EFFECTIVENESS OF PROBLEM SOLVING METHOD IN TEACHING GEOMETRY

A

THESIS

BY

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FOR THE PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE

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LETTER OF CERTIFICATE

This is to certify that Mr. Ganesh Pathak, a student of academic year **2072/73** with Campus Roll Number **342**, Thesis Number **1576**, Exam Roll Number **7228280** and TU Registration Number **9-2-375-266-2011** has completed this thesis for the period prescribed by the rules and regulations of Tribhuvan University, Kirtipur, Kathmandu, Nepal.

This thesis entitled "**Effectiveness of Problem Solving Method in Teaching Geometry"** has been prepared based on the results of his investigation. I hereby recommend and forward that his thesis be submitted for the evaluation as the partial requirements to award the degree of Master of Education.

Date: 26 Nov,2021

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(Prof. Dr. Bed Raj Acharya)

Head of the Department

LETTER OF APPROVAL

This thesis entitled **" Effectiveness of Problem Solving Method in Teaching Geometry"** is Submitted by Mr. Ganesh Pathak in partial fulfillment of the requirements for the Degree of Master of Education has been approved.

Viva-Voce Committee   **Signature**

1 Prof. Dr. Bed Raj Acharya   ……………

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   (Supervisor)

Date: 28 Dec, 2021

RECOMMENDATION FOR ACCEPTANCE

This is to certify that Mr. Ganesh Pathak has completed his M.Ed. thesis entitled

"**Effectiveness of Problem Solving Method in Teaching Geometry**" under my

supervision during the period prescribed the rules and regulations of Tribhuvan

University, Kirtipur, Kathmandu, Nepal. I recommended and forward his thesis to the

Department of Mathematics Education to organize final viva-voce.

Date: 28 Dec, 2021

……………………….

Mr. Arjun Neupane

Supervisor

DECLARATION

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

Date: 28 Dec, 2021

…………………

Ganesh Pathak

Defense Date: 28 Dec,2021

Dedication TO

To My Respected Parents:

Jhamka Prasad Pathak and Kamala Pathak

ACKNOWLEDGEMENTS

ABSTRACT

This is an experimental research related to find the Effectiveness of Problem Solving Method on Students' Achievement in Teaching Geometry at Grade IX. The objectives of this study were to find out the effectiveness of problem solving method on student's achievement in teaching geometry at grade IX and to explore the students' perception and practice towards the problem solving approach in learning geometry at grade IX. A pre-test and post-test of quasi-experimental research design was used to compare the achievement scores of experimental group and control group. The experimental group was taught by using problem solving method whereas the control group was taught by traditional method. There were 30 and 32 students in experimental and control group respectively from same locality.

To measure the effectiveness of problem solving method in teaching mathematics, the researcher developed and administered both pre-test and post-test. The test scores were collected and descriptively analyzed by using different mathematical tools such as mean, standard deviation, coefficient of variation, t-test. The duration of instruction was about three weeks. After the completion of experiment, researcher collected the data from mathematics achievement test and an opininonnaire. The achievement test was used to compare the achievement of the students taught by using problem solving method and traditional method and opinionnaire was used for the experimental group to explore the students' view towards the problem solving method.

The results indicated that there was a significant difference between the average achievement score of experimental and control groups on post-test. This finding illustrated that the students in the experimental group performed better when using problem solving method than the students of control group who were taught by traditional teaching method.

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ABBREVIATIONS

3D   : Three Dimensional

AD   : After the Death of Christ

BS   : Bikram Sambat

D   : Discrimination index

d.f.   : Degree of freedom

F   : F-distribution

ICT   : Information and Communication Technology

i.e.   : That is

MS   : Micro Soft

NCTM   : National Council of Teacher of Mathematics

NO.   : Number

P   : Difficulty level

SD   : Standard Deviation

TU   : Tribhuvan University

T   : t-distribution

$\bar{x}$:   : Mean

r_{xy} : Pearson's correlation coefficient

r   : Reliability of coefficient

α   : Level of significance

%   : Percentage

CHAPTER I

INTRODUCTION

This is the first and initial part of the study. This chapter clearly and precisely explains the issue/ problem that has been selected for the study. This chapter describes what the study is about and why it is important.

Background of the Study

Geometry is one of the oldest branches of mathematics. The growth and development of geometry is developed from ancient age. This is the era of science and technology. So, the aim of education is also changed due to the change in needs and demands of the society (NCTM). Geometry is used as language, to develop thinking skills, subjects as deductive science (Pandit, 2007). Geometry is one of the useful and important branch of mathematics. It concerned with the shape of individual objects, spatial relationships among various objects, and the properties of surrounding space (Howson, 1973).

The curriculum of Nepal has given emphasis on geometry learning from the beginning of schooling. Geometry is one of the most applied fields of mathematics (MOEC,1992). The curriculum has aimed to develop students understanding of intended geometric concepts at secondary level. According to NCTM, geometry is one of the content standards of school mathematics, whose aims is developing spatial reasoning, problem solving skills in geometry. Mathematics is taken as difficulties subjects because the achievement score of mathematics is low (below average) according to SEE result 2075 and BLE result 2075 in Neelkantha Municipality of Dhading district. To improve the existing situation of geometry teaching, it is

necessary to know the existing condition of student's thinking (understanding) in geometry. And different education research shows that achievement of learner's in geometry is very poor. This is why the researcher applied the problem solving method to teach geometry in grade IX.

There may have many problems in profession and discipline. In the experience of school mathematics teacher, most of the students are feeling difficulty in school geometry (Joshi D.R.,2017). The reason behind this fact will be the lack of sufficient experiences in students in geometry part from the lower level. There are several problems and issues of geometry teaching to improve an achievement of students. Is there any special method of teaching geometry appropriate at grade IX for improving achievement? how the students understand the geometry? so, the researcher wants to study on the appropriateness of polya's teaching method to teach geometry. Researcher tries to study on Polya's problem solving method in teaching geometry.

Polya. (1945) defines problem solving as "to find a way when no way is known off- hand, to find a way out of difficulty, to find a way among an obstacle, to attain a desired end that is not immediately attainable by appropriate means". There is no problem unless the individual has the desire to find a solution." (NCTM, 1980, P1)

Statement of the Problem

In the modern era, many materials, different kinds of techniques and learning by doing approach should be followed. But in the context of Nepal and in my own experience, only the chalk and talk approach are mostly used in the classroom. It is widely considered that only telling is not a teaching and listening is not a learning. Most of the learners are feeling geometry is difficult part in mathematics. Most of the

students have their achievement under the average level. (SEE/Grade 8 result 2075, *Education Office Dhading*).

I realized that the curriculum of mathematics and the needs and demands of students in the local level are not getting matched. The result at grade IX is less than the average, but this grade is the time to make foundation for higher study. There may have several reasons behind low achievement of students; out of them learning geometry can be one of the major problems. There are various methods and techniques to teach geometry in grade IX; out of them problem solving method is one of the new techniques of teaching geometry. I tried to state the problem related to this study in my own experience. In my teaching experience at Shree Sankosh Secondary School Neelkantha-12, Dhading and Shree Rastriya Secondary School Panchakanya-02, Nuwakot, I had faced several difficulties in teaching and learning geometry at grade IX.

I had not seen any study and not used the problem solving method in my school. The researcher thought that this method can be one of the appropriate methods to teach geometry here. The students of this locality had not performed their mathematical knowledge effectively, so that the researcher wants to study on this area to find out the effectiveness of problem solving method. Most of the students feel geometry is difficult part. Researcher had realized that the problem solving method is better than the traditional method while teaching geometry at grade IX. And this method is student centered too and it also develops thinking capacity of the students.

So, the researcher wanted to study the effectiveness of problem solving method in teaching geometry at grade IX. This study answered the following research questions.

- Does the problem solving method of teaching in mathematics is appropriate than traditional method of teaching in grade IX?

- What are student's perception and practice towards the level of understanding in geometry followed by problem solving method at grade IX?

