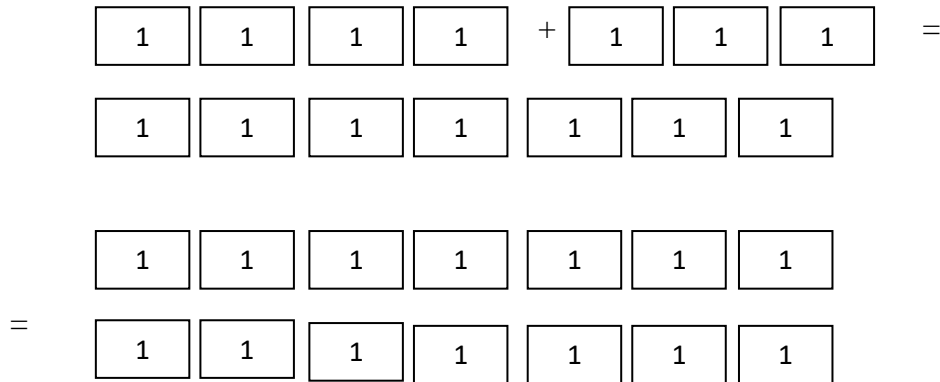
2. Teaching Materials: Different types of tiles.

3. Teaching Procedure and Activities:

First of all, make students understand about axioms of equality by giving arithmetic examples/problems and discuss with question/answer with students as well as tiles.

E.g. $4 + 3 = 7$

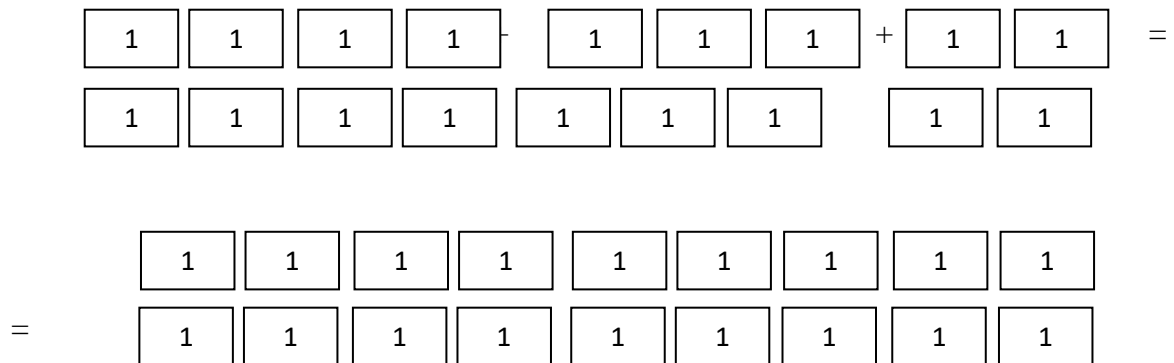
Through tiles,



$\Rightarrow 7 = 7$

What will be the result when 2 is added to both sides?

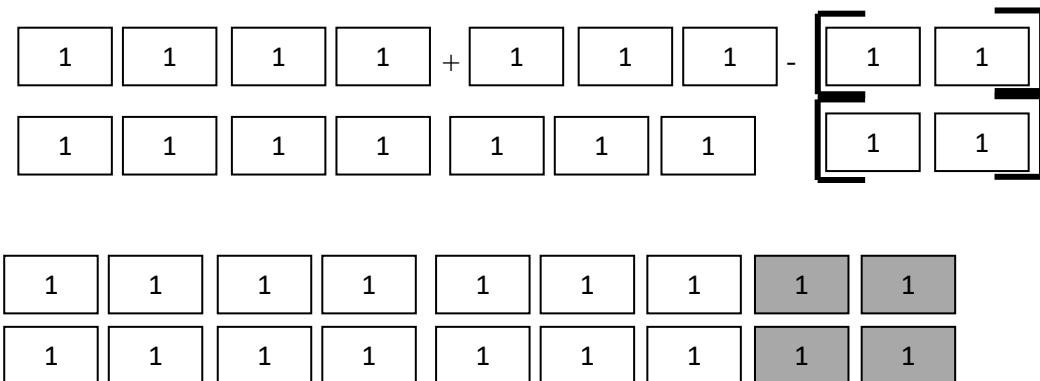
$$(4 + 3 + 2) = 7 + 2$$



$\Rightarrow 9 = 9$

If the same value is added to both sides, then result also is equal.

What will be the result when 2 is subtracted in both sides?



=

⇒

1	1	1	1	1
---	---	---	---	---

 =

1	1	1	1	1
---	---	---	---	---

⇒ $5 = 5$

If the same value is subtracted from both sides, then result also is equal.

Similarly, if both sides are multiplied or divided by the same value, the both sides are also equal.

4. Evaluation: Check the equation $7 + 9 = 16$ adding, subtracting, multiplying or dividing the same number 8 in both sides.

5. Homework: Solve the questions 1 & 2 of Exercise 16.4 of Mero Ganit.

Teaching Episodes 9

Unit: Algebra

Class: V

Lesson: Solution of Equation

Time: 45 min.

Name of School:

Date:

1. Specific Objectives

At the end of this lesson, the students will be able to solve the problems of equation on the basis of axioms of equality.

2. Teaching Materials: Different types of tiles

3. Teaching Procedure and Activities:

Firstly, recall the axioms of equality to the students and above solve the equation by using tiles. E.g. $X - 5 = 3$

Through tiles,

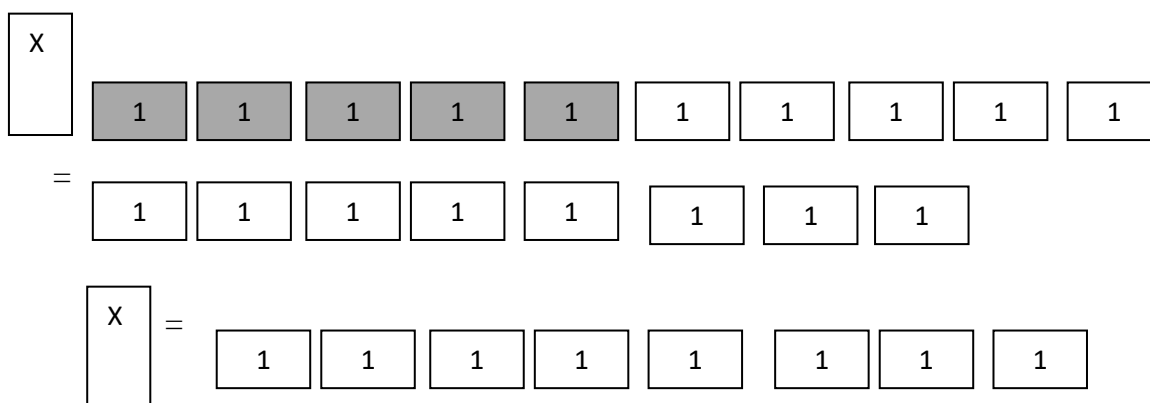
X

1	1	1	1	1
---	---	---	---	---

 =

1	1	1
---	---	---

$$X - 5 + 5 = 3 + 5 \text{ (adding 5 on both sides)}$$



$$\Rightarrow X = 8$$

4. Evaluation: Solve $3X - 5 = 10$.

5. Homework: Solve the questions 3, 4 & 5 of Ex-16.2 of Mero Ganit.

Teaching Episodes 10

Unit: Algebra

Class: V

Lesson: Solution of Equation

Time: 45 min.

Name of School:

Date:

1. Specific Objectives:

At the end of this lesson students will be able:

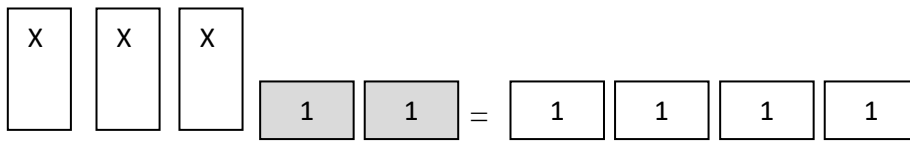
- To solve the problems of equation.
- To check whether the solution is right or not.
- To check whether the solution in right or not.

2. Teaching Materials: Different types of tiles.

3. Teaching Procedure and Activities:

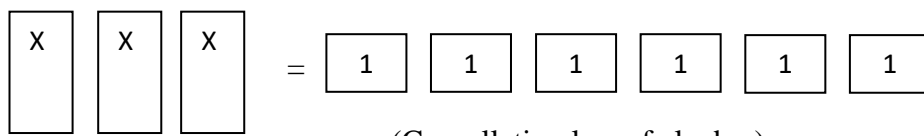
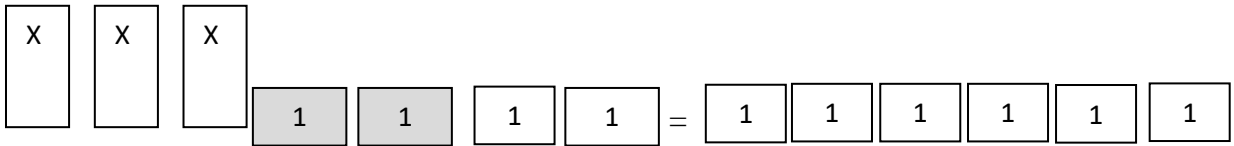
Firstly, write an equation on the board, solve and check the equation whether right or not, by using tiles.

E.g. Solve: $3X - 2 = 4$.



(In left side three white X tiles, two black 1 x 1 tiles and in right side 4 white 1 x1 tiles).

Or, $3X - 2 + 2 = 4 + 2$



(Cancellation law of algebra)



(law of distribution)

$\Rightarrow X = 2$

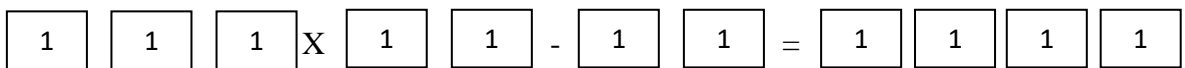
Check, $2X - 2 = 4$

Or, $2 \times 2 - 2 = 4$

Or, $4 - 2 = 4$

Or, $4 = 4$

Through tiles



4. Evaluation: Solve and check whether right or not, $5X + 3 = 18$

5. Homework: Solve the question 6 of Exercise 16.4 of Mero Ganit.

Teaching Episodes 11

Unit: Algebra

Class: V

Lesson: Application of Equation

Time: 45 min.