Justification of the Study

Mathematics plays a very important role in school education. It is a compulsory subject in school curriculum. I applied problem solving method in teaching mathematics in my sector and found that students can understand and solve the problem easier than using other methods. This method developed thinking level and analytical power of the students. The following are the major significance of the study.

- This study helped to the curriculum designer, specialist, textbook writer, teacher trainers and other.

- The study helped new teacher as well as partially trained teacher.

- This study helped on developing teaching strategies in classroom teaching.

- This study provided the information about present trend of problem solving method at grade IX.

Objectives of the Study

Research Objectives are clear, concise, declarative statements, which provide direction to investigate the variable under the study.

The objectives of the study were as follows: -

- To find out the effectiveness of problem solving method on student's achievement in teaching geometry at grade IX.

- To explore the students' perception and practice towards the problem solving approach in learning geometry at grade IX.

Delimitation of the Study

The delimitation of the study are as follows:

- Only the government schools of Dhading district was selected for this study.

- This study was concerned with the experimental group and control group of the students of grade IX.

- The experiment of this study was performed within three weeks.

- In the experimental phase, only the geometric part was selected for teaching by applying problem solving method.

- The study was based on effectiveness of teaching mathematics using problem solving method as mentioned by G Polya.

Hypothesis of the Study

In conducting any research, the next step after selecting the problem is to formulate hypothesis. Hypotheses are the assumptions or guesses about the population involved. So, the assumptions that may or may not be true are called hypothesis (Pandit and Pahari,2015).The research hypothesis and alternative hypothesis were as follows:

Research Hypothesis

The mean achievement score of the students taught by using problem solving method of teaching was higher than the students taught by using traditional method of teaching.

Statistical Hypothesis

The null and alternative hypotheses were as follows:

H_0**:** There is no significant difference between the average achievement score of experimental group and control group i.e. $\mu_1 = \mu_2$ on pre-test

H_1**:** The average achievement score of experimental group is not equal to the control group i.e. $\mu1 \neq \mu2$ on pre-test

H_0**:** There was no significance difference between the average achievement score of experimental group and control group i.e. $\mu_1 = \mu_2$ on post-test

H_1**:** The average achievement score of experimental group is not equal to that of control group i.e. $\mu1 \neq \mu2$ on post-test

Where, $\mu_1 =$ Average achievement score of experimental group

And, $\mu_2 =$ Average achievement score of control group

Operational Definition of Related Terms

The terms that were used in this study have their specific meanings. The researcher used the related terms for the following meanings:

Achievement. The achievement in this study was defined as the scores obtained by the students in mathematics tests constructed by the researcher.

Control Group. The group that was taught by the researcher using traditional method of the teaching is defined as "Control Group" in this research.

Experimental Group. The group that was taught by the researcher by using problem solving method of teaching is called "Experimental Group" in this research.

Traditional Method. A method of teaching in which teacher is central figure of teaching learning activity and the students passively accept the fact exposed by the teacher. Simply, teachers are feeder and the students are passive listener.

Effectiveness. The effectiveness in this study was defined in terms of the magnitude of the score obtained by experimental and control groups in the mathematics achievement test.

Problem Solving Method. The process of solving the problems by following the steps created by George Polya (1945) is problem solving method. Understanding the problems, making a plan, carrying out the plan, Looking back are the steps of problem solving method according to G. Polya. The students are excepted to observe, understand, analyze, interpret find solutions, and perform applications that lead to a holistic understanding of the concept.

CHAPTER II

REVIEW OF LITERATURE

Review of related literature is an essential part of research for the researcher because literature helps and guides research to meet theoretical way for the study. The main purpose of review of literature is to find out what works have been done in the area of research problem under study and what has been remaining to be done in the field of research studying being undertaken. Literatures will provide authentic and strong knowledge. Mainly the literatures are previous thesis, books and journals, different sources use to site literature. In this regard the following are the related literature in this study. The literature can be divided into two part; they are empirical review and theoretical review.

Empirical Review

The review of empirical literature of the study was very important and necessary. If researcher did not review this literature then the researcher cannot proceed ahead and cannot be clear about the research way, concept, design and analysis process. It provides the psychological, sociological, philosophical, contextual, historical knowledge, concept and traditional way of study. From it, researcher gains pre-knowledge of study, pre- techniques, pre-methods and pre-analysis procedures. So, researcher reviewed the following literature:

A study carried out by Shrestha (1975) conducted his research study entitled "A study comparing the effectiveness of the discovery method and traditional method in lower secondary class of Nepal". The aim of the research was to test the effectiveness of the discovery method of teaching mathematics. He concluded that the discovery

method is more effectiveness for teaching mathematical concept rather than that of traditional method.

Pandey (1985) did an experimental research work on "Use visual aids in teaching fraction". The aim of research was to develop a teaching model for teaching fraction at grade VI. A teaching model with visual aids and a plan verbal exposition model were prepared. His research shows that the teaching model with visual aids was found to be more effective than the plan verbal exposition model.

Raut (2000) did an experimental research on " A study on the effectiveness of inductive deductive teaching approach in secondary schools" with the objectives to identify the difficulties and cause of difficulties in learning mathematics of secondary level students were selected from grade 10 with purposive sampling techniques. The researcher analyzed the data in descriptive way. And found the conclusion secondary level students taught by inductive deductive approach with teaching materials affects on mathematics achievement as compared to the performance of them taught by traditional approach.

A study done by Quaiyam (2003), conducted the research entitled on "A study of students' problem solving methods in mathematics at secondary level of Nepal" with the aim to determine the difference in the achievement level between boys and girls of secondary school. He applied problem solving approach and to assess the difference between boys and girls of secondary school with regard to attitude towards mathematical problem solving. Multi stage stratified random sampling had been used in the selection of districts, schools and students from central development region of Nepal. The sample consisted of 250 boys and 182 girls of grade IX from five districts. The t-test was applied and concluded that there was significance difference between

boys and girls regarding applying problem solving approach to mathematics and found with regard to attitude towards mathematical problem solving. He concluded that boys seemed to be more capable in comparison to girls.

Kandel (2007), did a research on "Effectiveness of problem solving approach in arithmetic at lower secondary level" with the aim to explore the effectiveness of problem solving approach in addressing genders in learning arithmetic at grade VII. In 130 students, 25 students were selected for experiment and 25 were selected for control group. Statistical tools were mean and standard deviation and t-test was used to compare the achievement at 0.05 level of significance. He concluded that problem solving approach of teaching was better than the traditional approach of teaching.

Parajuli (2009), did an experimental research on "A study on the effectiveness of teaching mathematics by using problem solving method at lower secondary level mathematics" with the aim of prior use of experimental verification by teaching arithmetic with problem solving method. Among 60 students, 30 students were selected randomly with 15 students for experiment and 15 for control group. The data obtained from final achievement test was analyzed and interpreted by using t-test at 0.05 level of significance and concluded that the experimental verification have significant effect on teaching mathematics.

Dewan (2011), did an experimental research on "Effectiveness of problem solving method in teaching arithmetic at grade VI" with the aim to compare the achievement levels of students taught by experimental problem-solving approach to the achievement of students taught by traditional approach. A post test equivalent group design was adopted to conduct the experiment in grade VI. The researcher selected carried out this experiment in two schools of Dhankuta district. Among the

population of the study, 46 students were randomly selected with 21 for experimental and 25 for control group. Mean, standard deviation and t-test were used to compare the achievement level of students. She concluded that problem-solving approach of teaching mathematics was better than the usual traditional approach of teaching mathematics.

Paudel (2014) conducted an experimental research on "Effectiveness of problem solving methods in teaching mathematics in Syangja district" with the aim of the experimental verification by teaching arithmetic with problem solving method at lower secondary level. He took40 students from two schools, 21 students were selected for experiment and 19 for control group. The criteria for the selection was marks obtained in pre-test between 20-33 marks. The data obtained from final achievement test was analyzed and interpreted by using t-test at 0.05 level of significance and concluded that the experimental verification have significant effect on teaching mathematics.