Name of School:

Date:

1. Specific Objectives

At the end of this lesson, the students will be able to write word problems into equation.

2. Teaching Materials: Different types of tiles

3. Teaching Procedure and Activities:

By asking oral questions and making discussion with students and let them answer orally.

- a) Hari is 25 years old. How old he will be after 5 years?
- b) If 28 students are present out of 40, then how many students are absent on that day?
- c) If the perimeter of the square is 24 cm, then find out the length of side.

In above problem, let unknown number be X , then write the equation on the board term by term.

E.g.

- i. $X = 25 + 5$ or, $X - 5 = 25$.
- ii. $X = 40 - 28$ or, $X + 28 = 40$ or, $40 - X = 28$.
- iii. $X = 24 / 4$ or, $4X = 24$.

4. Evaluation: Write word problem into equation: If Ram bought ink in 15 rupees, then he got return 5 rupees. Which note did he give to shopkeeper?

5. Homework: Write word problem into equation of Exercise 16.5 of Mero Ganit.

Teaching Episodes 12

Unit: Algebra

Class: V

Lesson: Application of Equation

Time: 45 min.

Name of School:

Date:

1. Specific Objectives:

At the end of this lesson, the students will be able to write word problems into equation and check whether they are right or not.

2. Teaching Materials: Different types of tiles.

3. Teaching Procedure and Activities:

Firstly, review the last lesson and write a word problem. Discuss and convert it into equation and show by checking whether it is right or wrong.

For example, if 4 is added to a number sum is 9. Find the number.

Solution: Let the required number be X.

Now 4 is added to X, written as X+4, and the sum is 9.

Therefore, $X+4=9$

Through tiles,

$$\boxed{X} + \boxed{1} \boxed{1} \boxed{1} \boxed{1} = \boxed{1} \boxed{1} \boxed{1} \boxed{1} \boxed{1} \boxed{1} \boxed{1} \boxed{1} \boxed{1}$$

[In left side, one white X tile with four white 1 x 1 tiles and in right side, 9 white 1 x1 tiles are placed.]

Or, $X + 4 - 4 = 9 - 4$

Or, $\boxed{X} = \begin{array}{cccc|cccc} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{array} =$

$\begin{array}{cccccccc|cccc} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{array}$

(By cancelling 4 white 1 x 1 tiles in left side, 4 black 1 x 1 tiles are also cancelled in the right side.)

$\Rightarrow X = 5$

Check, $\boxed{X} = \begin{array}{ccccc} 1 & 1 & 1 & 1 & 1 \end{array}$
 $X + 4 = 9$

Or, $5 + 4 = 9$

Or, $9 = 9$

Through tiles,

$\boxed{X} = \begin{array}{cccc|cccc} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{array} = \begin{array}{cccc|cccc} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{array} =$

$\begin{array}{cccc|cccc} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{array} =$

$\begin{array}{cccc|cccc} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{array}$

4. Evaluation: If a number is multiplied by 8 and 5 is added to it, then the result is 21.

Find the number.

5. Homework: Solve the questions of Exercise 16.5 of Mero Ganit.

Teaching Episodes 13

Unit: Algebra

Class: V

Lesson: Application of Equation

Time: 45 min.

Name of School:

Date:

1. Specific Objectives:

At the end of this lesson, the students will be able to write word problems into equation and check whether they are right or not.

2. Teaching Materials: Different types of tiles.

3. Teaching Procedure and Activities:

First of all, discuss about the exercise problem and solve the problem if it is difficult.
E.g. If the sides of the rectangle are $(X - 3)$ cm & $(X + 3)$ cm and its perimeter is 20cm, find the length and breadth of sides.

Solution: By using the tiles, solve the problem

Here, length $(l) = (X+3)$ cm

Breadth $(b) = (X-3)$ cm

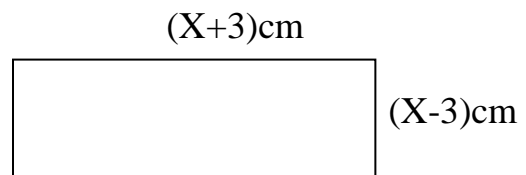
Perimeter of the rectangle $(P) = 2(l+b)$

Or, $20 = 2(X + 3 + X - 3)$

Or, $20 = 4X$

Or, $X = 20/4$

Or, $X = 5$



Thus, Length $(l) = (X+3)$ cm = 8cm,

Breadth $(b) = (X-3)$ cm = 2cm

4. Evaluation: If the length of the rectangle is triple of the breadth and the perimeter is 32cm, find the length and breadth.

5. Homework: Solve the remaining questions of Exercise 16.5 of Mero Ganit.

Teaching Episodes 14

Unit: Algebra

Class: V

Lesson: Base, Exponent and Coefficient

Time: 45 min.

Name of School:

Date:

1. Specific Objectives:

At the end of this lesson, the students will be able to define base and exponent.

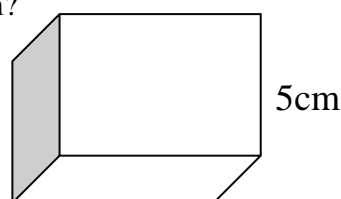
2. Teaching Materials: Different types of tiles.

3. Teaching Procedure and Activities:

Sometimes while multiplying same number by same number we have to multiply once and many times.

E.g., What is the volume of cube whose length is 5cm?

Here, volume of cube (V) = $1 \times 1 \times 1 = 5 \times 5 \times 5$
 $= 125\text{cm}^3$



In above example 5 is multiplied three times because $125 = 5 \times 5 \times 5$. Here to mention 5 is multiplied three times, we can write $5 \times 5 \times 5 = 5^3$ and while reading, power of 5 is 3 as 5 cubed.

In arithmetic, we can write $5 \times 5 = 5^2$, $5 \times 5 \times 5 = 5^3$, $5 \times 5 \times 5 \times 5 = 5^4$

Similarly, in algebra, we can write $a \times a = a^2$ and read as 'a square'.

$a \times a \times a = a^3$ and read as a cube.

Similarly, $a \times a \times a \times a = a^4$ and read as a raised to fourth power or a to the power four and so on.

In a^2 , a^3 & a^4 , the number 2, 3 and 4 are called the indices or exponent of a & a is called the base.

4. Evaluation: Write down the exponent and base of the following: X^4 , a^4 , Z^7 , Y^3

5. Homework: Solve questions 1, 2 & 3 of Exercise 16.3 of Mero Ganit.

APPENDIX-D

Pilot Test Paper

नाम:

कक्षा: ५

रोल नः

विषय: गणित

समय: १ घण्टा ३० मिनेट

समुह (क) बस्तुगत प्रश्नहरु

तल दिइएका ४ उत्तर मध्ये सहि उत्तर छानेर चिन्ह $\sqrt{\quad}$ लगाऊ ।

1) $12 X^2$ मा 12 लाई के भनिन्छ ।

क) घात ख) घाताङ्क ग) आधार घ) गुणाङ्क

2) यदि $X = 1$ र $Y = 2$ भए $4XY$ को मान कति होला?

क) 0 ख) 2 ग) -1 घ) 8

3) यदि $a = 5$ भए, $5a^2$ को मान कति होला?

क) 110 ख) 125 ग) 155 घ) 120

4) विजातीय पद भनेको के हो ?

क) आधार एउटै भएको ख) गुणाङ्क एउटै भएको
ग) घाताङ्क एउटै भएको घ) फरक आधार र घाताङ्क भएको

5) $2(X - Y)$ जनाउने भनाई लेख ।

क) X र Y को फरकको दुई गुणा ख) X र Y को फरक
ग) X र Y को दुई गुणा घ) X र Y को योगफलको दुई गुणाँ

6) $6X$ मा X को घाताङ्क कति छ ?

क) 0 ख) 2 ग) 1 घ) 6

7) लम्बाई a cm र चौडाई b cm भएको आयातको परिमिति कति हुन्छ ?

क) $(a+b)$ cm ख) $2ab$ cm ग) $2(a+b)$ cm घ) ab cm²

8) $(X^2 - Y^2) + (Y^2 + X^2)$ बराबर कति हुन्छ ?

क) X^2 ख) X^4 ग) X^2Y^2 घ) $2Y^2$

9) $X^2 \times X^3$ बराबर कति हुन्छ ?

क) X^6 ख) X^3 ग) X^5 घ) X^2

10) $(b + b + b + 2b)$ को योगफल कति हुन्छ ?

क) $4b$ ख) $5b^4$ ग) b^4 घ) $5b$

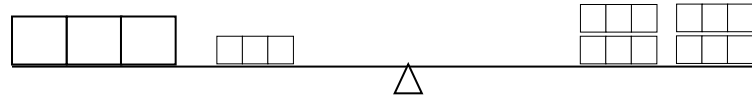
11) राजुसंग 8 वटा सुन्तला थियो उसले भाईलाई X वटा सुन्तला दियो अब राजुसंग कतिवटा सुन्तला बाकी छन् ? यस भनाइलाई जनाउने विजिय अभिव्यञ्जक लेख ।

क) $8X$ ख) $8 - X$ ग) $8 + X$ घ) $8/X$

12) रु. 10 खर्च गरीसकेपछि रामसँग रु. 10 बाँकि रहन्छ भने, पहिले उ सँग कति रुपियाँ थियो होला ? यसको समिकरण लेख ।

क) $X-10=10$ ख) $X+10=10$ ग) $10X=10$ घ) $X/10=10$

13) तलका मध्ये कुन चाहि वाक्यले चित्रमा दिइएको सन्तलित नमूना जानउछ ?

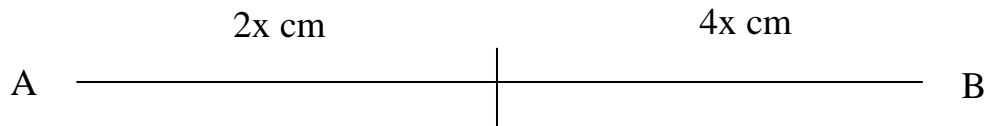


क) $X + 5 + 9 = 0$ ख) $2X + 3 - 6 = 0$ ग) $3X = 12$ घ) $3X + 3 = 12$

14) $X + Y$ को तिन गुँणा र Z को फरक कति हुन्छ ?