Shrestha (2015), did an experimental research on "Effectiveness of problem solving methods in teaching mathematics in Lamjung district" with the aim of the experimental verification by teaching arithmetic with problem solving method at secondary level. He took 60 students from two schools, 32 students were selected for experiment and 28 for control group. The criteria for the selection was obtained in pre-test between 35-50 marks. The data obtained from final achievement test was analyzed and interpreted by using t-test at 0.05 level of significance and concluded that the experimental verification have significant effect on teaching mathematics.

The researches which have been conducted before showed that problem solving method is more effective in teaching learning process in different topic. But,

in geometry part of grade IX, no such researches have been previously performed. There was not any research in my locality. Also, the students' achievement has not been compared towards using problem solving method versus traditional method. The researcher sees the gap in the above mentioned part. And the researcher wants to fill the above mentioned gap from this study.

Theoretical Literature

This chapter reviews the literature about the educational or psychological learning theory which provides the theoretical foundation to this study and discussed the theoretical framework of the study. The theoretical framework supports to fulfill the research question and the significance of the study. There are many learning theories related to mathematics and learning mathematics. Researcher wants to discuss about Polya's problem solving method.

Problem is a situation for a person if he/ she is aware of its existence, recognizes that it requires action, wants or needs to act and does so, and is not immediately able to resolve the situation (Bell, 1978). However, problem solving is an appropriate and important activity in school mathematics because the learning objectives that are met by solving problem and learning general problem - solving procedures are of significant importance in our society (Bell, 1978). Since solving problems helps students learn mathematical facts, skills, concepts and principles. The mathematical activities such as generalization, abstraction, theory building and concepts formation are based on problem solving (Acharya, 2017). Polya (1945) writes problem solving method as to endeavor to understand and the process of solving problem, especially the mental operation is typically useful in this process.

Problem solving is a method of teaching to accomplish the instructional goals for various problems of learning facts, concepts and procedures as well as goals for problem solving within the problem context. He believes that the students should acquire as much experience of independent work as possible. The teacher should think the level of the students and ask as much key questions or make useful suggestions as possible. The questions and suggestions offered to the students should be based on general principles and practically of the students' common sense that the students could have thought of themselves. Problem solving strategies include making a model, picture or diagram, looking for pattern, guessing and checking, making assumption etc. It is also taken for research in psychology. In mathematics, problem solving method is used for various reasons that it allows students to develop mathematics understanding and gives meaning to skill and concepts in all stands, it increases opportunities for the use of critical thinking skills, it initiates students communicate ideas, make connections and apply appropriate knowledge and skills in the obstruct institution.

Polya (1945) collected various questions and suggestions that were useful in problem solving and grouped them under different headings of problem solving (Polya, 1945). For problem solving Polya suggested so many methods to solve the problem. But Polya's problem solving method is the way to describe as understanding the problem, making a plan, carrying out the plan and looking back.

Understanding the problem

Polya mentioned to ask questions such as: Do you understand all the words used in stating the problem? What are you asked to show/find? Can you restate the problem in your own words? These kinds of questions help to understand the

problem? Do you understand all the words used in stating the problem? What are you asked to find or show? Can you restate the problem in your own words? Can you think of a picture or diagram that might help you understand the problem? Is there enough information to enable you to find a solution

Making a plan/ devise a plan

Polya mentions that there are many reasonable ways to solve problems. The skills at choosing an appropriate strategy is best learned. Polya mentions that there are many reasonable ways to solve problems. The skill at choosing an appropriate strategy is best learned by solving many problems. You will find choosing a strategy increasingly easy. A partial list of strategies is included: Guess and check, Look for a pattern, Make an orderly list, Draw a picture, Eliminate possibilities, Use direct reasoning, Use symmetry, Use a model , Consider special cases, Work backwards.

Carry out the plan

This is the step to apply our plan. You have already necessary skills and techniques. We can use and check each steps. Carrying out our plan with the solution. How the mathematics is done? If this method is not good, choose another.

Looking back

Polya mentions that the solution is analyzed to determine whether they are reasonable. In this step, examine the solution obtained, check the result, check the arguments are the main attempts. Polya mentions that much can be gained by taking the time to reflect and look back at what you have done, what worked, and what didn't. Doing this will enable you to predict what strategy to use to solve future problems.

This theory was used while making the lesson plans to teach to the students of experimental group. Particularly, in teaching learning activities of lesson plan, teacher focused on solving the problems by following these four steps and teacher motivated the students to follow these steps while solving the problems. So Problem solving method develops higher level of thinking skills. This is student centered strategy.

Conceptual Framework of the Study

A conceptual framework is a representation, either graphically or a narrative form, of the main concepts or variables, and their presumed relationship with each other (Punch, 2005). It has been developed on the basis of the previous researches and studies carried in the similar topics. The idea can be presented in the following framework.
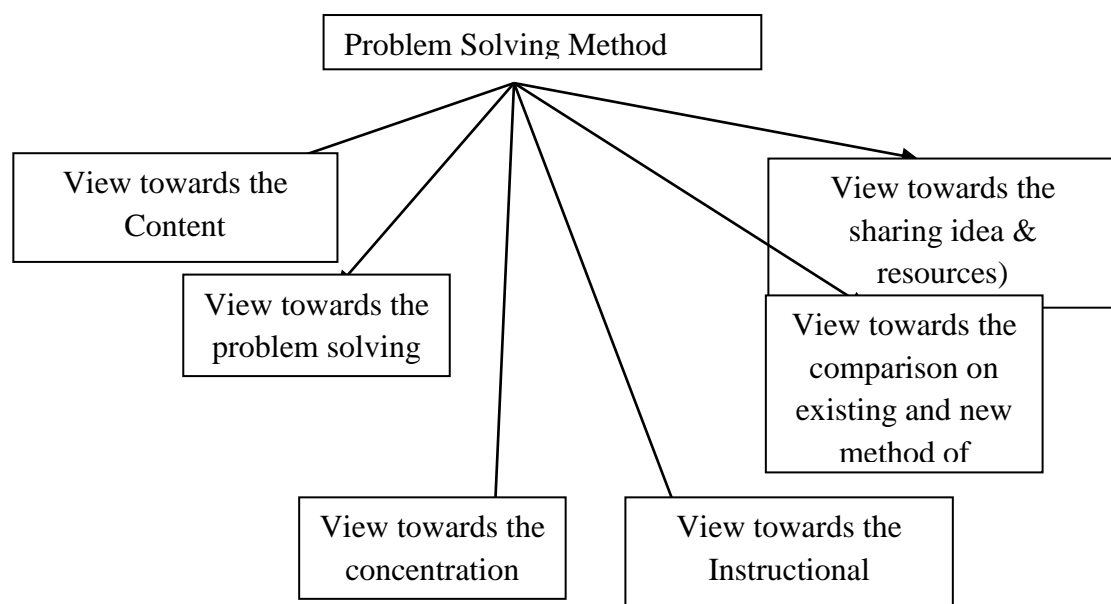
Figure 1 conceptual Framework of the Study

CHAPTER III

METHODS AND PROCEDURES

This chapter contains the methods and procedure which is helpful to obtain the objectives of the study and to get answer of the statement of the problems. Method means technique and procedure means the process of collecting the data and analyzing it. It describes the design of the study, population and the sample, data collection tools, reliability and validity of tools, data collection procedures and data analysis procedures. In this chapter, design of the study, population and sample, tools of the study, calculation of reliability, item analysis, selection criteria, data collection procedure, data analysis procedure were as follows:

Design of the Study

This is the detail path of the investigation. This study is a quasi-experimental design, having two group experimental and control groups. Researcher has taken this design because two groups were taken from different schools and we can't study by mixing both groups. Quasi-experiments are most likely to be conducted in field settings in which random assignment is difficult or impossible. Thus, research design comprises the overall strategy that was followed in collecting and analyzing the data (Gay, L.R., Mills, G.E. and Peter, W.A., 2012).