क) $3X+Y-Z$ ख) $3(X+Y)-Z$ ग) $3(X+Y)+Z$ घ) $X+Y-3Z$

15) चित्रमा दिइएको रेखाखण्डको वास्तविक लम्बाई कति हुन्छ ?



क) $X + 2 \text{ cm}$ ख) $2X - 3 \text{ cm}$ ग) $6X \text{ cm}$ घ) $2 + 3X \text{ cm}$

16) तलका दिइएका मध्ये $X + 10$ को अर्थ कुन हो ?

क) X र 10 को जोड ख) X र 10 को फरक
ग) X र 10 को गुणन घ) X र 10 को भाग

समुख (ख) विषयगत प्रश्नहरू

17) यदि $a = 1, b = 0, c = -2$ र $d = 1$ भए, $4a^2 - cd + 5a^2 c - abc$ को मान कति होला ?

18) i) $a - 5b$ लाई $a+5b$ ले गुणन गर ।

ii) $a + b$ लाई $a^2 - b^2$ ले गुणन गर ।

19) i) $5a - 2a + 3b - b$ लाई सरल गर ।

ii) $3a + 6b$ र $4a - 7b$ को योगफल कति हुन्छ ?

20) $a - 4b + 3c$ बाट $3a - 6b + c$ घटाउ ।

21) सजातिय पदहरूको सरल गर :

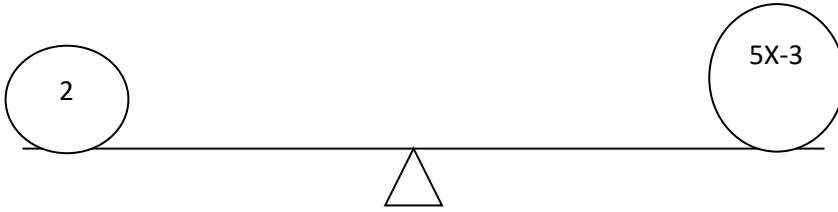
$$8a + 5b - 3c + 4 - (a + 4b - 6c + 1)$$

22) बराबरी तथ्यको प्रयोग गरी हल गर :

i. $a - 8 = 12$

ii. $3X = 9$

23) तल चित्रमा दिएको सन्तुलनलाई: i. समीकरणमा व्यक्त गर र ii. X को मान निकाला



24) एउटा संख्या र त्यसको दुई गुणाँ मिलाएर जम्मा 30 हुन्छ भने,

i) यसको समीकरण लेख ।

ii) त्यो संख्या कति रहेछ पत्ता लगाऊ ।

APPENDIX-E

Item Analysis for Validity of Test Paper

Upper 27% students giving correct responses (R_u) (top 6 out of 22 students)								Lower 27% students giving correct responses (R_l) (lower 6 out of 22 students)								P- Level	D- Score	Remarks
Student	1	2	3	4	5	6	Total	1	2	3	4	5	6	Total	$\frac{R_u + R_l}{N} \times 100\%$	$\frac{R_u - R_l}{N/2}$		
Question																		
1	1	1	1	1	1	0	5	1	0	0	1	1	0	3	67	0.33		
2	1	1	1	1	0	1	5	1	0	0	0	0	1	2	58	0.50		
3	1	1	1	1	1	1	6	1	1	1	0	1	1	5	92	0.17	Cancelled	
4	1	0	0	1	0	1	4	0	0	0	1	0	0	2	50	0.33		
5	1	1	0	0	0	0	2	1	1	0	0	0	0	2	33	0.00	Cancelled	
6	1	0	1	1	1	1	5	1	0	0	0	0	1	2	58	0.50		
7	0	1	1	1	1	0	4	0	0	1	0	0	0	0	33	0.67		
8	1	1	1	1	1	1	6	0	1	0	1	0	0	3	75	0.50		
9	1	0	1	1	1	1	4	1	0	0	0	0	0	1	42	0.50		
10	1	1	1	1	1	1	6	1	0	0	1	1	1	4	83	0.33		
11	1	1	1	1	0	0	4	0	0	1	0	0	0	0	33	0.67		
12	0	0	1	1	0	0	2	0	0	1	0	0	0	1	25	0.17	Cancelled	
13	0	1	1	1	0	0	3	0	0	1	0	0	0	1	33	0.33		
14	1	0	1	1	1	1	5	1	0	0	1	1	0	4	75	0.17	Cancelled	