Nonequivalent Groups Design

Researchers using a nonequivalent groups design can take steps to ensure that their groups are as similar as possible. Here, the researcher could try to select two schools from the same locality, where the students in the two groups have similar scores on a standardized math test and the teachers are the same and have similar

teaching styles. Taking such steps would increase the internal validity of the study because it would eliminate some of the most important confounding variables. The pre-test and post-test nonequivalent design was followed for the purpose of this study.

Phases of Experimental Stages.

An experiment is a scientific investigation in which the researcher manipulates one or more independent variables controlled by any other relevant variables and observes the effect of the manipulates on the dependent variables. Experimental stage was categorised into three stages, which were mentioned as follows:

Pre-Experimental Stage. It is the stage, researcher has to test the present situation of any event before conduction and the detail information should be collected. In the pre-experimental stage, the researcher developed the test item, opinionnaire and class observation form.

Test items included the subjective questions. The opinionnaire related to five point Likert scale based upon the student's view on mathematical content and practice towards the problem solving method. To make questions, Researcher took help from the supervisor. Mathematics achievement test items piloted on the group of students that was not included in sample for pre-test and post-test. Analysis of the result of pilot test was done and the pre-test and post-test item of mathematics achievement test was finalised.

After selecting test item of mathematics achievement test, pre-test was administered among the students of experimental and control groups for the purpose of group comparison. The pre-test was consisting of subjective questions and there was altogether thirty full marks.

Experimental Stage. In this stage, researcher himself taught for the experimental and control group regularly for three weeks. The experimental group of students had been taught by using problem-solving method but the control group of students had been taught by using traditional method. Researcher himself taught about three weeks for both groups.

Post-Experimental Stage. In post-experimental stage, the post-test was administered among both groups. The post-test was consisting of 30 full marks, where, short questions and long questions were included. Also, the set of questionnaire was administered only on experimental group. It was consisting of 10 statements related to student's view about problem solving method. The class observation was taken during this phase, where Participation and Interest, Performance about Subject Matter and Attendance were included. After collecting the students answer and response, the data was analyzed. After collecting the students answer and response, the data was analyzed by constructing suitable tools.

Population of the Study

Grade nine students are the beginning and foundation of the secondary level education. The population of the study was all the students who were studying at grade IX in academic year 2077 of Dhading district.

Sample of the Study

For the sample of this study, two schools were selected. But, firstly five schools named Pashupati Secondary School, Sangkosh Secondary School, Bal Mandir Secondary School, Mahendra Secondary School and Manarupi Secondary School of same locality were chosen conveniently for the pre-test. After the

administration of pre-test, only two schools named Manarupi Secondary School and Sangkosh Secondary School were selected as control group and experimental group respectively as the researcher purposed on the basis of their mean scores to make homogeneous groups. To divide the experimental group and control group, a fair coin was tossed.

Tools of Data Collection

For this study, following instruments were used for the purpose of data collection: Achievement test (pre- achievement test and post- achievement test), class observation note and opinionnaire.

Achievement Test. The achievement test was developed for both pre-test and post-test. Each test was consisted of subjective questions and the model was mentioned in appendix I. The time for test was an hour. But, the items of both tests were same.

Opinionnaire. In order to elicit students' perception towards the concepts of mathematics and on problem solving method in solving the problems of geometry. The perception towards the mathematical understanding and teaching learning activities was taken. Such opinionnaire was performed taking all students of experimental group. All the statements were related to the problem solving method and traditional method of teaching. According to their opinionnaire, the data was converted into the quantitative form by using Likert five point scale. The items of questionnaire were standardized by testing the reliability and validity and declaring its dimensions and number of items for each dimension.

Variables

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

Different variables are used in educational research. An independent variable is an attribute or characteristic that influences the effect or dependent variable. A dependent variable is an attribute or characteristic that is dependent on or influenced by the independent variable (Creswell, 2012). It means if one variable depends upon or is a consequence of the other variable, it is termed as a dependent variable, and the variable that is antecedent to the dependent variable is termed as an independent variable. Variables that are not related to the purpose of the study, but may affect the dependent variable are termed as extraneous variables.

The independent variables are the condition or characters that the experimenter manipulates or controls in his or her attempt to a certain their relationship to observed phenomena. But the dependent variables are the conditions that appear or change as the experimenter introduces, the independent variables.

In this study, using problem solving method while teaching geometry was taken as independent variable. And, students' score on mathematics achievement test (post-test) was taken as dependent variable. Selection of school, instructor/teacher, subject matter, group, experimental time, test, scoring, student's labor and home environment were considered as extraneous variables in this study.

Selection Bias. Experiment and control group should be equivalent in research**,** but it is difficult to make these groups equivalent. Researcher tried to control effect of selection bias procedure which has been mentioned before. Some other variables such as teacher's variables, students' variables, subject matter taught, length of experiment, equivalence of groups, evaluation instrument were controlled as:

Teacher variables. The researcher himself taught both the groups by controlling the extraneous variables such as behavior, personality, emotion and qualification of the teacher.

Student Variables. Researcher took samples from same socio-economic status from same local level.

Length of Experiment. Researcher taught himself for three weeks by using different method i.e. by problem solving method to the experiment group and by traditional group to the control group.

Subject Matter. Same content of geometry part of grade nine was taught to the both group and same textbook prescribed by CDC.

Experimental Time. Researcher provided equal time to both groups.

Evaluation Instrument. After the end of the experiment, same test paper was given to both groups and marked the test paper of the students by himself.

Uncontrollable Affecting Variables in the Experiments

Student's Labor. Students may labor more or less than expected by the researcher and self-study of the students may affect in the result of research, which was out of control.

Student's Home Environment. Student's home environment has great effect on student's behavior and attitude but it couldn't be controlled by the researcher.

Control Mechanism. In the experimental research, this above mentioned variables may be affect to the conclusion of the research, and can't be controlled directly.

But by perfectible, effect of some possible variables should make low carefully. Research tried to make learner mature and let them activities to make busy, giving feedback and demonstration.

Validity and Reliability of Tools

Reliability refers to how consistently a method measures something. It can be estimated by comparing different versions of the same measurement. For this purpose, every test item was piloted and reliability was assured by using Karl Pearsons' correlation coefficient following split half method before it was administered. Reliability was assured by taking the scores of five students (from different five schools where each of them was selected by lottery system) using Karl Pearson's correlation coefficient with the reliability coefficient being 0.83 following split half methods before it was administered which ensured that the same test items for both test were reliable enough.

Validity is the degree to which a test measure what is supposed to measure. It refers to how accurately a method measures what it is intended to measure. If research has high validity then it produces results that correspond to real properties, characteristics, and variations in the physical. Validity of the achievement test and opinionnaire were established by the help of subject teacher, expert and supervisor.

Likert Scale Opinionnaire. The researcher prepared a set of opinionnaire consisting ten items for the purpose of the research. The validity of those items was established by the export judgment and reliability by pilot study.

Class Observation Note. During the experimental phase, the researcher coded the students' regularity in classroom, participation, performance, interaction and interest on subject matter which reflect the effectiveness of problem solving method. The class observation form was prepared with the help of expert, thereby ensuring reliability.

Data Collection Procedure

In the beginning of data collection process, pre-test was conducted within both groups-experimental group and control group. Then, quantitative analysis was performed of the achievement of pre-test. After experiment, post-test was administered within same groups. After that, quantitative analysis of the result of post-test was performed. Finally, a closed form of opinionnaire was conducted in the experimental group only and such information was converted into the numerical form

Achievement test was based on subjective type questions such that researcher wants to know the level and understanding of the students towards the geometry. And the opinionnaire conducted on experimental group and was changed the data in quantitative form by using Likert's five point attitude scale. In student's opinionnaire, researcher made ten statements related to the understanding of mathematical concepts based on problem solving method.

Data Analysis Procedure

The collected data was analyzed and interpreted by using different statistical devices such as mean, standard deviation, variance and t-test. The collected data tabulated and analyzed according to the objectives of study. Mean and standard deviation were calculated with the help of Microsoft Office Excel to analyze the scores in the achievement test. Pooled variance was taken out to find t-test value. The t-test was used at 0.05 level of significance to find whether the significant difference existed between the means of experimental and control group. For the analysis of students' perception towards the mathematical concepts and content in experimental group taught by problem solving method, Likert's five point attitude scale was used. Interview data was used to identify the student's perception towards the problem solving method assisted classroom teaching and learning. The data obtained from the opinionnaire was analyzed by calculating mean, standard deviation and percentage by assigning 1 for strongly disagree, 2 for disagree, 3 for undecided, 4 for agree and 5 for strongly agree for all positive statements and reversing the process for negative statements

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

This chapter deals with the analysis and interpretation of data. This chapter is mainly organized in accordance with the problem, objectives, hypothesis and all the collected data thereby following the process of sequentially. An experimental research was performed in concern to the topic "Effectiveness of Problem Solving Method on Students' Achievement in geometry". The objectives of the study were 'to find out the effectiveness of problem solving method on student's achievement in teaching geometry at grade IX and 'to explore the students' perception and practice towards the problem solving approach in learning geometry at grade IX.

A pre-test, post-test equivalent group design was adopted for the purpose of the study. A pre-test was taken to make the group comparable. Primarily, the achievement test of the students in post-test was taken to fulfill the first objective of the study. Then, for the second objective of the study, opinionnaire related to Likert scale was used. The score of the students were analyzed using statistical method with help of Microsoft Office Excel 2007 for mean, variance and standard deviation. And the students' views on problem solving method were analyzed using Microsoft Office Excel 2007 for mean and standard deviation with based on Likert scale analysis. To fulfill our objectives, the data have been organized, tabulated, analyzed as follows:

Analysis of Pre-test Result

The pre-test was conducted in all five sample schools from same locality named Pashupati Secondary School, Sangkosh Secondary School, Bal Mandir Secondary School, Mahendra Secondary School and Manarupi Secondary School .

The mean and standard deviation of scores of other three schools were not even close. So, the researcher took only Sankosh Secondary School and Manarupi Secondary School as their mean and standard deviation were close enough. In Appendix-II, the pre-test score of students of both groups are presented. The summary of statistical calculation for the experimental and control group on the pre-test is given in Table 4.1 and Figure 4.1 below.

Table 4.1: Result of the Pre-test

Group	Number of students	Mean	Variance	Standard Deviation	Calculated t-value	Tabulated t-value
Experimental	$N_1 = 30$	$\bar{x}_1 = 8.03$	$S_1^2 = 15.95$	$S_1 = 3.99$	1.74	1.96
Control	$N_2 = 32$	$\bar{x}_2 = 6.44$	$S_2^2 = 9.59$	$S_2 = 3.1$		

The above Table- 4.1 shows that, there were 30 and 32 students in experimental and control group respectively. In pre-test, 30 marks of mathematics achievement test was administered (see pre-test questions in Appendix-I and pre-test score of students in Appendix-II). The mean, variance and standard deviation of experimental group were 8.03, 15.95 and 3.99 respectively. Similarly, the mean, variance and standard

deviation of control group were 6.44, 9.59 and 3.1 respectively. Here tabulated t-value at $\alpha = 0.05$ level of significance for two tailed test is 1.96 but calculated t-value was 1.74. Calculated t-value was lying in critical region i.e $-1.96 < 1.74 < 1.96$. So H_0 is accepted. Hence, it could be concluded that there is no significance difference between the average achievement score of experimental and control groups students in pre-test. Also, these groups are almost similar with respect to consistency as their c.v. are 49.68% and 48.13%. Thus, both groups were homogeneous.

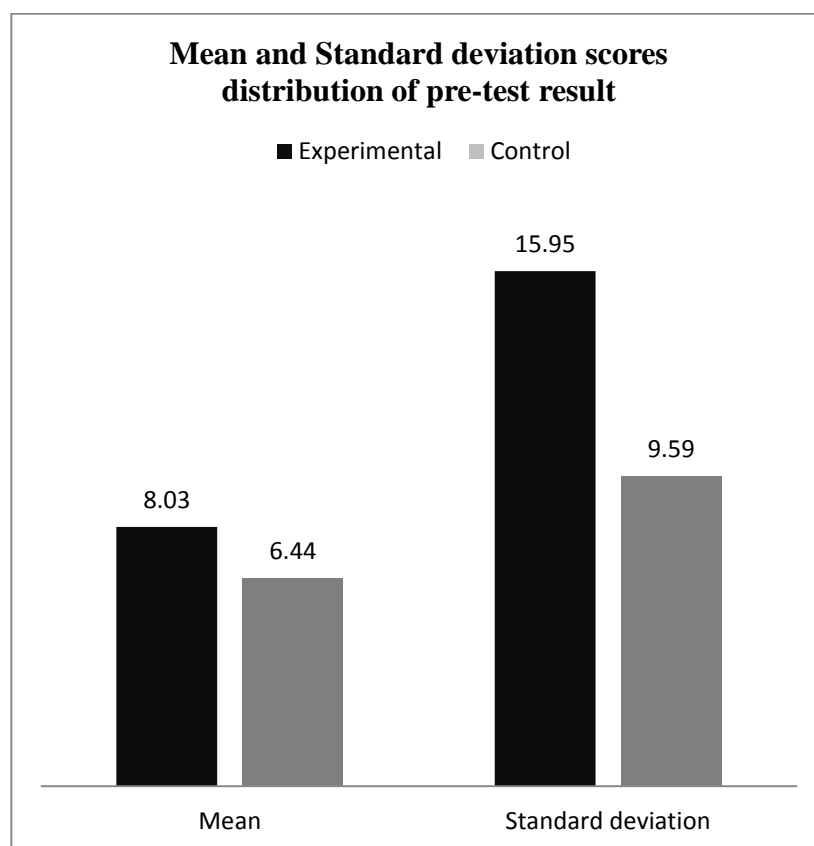**Figure 4.1: Mean and Standard Deviation Scores Distribution of Pre-test Result**

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

Analysis of Post-test Result

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

Table 4.2: Result of Post-test

Group	Number of students	Mean	Variance	Standard Deviation	Calculated t-value	Tabulated t-value
Experimental	$N_1 = 30$	$\bar{x}_1 = 19.83$	$S_1^2 = 28.47$	$S_1 = 5.33$	4.32	1.645
Control	$N_2 = 32$	$\bar{x}_2 = 13.78$	$S_2^2 = 31.64$	$S_2 = 5.62$		

The above Table 4.2 shows that there are 30 and 32 students in experimental and control group respectively. In post-test, the mathematics achievement test of 30 marks was administered (see post-test questions in Appendix-I and post-test score of students in Appendix-III). The mean score of experimental and control group are 19.83 and 13.78 with variances 28.74 and 31.64 respectively. Although, an average achievement score of experimental group is greater than that of control group, it does not ensure that teaching by applying problem solving method is more effective. So, the further analysis is required which is mentioned below:

Here, tabulated t-value at $\alpha = 0.05$ level of significance for two tailed test is 1.645. But, calculated t-value is 4.32. Here $4.32 > 1.645$, so that H_0 is rejected and H_1 is accepted i.e. it can be concluded that there is significance difference between average achievement scores of experimental and control groups. Hence, the average achievement score of experimental group is higher than that of control group on post-test. Thus, the students who were taught by applying problem solving method scored more than the students taught by traditional method of teaching. Also, the scoring pattern of the students of experimental group seems more consistent as the c.v. of experimental group (26.87%) is less than that of controlled group (40.78%).