15	1	1	1	1	1	1	6	1	1	0	0	0	0	2	67	0.67	
16	1	1	0	0	1	1	4	0	1	1	0	0	0	1	42	0.50	
17	1	0	1	1	1	1	5	0	0	0	1	1	0	3	67	0.33	
18	1	1	0	0	1	1	5	1	1	0	0	1	1	4	75	0.17	Cancelled
	1	0	0	0	1	0	2	1	0	1	0	0	0	1	25	0.17	Cancelled
19	1	0	1	1	0	1	5	0	0	0	0	0	0	1	50	0.67	
	1	1	0	0	1	1	4	0	0	0	0	0	0	0	33	0.67	
20	1	1	0	0	1	1	5	0	1	0	0	0	1	2	58	0.50	
21	0	1	0	0	1	1	3	0	0	0	0	0	1	1	33	0.33	
22	1	0	1	1	1	1	4	0	0	0	0	0	0	0	33	0.67	
	1	1	0	0	1	1	5	1	0	0	0	1	0	2	67	0.50	
23	0	1	1	1	1	1	5	0	1	0	0	0	0	1	50	0.67	
	1	0	1	1	0	1	3	0	0	0	0	0	0	0	33	0.67	
24	1	1	1	1	1	1	6	1	1	1	1	1	0	5	92	0.17	Cancelled
	1	0	0	0	0	0	2	0	0	1	0	0	0	1	25	0.17	Cancelled

APPENDIX-F

Item Analysis for Reliability of Test Paper

S.N.	Even (X)	Odd (Y)	XY	X ²	Y ²
1	21	18	378	441	324
2	19	15	285	361	225
3	15	17	255	225	289
4	14	10	140	196	100
5	12	12	144	144	144
6	13	12	156	169	144
7	11	10	110	121	100
8	10	9	90	100	81
9	8	7	56	64	49
10	6	4	24	36	16
11	6	3	18	36	9
12	5	4	20	25	16
N = 12	∑X = 140	∑Y = 121	∑XY = 1676	∑X ² = 1918	∑Y ² = 1497

Here, By Spearman-Brown Formula,

$$r_{xy} = \frac{N \sum XY - \sum X \sum Y}{\sqrt{N \sum X^2 - (\sum X)^2} \sqrt{N \sum Y^2 - (\sum Y)^2}}$$

$$= \frac{12 \times 1676 - 140 \times 121}{\sqrt{12 \times 1918 - (140)^2} \sqrt{12 \times 1497 - (121)^2}} = \frac{3172}{58.45 \times 57.65}$$

$$= 0.94$$

So,

$$r_{tt} = \frac{2r_{xy}}{1+r_{xy}} = \frac{2 \times 0.94}{1+0.94} = 0.96$$

Therefore, the value for the reliability of the test paper = 0.96

APPENDIX-G

Achievement Test Paper (Pre-test and Post-test)

नाम:

कक्षा: ५

रोल नः

विषय: गणित

समय: १ घण्टा ३० मिनेट

समुह (क) बस्तुगत प्रश्नहरु

तल दिइएका ४ उत्तर मध्ये सहि उत्तर छानेर चिन्ह लगाऊ ।



1) $12 X^2$ मा 12 लाई के भनिन्छ ।

क) घात ख) घाताङ्क ग) आधार घ) गुणाङ्क

2) यदि $X = 1$ र $Y = 2$ भए $4XY$ को मान कति होला?

क) 0 ख) 2 ग) -1 घ) 8

3) विजातिय पद भनेको के हो ?

क) आधार एउटै भएको ख) गुणाङ्क एउटै भएको
ग) घाताङ्क एउटै भएको घ) फरक आधार र घाताङ्क भएको

4) $6X$ मा X को घाताङ्क कति छ ?

क) 0 ख) 2 ग) 1 घ) 6

5) लम्बाई a cm र चौडाई b cm भएको आयातको परिमिति कति हुन्छ ?

क) $(a+b)$ cm ख) $2ab$ cm ग) $2(a+b)$ cm घ) ab cm²

6) $(X^2 - Y^2) + (Y^2 + X^2)$ बराबर कति हुन्छ ?

क) X^2 ख) X^4 ग) X^2Y^2 घ) $2Y^2$

7) $X^2 \times X^3$ बराबर कति हुन्छ ?

क) X^6 ख) X^3 ग) b^4 घ) X^2

8) $(b + b + b + 2b)$ को योगफल कति हुन्छ ?

क) $4b$ ख) $5b^4$ ग) b^4 घ) $5b$

- 9) राजुसंग 8 वटा सुन्तला थियो उसले भाईलाई X वटा सुन्तला दियो अब राजुसंग कतिवटा सुन्तला बाकी छन् ? यस भनाइलाई जनाउने विजय अभिव्यञ्जक लेख ।

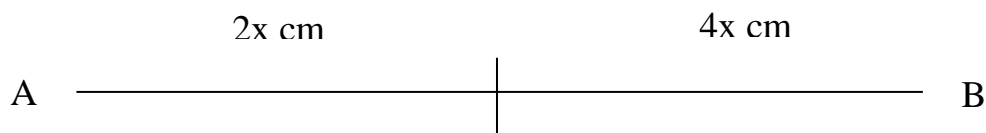
क) $8X$ ख) $8 - X$ ग) $8 + X$ घ) $8/X$

- 10) तलका मध्ये कुन चाहि वाक्यले चित्रमा दिइएको सुन्तलित नमूना जानुछ ?



क) $X + 5 + 9 = 0$ ख) $2X + 3 - 6 = 0$
 ग) $3X = 12$ घ) $3X + 3 = 12$

- 11) चित्रमा दिइएको रेखाखण्डको वास्तविक लम्बाई कति हुन्छ ?