Mean and standard deviation scores distribution of post-test result

■ Experimental   ■ Control

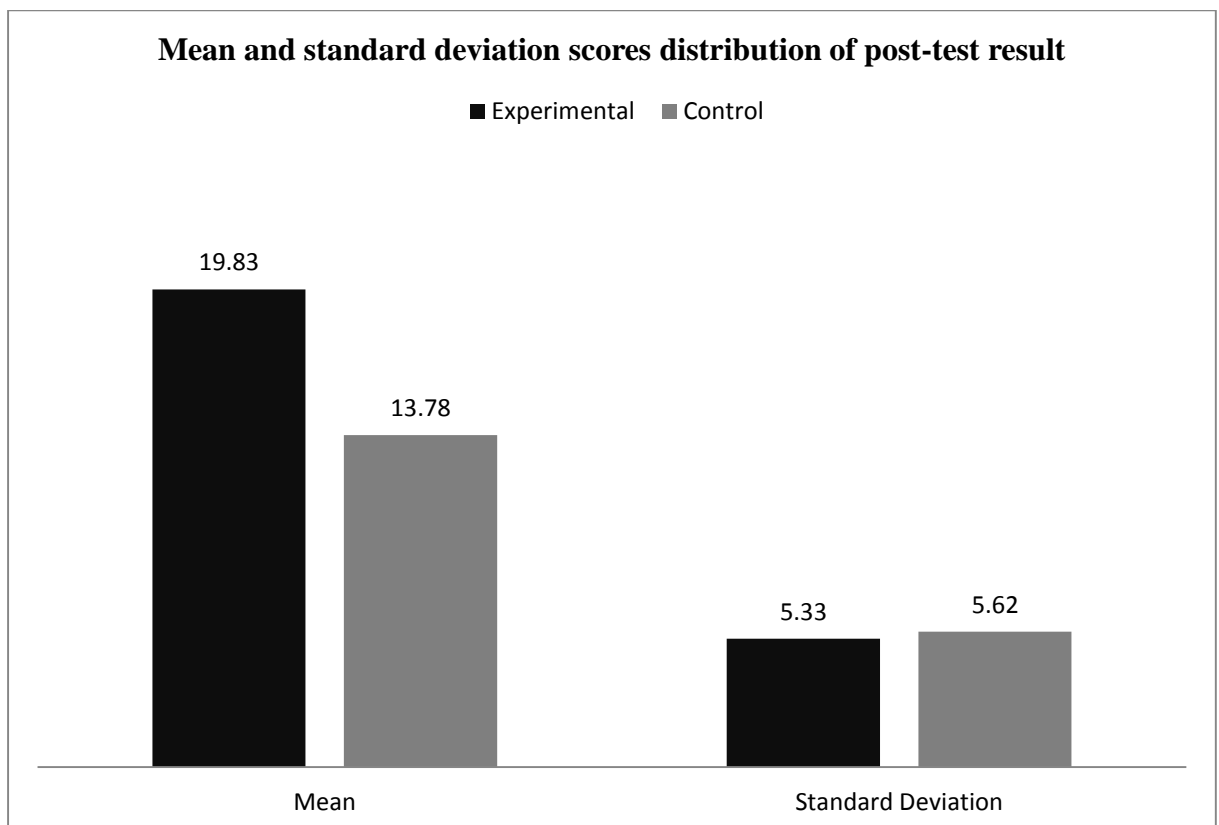|	Experimental	Control
Mean	19.83	13.78
Standard Deviation	5.33	5.62

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

The mean and standard deviation scores obtained by the students of each groups in the achievement test (post-test) score have been shown in above diagram (Figure 4.2). The column of experimental group of students is longer than that of

control group students with respect to mean. This shows that there is a difference in achievement score between experimental group and control group on post-test. Since the difference between the mean, standard deviation on the post-test was 6.05 and 0.29 respectively. Therefore, the diagram (Figure 4.2) indicates that the teaching using problem solving method is more effective than traditional method in teaching geometry

Comparison percentage of mean score on pre-test and post-test

■ Pre-test ■ Post-test

66.1 %

45.93 %

26.76%

21.46 %

Experimental   Control

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

The above diagram (Figure 4.3) shows that percentage of mean score on pre-test of experimental and control group are 26.76% and 21.46% respectively. But percentage of mean score on post-test of experimental group is 66.1% and control group is 45.93%. So 39.34% increment in mean score of experimental group but 24.47% increment in mean score of control group. Therefore, percentage of mean score of experimental group is higher than control group. Thus, the above diagram

shows that the teaching using problem solving method is more effective than traditional method in teaching geometry at grade IX. As a con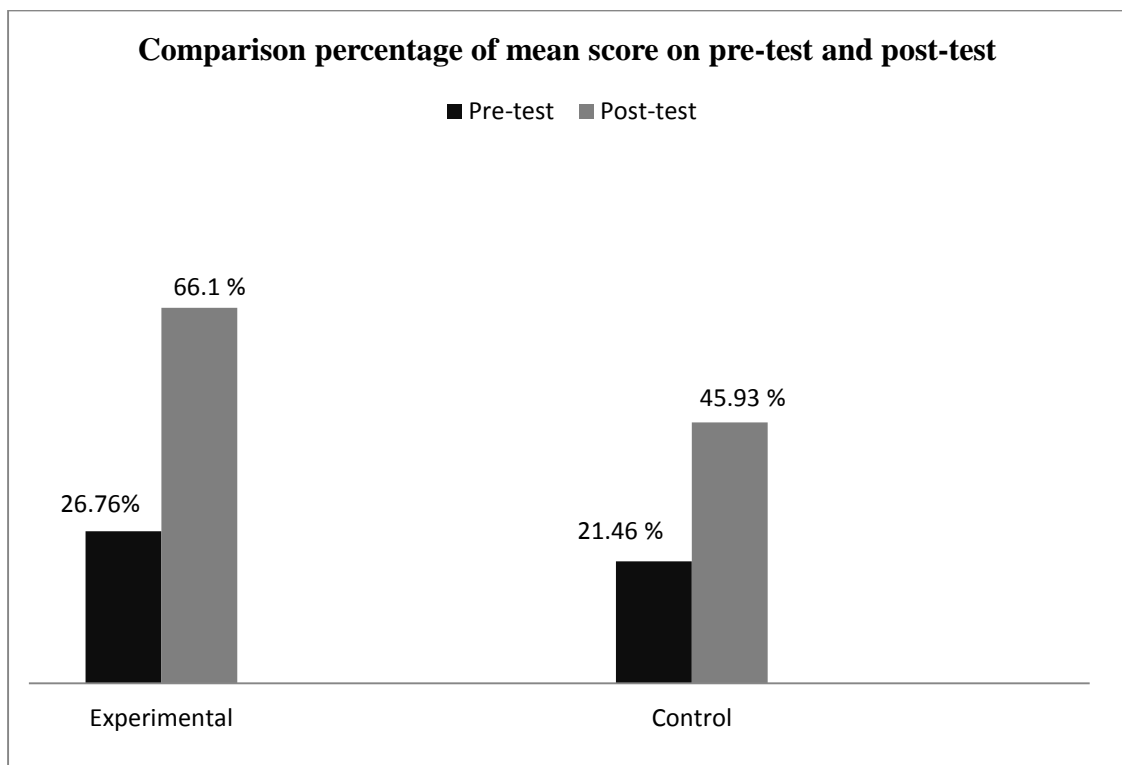clusion, it gives positive result on students' achievement when we apply the steps of problem solving method in teaching geometry at grade IX.

During the experimental period researcher also found that every students of experimental group were curious and interested to learn mathematics seriously and all students of that group were not making noise and also, they told me to teach regularly and to call me time to teach. Similarly researcher had found that his teaching was not effective on control group because students of control group were not curious and interested to learn and also they neglect me. Hence the researcher found that there was significant effectiveness of problem solving on teaching mathematics at grade IX.

This study investigated the effects of problem-solving teaching methods on government school students' mathematics achievement a government school. In this investigation, an experimental research procedure was used. Along with this, a sample of 30 students was taken. Mathematics achievement test (pre-test and post-test) was used. Students in the experimental group were taught using the problem-solving teaching method, while those in the control group were instructed with the traditional teaching method. The post-test constructed by the researcher in the sample unit taught was administrated to both groups immediately after the treatment was over. Finally, the results of the study revealed that the problem-solving teaching method was more effective in teaching geometry when compared with the traditional method at grade IX.

Student-centered method involves students in doing things, interacting, discussing, debating and asking questions, exploring, experimenting and thinking about the things they are doing and observing their own knowledge through active participation. Moreover, the study may contribute to promote an active learning strategy of constructivist approach. Based on the study purpose, the pre-test and post-test as well as classroom observations about the interaction among the experimental group of students and with the researcher were used as data gathering tools. In this respect, subjective type of questions was prepared by the researcher in grade IX mathematics curriculum material. Students' knowledge of fundamental concepts, skills and degree of performance. Generally, three instruments such as pre-test made questions, post-test made questions and classroom observation were used. A pre-test consisting of subjective questions of thirty marks. It was validated by the expert and thereby administered to the selected section of students by the researcher before treatment. Its purpose was to know the knowledge of sample students in the subject area selected and taught for both the experimental and control groups by the researcher using the same time schedule with different teaching methods. In this manner, students in the control group were taught using traditional method, whereas students in the experimental group were taught through problem solving method that involved procedures for solving problems. Then, both groups were taught for three weeks a period of 45 minutes. Along with this, classroom observations were undertaken while students in the experimental group were taught the sample chapter through problem-solving methods to collect detailed data. In the next period, the strong sides were encouraged while the gaps were filled through interactions accordingly until the lesson was completed.

Students Perception and Practice in Learning Geometry

During the period of experimentation, I found that students were interested to learn geometry with problem solving method. At that time, they were actively participated in the learning activities. They made the classroom more interactive with discussing with each other. When I started to teach by using problem solving method, they came to school regularly and gave great effort to learn concepts of geometry.

An opinionnaire related to student's perception towards problem solving method was administered among 30 students of experimental group only (see the statement in Appendix-IV) whose responses are tabulated, the quantitative data are provided in Table 4.3 (in Likert scale). 5, 4, 3, 2 and 1 indicated strongly agree, agree, undecided, disagree and strongly disagree respectively for positive statement. And 1, 2, 3, 4 and 5 indicated strongly agree, agree, undecided, disagree and strongly disagree respectively for negative statement.

Below the Table 4.3, the statements 'I prefer to learn Mathematics with problem solving method and problem solving method makes geometry class boring' have the same mean score i.e. 4.8, which is the highest mean score. While the lowest mean was 2.93 which is obtained from the statement 'At the beginning, I did not like problem solving method. Other items mean were near about the highest mean.

According to Denbel (2015) and Shadaan and KwanEu(2013), a mean score of 3.0 or higher indicates a positive feedback or opinionnare about problem solving method and the mean score lower than 3.0 indicates negative feedback or opinionnare about problem solving method in learning geometry. The result from overall mean 4.35 shows that students generally gave positive feedback about the problem solving method in learning geometry at grade nine.

Table 4.3: Result of Students Perception on Problem Solving Method

S.N.	Statements		Strongly agree	Agree	Undecided	Disagree	Strongly disagree	Total	Weighted Mean	Perception Positive-P, Negative-N
1	Problem solving method helps to learn Mathematical concepts.	fre.	21	9	0	0	0	30	4.7	P
		%	70	30	-	-	-	100		
2	At the beginning, I did not like problem solving method.	fre.	-	16	-	14	-	30	2.93	N
		%	-	53.3	-	46.7		100		
3	I feel confident when the activities are performed by using problem solving method.	fre.	16	14	0	0	0	30	4.53	P
		%	53.3	46.7	-	-	-	100		
4	Using problem solving method makes geometry more difficult for me.	fre.	0	0	2	7	21	30	4.6	N
		%	-	-	6.7	23.3	70	100		
5	I prefer to learn Mathematics with problem solving method.	fre.	27	2	0	0	1	30	4.8	P
		%	90	6.7	-	-	3.3	100		
6	Problem solving method helps solving the problems of geometry significantly.	fre.	23	6	0	1	0	30	4.7	P
		%	76.7	20	-	3.3	-	100		
7	Problem solving method helps to increase my achievement in the geometry	fre.	3	23	0	4	0	30	3.83	P
		%	10	76.6	-	13.3	-	100		
8	Problem solving method can help to make the learning more enjoyable	fre.	10	17	2	1	0	30	4.2	P
		%	33.3	56.6	6.7	3.3	-	100		
9	I am happy if the teachers use problem solving method in teaching geometry	fre.	18	11	0	1	0	30	4.5	P
		%	60	36.7	-	3.3	-	100		
10	Problem solving approach makes geometry class boring.	fre.	0	0	2	2	26	30	4.8	N
		%	-	-	6.7	6.7	86.6	100		
Overall Mean **4.35**										

Note: If the weighted mean is greater than 3, the perception is considered to be positive and if the weighted mean is less than 3 then the perception is considered to be negative.

For the positive statement 1, whose weighted mean is 4.7 which indicates that most of the s students were strongly agree and some were agree with this statement. For the statement 2, 16 students were agree , 14 were disagree and the weighted mean was 2.93 (less than 3) which indicates that majority of the students did not like the problem solving method at the beginning. For the statement 3, 16 students were strongly agree and 14 students were agree with weighted mean 4.53 which means that the students feel confident when the activities are performed by using problem solving method. Similarly for the negative statement 4, the weighted mean is 4.6 which show that most of the students were against the statement that reflects students do not feel difficult to learn the concept of geometry by using problem solving method.

For the positive statements 5, the weighted mean is 4.8 and all most all students were strongly agree and only one student was strongly disagree which represents that the students prefer to learn the geometry by using problem solving method. For the statement 6, the weighted mean is 4.7 with 23 students were strongly agree and 6 students were agree that means problem solving method helps in solving the problems significantly. For the statement 7, most of the students were agree and 4 students were disagree. Although some students were disagree, since the weighted mean was 3.83, it could be concluded that the problem solving approach helps to increase students' achievement in the geometry.

Similarly, for the statement 8, the weighted mean is 4.2 where 10 students were strongly agree and 17 students were agree with this statements that means exactly 90 percent of the students feel that the problem solving approach helps to make the learning more enjoyable. Similarly for the statement 9, 18 students were strongly agree and 11 were agree with the weighted mean 4.5 , the weighted mean

shows that the students would be happy if the teacher uses the problem solving method in teaching mathematics. Finally, for the negative statement 10, the weighted mean is 4.8 where almost all students rejected the statement that means problem solving method does not make geometry class boring at all. The overall mean of the all 10 statements is 4.35 which represents that problem solving method is more applicable in teaching geometry. If we apply problem solving method in teaching geometry, students can learn concepts of geometry in enjoyable and fruitful way.

Statistical result of this study indicates that there is significant difference between the average achievement score of experimental and control group in post-test. Also, above result shows, that problem solving method is very helpful for teaching and learning geometry. Application of problem solving method increases the students' achievement in their learning. Hence, teaching using problem solving method is more effective than traditional method in geometry at grade IX. Moreover, students gave positive response about the problem solving method.

Result of Class Observation

The researcher had developed a class observation form to measure the participation, interest, performance and attendance of the students of the both groups (Appendix Vii). The percentage of the students was calculated as follows: the students are more active in their classroom in experimental group (91.42). The experimental group has more numerical value in attendance, performance and subject matter and participates and interest while comparing it with control group. the use of problem solving method seems to be more effective than the use of traditional method in teaching geometry

Result of Class Observation

		Groups	
		Experimental	Control
Participation and Interest (%)	Active	91.42	78.12
	Moderate	5.71	6.25
	Passive	2.87	15.63
Performance about subject matter (%)	Class work	95	95
	Homework	98	87
Attendance (%)		94	90

From the above table we can easily see that the students are more active in their classroom in experimental group. They seem as if they had done the home works and class works regularly. In the experimental group, 91.42% of the students were actively participated while only 78.12% of the students of the control group were actively participated in the classroom. Moreover, the experimental group has more numerical value in attendance, performance and subject matter and participates and interest while comparing it with control group. More precisely, the use of problem solving method seems to be more effective than the use of traditional method in teaching geometry.