क) $X + 2 \text{ cm}$ ख) $2X - 3 \text{ cm}$
 ग) $6X \text{ cm}$ घ) $2 + 3X \text{ cm}$

- 12) तलका दिइएका मध्ये $X + 10$ को अर्थ कुन हो ?

क) X र 10 को जोड ख) X र 10 को फरक
 ग) X र 10 को गुणन घ) X र 10 को भाग

समुख (ख) विषयगत प्रश्नहरू

- 13) यदि $a = 1$, $b = 0$, $c = -2$ र $d = 1$ भए, $4a^2 - cd + 5a^2c - abc$ को मान कति होला ?

- 14) i) $5a + 2b + 3b - b$ लाई सरल गर ।

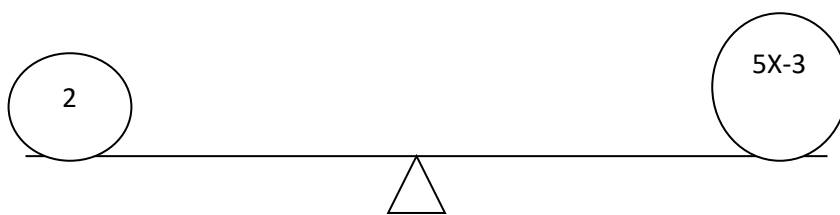
ii) $3a + 6b$ र $4a - 7b$ को योगफल कति हुन्छ ?

- 15) $a - 4b + 3c$ बाट $3a - 6b + c$ घटाउ ।

- 16) सजातिय पदहरूको सरल गर : $8a + 5b - 3c + 4 - (a + 4b - 6c + 1)$

- 17) बराबरी तथ्यको प्रयोग गरी हल गर : i. $a - 8 = 12$ ii. $3X = 9$

18) तल चित्रमा दिएको सन्तुलनलाई : i. समीकरणमा व्यक्त गर र ii. X को मान निकाल।



APPENDIX - H

Pre-test result of the students of Experimental and Control Group

(Obtained Scores arranged in Descending Order)

S. N.	Experimental			Control		
	X	$X - \bar{X}$	$(X - \bar{X})^2$	X	$X - \bar{X}$	$(X - \bar{X})^2$
1	21	12.35	152.52	19	11.3	127.69
2	18	9.35	87.42	14	6.3	39.69
3	17	8.35	69.72	13	5.3	28.09
4	14	5.35	28.62	11	3.3	10.89
5	11	2.35	5.52	10	2.3	5.29
6	10	1.35	1.82	9	1.3	1.69
7	9	0.35	0.12	8	0.3	0.09
8	8	-0.65	0.42	8	0.3	0.09
9	7	-1.65	2.72	7	-0.7	0.49
10	7	-1.65	2.72	7	-0.7	0.49
11	7	-1.65	2.72	6	-1.7	2.89
12	7	-1.65	2.72	6	-1.7	2.89
13	6	-2.65	7.02	6	-1.7	2.89
14	5	-3.65	13.32	6	-1.7	2.89
15	5	-3.65	13.32	6	-1.7	2.89
16	5	-3.65	13.32	5	-2.7	7.29
17	5	-3.65	13.32	4	-3.7	13.69
18	4	-4.65	21.62	3	-4.7	22.09

19	4	-4.65	21.62	3	-4.7	22.09
20	3	-5.65	31.92	3	-4.7	22.09
N = 20	173		492.50	154		22.09

For Experimental Group, Mean (\bar{X}) = $\frac{\sum X}{N} = 8.65$,

$$\text{Standard Deviation (SD)} = \sqrt{\frac{\sum(X-\bar{X})^2}{N}} = 4.96 \text{ and Variance } (\sigma^2) = 24.63$$

For Control Group, Mean (\bar{X}) = $\frac{\sum X}{N} = 7.70$,

$$\text{Standard Deviation (SD)} = \sqrt{\frac{\sum(X-\bar{X})^2}{N}} = 3.98 \text{ and Variance } (\sigma^2) = 15.81$$

$$\text{Hence, Value of t-test} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left(\frac{1}{N_1} + \frac{1}{N_2}\right) \left(\frac{(N_1-1)\sigma_1^2 + (N_2-1)\sigma_2^2}{(N_1+N_2-2)}\right)}} = 0.67$$

APPENDIX - I

Post-test result of the students of Experimental and Control Group

(Required Scores arranged in descending order)

S. N.	Experimental			Control		
	X	$X - \bar{X}$	$(X - \bar{X})^2$	X	$X - \bar{X}$	$(X - \bar{X})^2$
1	29	9.65	93.12	23	9.75	95.06
2	27	7.65	58.52	22	8.75	76.56
3	26	6.65	44.22	21	7.75	60.06
4	25	5.65	31.92	20	6.75	45.56
5	24	4.65	21.62	18	4.75	22.56
6	24	4.65	21.62	18	4.75	22.56
7	23	3.65	13.32	16	2.75	7.56
8	21	1.65	2.72	13	-0.25	0.06
9	21	1.65	2.72	12	-1.25	1.56
10	19	-0.35	0.12	12	-1.25	1.56
11	18	-1.35	1.82	12	-1.25	1.56
12	18	-1.35	1.82	11	-2.25	50.06
13	18	-1.35	1.82	10	-3.25	10.56
14	17	-2.35	5.52	10	-3.25	10.56
15	16	-3.35	11.22	9	-4.25	18.06
16	14	-5.35	28.62	8	-5.25	27.56
17	13	-6.35	40.32	8	-5.25	27.56
18	12	-7.35	54.02	8	-6.25	27.56

19	12	-7.35	54.02	7	-6.25	39.06
20	10	-9.35	87.42	7	-6.25	39.06
N = 20	387.00		576.50	265.00		539.70

For Experimental Group, Mean (\bar{X}) = $\frac{\sum X}{N} = 19.35$,

$$\text{Standard Deviation (SD)} = \sqrt{\frac{\sum(X-\bar{X})^2}{N}} = 5.37 \text{ and Variance } (\sigma^2) = 28.83$$

For Control Group, Mean (\bar{X}) = $\frac{\sum X}{N} = 13.25$,

$$\text{Standard Deviation (SD)} = \sqrt{\frac{\sum(X-\bar{X})^2}{N}} = 5.19 \text{ and Variance } (\sigma^2) = 26.98$$

$$\text{Hence, Value of t-test} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left(\frac{1}{N_1} + \frac{1}{N_2}\right) \left(\frac{(N_1-1)\sigma_1^2 + (N_2-1)\sigma_2^2}{(N_1+N_2-2)}\right)}} = 3.65$$

APPENDIX - J

Statistical Formulae Used in Data Collection and Analysis

SN	Content	Notation	Formulae
1	Mean	\bar{X}	$\frac{\sum fx}{\sum f} \text{ or } \frac{\sum fx}{N}$ <p>Where, X= random variable and f =frequency</p>
2	Variance	SD ² or σ^2	$\frac{\sum fx^2}{N} - \left[\frac{\sum fx}{N} \right]^2$
3	Pooled Variance	S_p^2	$\frac{(n_1 - 1)s_1^2 - (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$
4	Standard Deviation	SD or σ	$\sqrt{\frac{\sum fx^2}{N} - \left[\frac{\sum fx}{N} \right]^2}$
5	Pearson's Correlation Coefficient	r_{xy}	$\frac{N \sum XY - \sum X \sum Y}{\sqrt{N \sum X^2 - (\sum X)^2} \sqrt{N \sum Y^2 - (\sum Y)^2}}$
6	Difficulty level of Items	P %	$\frac{R_u + R_l}{N} \times 100\%$
7	Discrimination Index		$\frac{R_u - R_l}{N/2}$, Where, R_u = no. of correct

	of Item	D	response given by upper 13% students R_l = no. of correct responses given by lower 13% students N = total students on 13%
8	Speaman Brown Spilt Half Reliability 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 groups	t	$\frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left(\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}\right) - 2r \cdot \frac{s_1}{\sqrt{N_1}} \cdot \frac{s_2}{\sqrt{N_2}}}}$
11	T-statistics	t	$\frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left(\frac{1}{N_1} + \frac{1}{N_2}\right) \left(\frac{(N_1 - 1)\sigma_1^2 + (N_2 - 1)\sigma_2^2}{(N_1 + N_2 - 2)}\right)}}$

APPENDIX – K

Critical Values of Student's t-Distribution

d.f.	Level of Significance for Two Tailed Test					d.f.
	0.20	0.10	0.05	0.02	0.01	
	Level of Significance for One Tailed Test					
	0.10	0.05	0.025	0.01	0.005	
1	3.078	6.314	12.706	31.821	63.657	1
2	1.886	2.920	4.303	6.965	9.925	2
3	1.638	2.353	3.182	4.541	5.841	3
4	1.533	2.132	2.776	3.747	4.604	4
5	1.476	2.015	2.571	3.365	4.032	5
6	1.440	1.943	2.447	3.143	3.707	6
7	1.415	1.895	2.365	2.998	3.499	7
8	1.397	1.860	2.306	2.896	3.355	8
9	1.383	1.833	2.262	2.821	3.250	9
10	1.372	1.812	2.228	2.764	3.169	10
11	1.363	1.796	2.201	2.718	3.106	11
12	1.356	1.782	2.179	2.681	3.055	12
13	1.350	1.771	2.160	2.650	3.012	13
14	1.345	1.761	2.145	2.624	2.977	14
15	1.341	1.753	2.731	2.602	2.947	15
16	1.337	1.746	2.120	2.583	2.921	16
17	1.333	1.740	2.110	2.567	2.898	17
18	1.330	1.734	2.101	2.552	2.878	18
19	1.328	1.729	2.093	2.539	2.861	19

20	1.325	1.725	2.086	2.528	2.845	20
21	1.323	1.721	2.080	2.518	2.831	21
22	1.321	1.717	2.074	2.508	2.819	22
23	1.319	1.714	2.069	2.500	2.807	23
24	1.318	1.711	2.064	2.492	2.797	24
25	1.316	1.708	2.060	2.485	2.787	25
26	1.315	1.706	2.056	2.479	2.779	26
27	1.314	1.703	2.052	2.473	2.771	27
28	1.313	1.701	2.048	2.467	2.763	28
29	1.311	1.699	2.045	2.462	2.756	29
Infinity	1.282	1.645	1.960	2.326	2.576	Infinity