During the experiment time, the students gave me the positive response about problem solving method. They were excited to reply answer of the teacher. At first,

the researcher has prepared some questions orally related to subject, content and method. Then the researcher had taken any five students randomly from experimental group. Also it is known that this method is student center method. Both teacher and student are good participants in this method because without understanding it, we can't go to next step. It is sequential programmed in classroom instruction. Every student was very excited to learn by this method. Student agreed with the step of the problem solving method.

Triangulation of Data

Triangulation refers to the use of multiple methods with theory and result. Here, triangulation of the data sources refers to the process of comparing the result of the data obtained by different tools in order to validate the findings of the research. The tools that used in the research shows that the data obtained by the use of problem solving method for effective teaching of geometry. Since all the data obtained from achievement test, an opinionnaire and class observation form lead to the same result, the finding of this study is thus valid.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSION AND RECOMMENDATIONS

This chapter presents the summary, findings and conclusion of study to improve the achievement level of students while teaching geometry by using problem solving method. Besides findings and conclusion, some recommendations have been forwarded which will be useful for further studies and educational implications.

Summary

This study was started with the problem that whether the use of problem solving method in teaching geometry is effective and at which extent it is and then selecting the topic "effectiveness of problem solving method in teaching geometry at grade IX". Among the different subjects, mathematics plays a vital role in individual's daily life and equally in school level to university level education. This study was focused on the mathematical achievement between control and experimental groups. This study also explores the effectiveness of problem solving method in teaching geometry at grade IX. Before and after the experiment, pre-test and post-test were administered respectively. The scores obtained from both tests were calculated and analyzed to obtain the findings of the study.

To compare the achievement score of the students taught by problem solving method and by using traditional teaching method, the population of this study consisted of all IX grade students of government schools of Dhading district. The students were taken in two groups which were experimental group and control group. The experimental group was instructed by using problem solving method whereas the control group was taught using traditional method. The test scores were calculated and analyzed in terms of their mean, variance and t-value.

The main objective of this study was to compare the achievement score of the students taught by problem solving method and by using traditional teaching method at grade IX. For the achievement of the study, the researcher developed an achievement test and various tools such as mean, variance standard deviation and t-test. The standard deviation and variance were used to test the homogeneity of the test. The effectiveness of achievement difference between the experimental and control groups was also analyzed on the basis of post-test scores of the students.

Findings of the Study

On the basis of analysis and interpretation of the data, the researcher was able to draw the following major findings of the study:

- There was no significant difference between the average achievement score of experimental and control groups on pre-test.

- There was significant difference between the average achievement score of these groups on post-test i.e. the average achievement score of experimental group was higher than that of control group.

- Use of Problem Solving Method helped students to embed geometric concepts. It helped students for meaningful learning.

- The students of experimental group were found to be more motivated and encouraging while learning mathematical problems in geometry than that of the control group. It means, the problem solving method is more effective than traditional method in teaching geometry.

- The active participation, punctuality and regularity in school as well as submitting assignment of the students of experimental group was found to be higher than that of the students of control group.

- The results show that students gave positive views about the problem solving method.

- Problem Solving Method made geometry class more interesting and enjoyable, motivating students in an appropriate way. It was observed during the class and noted as memo.

Conclusion

In this study, the use of problem solving method has been proven as one of the best strategy in teaching geometry for better understanding and learning for performance and increases students' scores than traditional approach of teaching in the context of Nepal. This is reflected through the improved score of the students in experimental group. The findings highlighted that the students in experimental group performed better using the problem solving method than the control group using the traditional method. Students in the experimental group performed better in the post-test compared to the control group. It increases the confidence level of students. Students generally gave positive views about the problem solving method while teaching geometry at grade IX. Students felt more comfortable while teaching geometry at grade IX applying problem solving method. I am sure that this will be the breakthrough for the teachers, students, school administrators and policy makers to apply this approach for teaching and learning geometry at this secondary level. So, I prefer this method to apply in teaching geometry at grade IX to all the mathematics teachers who are associated at secondary level.

In addition, the use of PSM provides the opportunities for interaction between students-students and teacher – students, during the learning sceneries and thus students are provided ample opportunities of learning through social interaction.

Implications of the Research

The result of the study has wide implications for mathematics teaching and learning. Improvement in achievements taught by this PSM method can reduce the effort devoted to tedious computations and increase students' focus on more important mathematical concepts. It could represent mathematics in ways that help students to understand concepts. PSM is essential and necessary in teaching and learning mathematics.

Recommendations for Better Learning

This study only focused the identification of the effectiveness of PSM in teaching geometry in terms of the students' achievement and perception based on quasi experimental research design taking only a few sample for the convenience of the researcher. On the basis of the findings, the researcher recommended some measures for the betterment of teaching mathematics. The recommendations are as follows:

- Active participation in classroom activities should be encouraged.

- The teacher should be trained and frequent training to the teachers should be emphasized.

- The mathematics teacher should be encouraged to use problem solving method while teaching geometry.

- The teacher training institutions should emphasize on problem solving method of teaching mathematics.

- The teacher should let the students to discover the answer of the given question on their own way instead of teachers' answer.

- The textbook writer, curriculum designer, policy maker should emphasize on problem solving method while making policy, and designing curriculum and textbooks.

- Teaching module should be highly technical to assist teaching and learning mathematics. So, teachers should be encouraged to use daily lesson plan with effective teaching materials.

Recommendations for Further Study

Since this study was limited in several aspects, the finding of this study can be generalized for Dhading district but cannot be generalized to all level all over the world. So, considering the limitation, the following recommendations have been made:

- This study has been performed only on mathematical achievement scores of class IX students. So, similar studies should be replicated in other subjects.

- It can be generalized for Dhading district but cannot be generalized all over the country. So, it is suggested to carry out separate nationwide research for the future researchers.

- Further study should be conducted with larger samples size. Complete random samples are needed in order to obtain more valid findings for broader generalization.

- The score of the students of experimental group was found better than that of control group. So, teacher should be trained and teaching should be managed properly for their better outcomes.

- In order to create consistency in score, the students should be taught through problem solving methods and traditional rote learning should be discouraged gradually.

- Resources, materials and qualified teachers are not easily available in schools. So, there should be easy access to these aspects in the public schools.

Daily lesson plan, effective teaching materials and internal assessment should be introduced by the concerned authority. This could bring better performance and outcomes among the school students. Therefore, workshop, seminars and conferences of the teachers should be organized, under the leadership of office that are related education. So, that improvement in the teaching learning activities and use of relevant technique of teaching mathematics can be promoted at the local level.

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APPENDIX-I

The Achievement Test (Pre-test/Post-test)   **F.M:30**
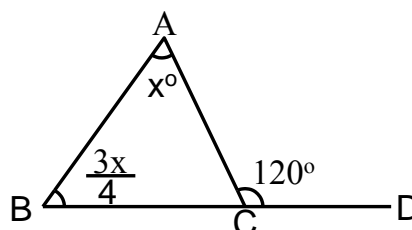
Group 'A' [5×2=10]

1. तल दिइएको त्रिभुजबाट 'x' को मान निकाल्नुहोस् ।

   (Find the value of 'x' from the given triangle.

2. i) समानान्तर चर्तुर्भुजको दुई गुणहरु लेख्नुहोस् ।

   (Write any 2 features of parallebgram)

   ii) समबाहु चर्तुर्भुजको दुई गुणहरु लेख्नुहोस् ।
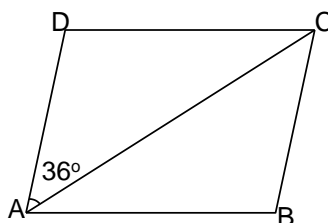
   (Write any two features of rhombus)

3. संगैको चित्रबाट ABCD एउटा समबाहु चर्तुर्भुज हो । यदि ∟DAC 60º भए ∟ABC को मान निकाल्नुहोस्

   (In the adjoining figure, ABCD is a rhombus. If ∟DAC 60º then find the value of ∟ABC.

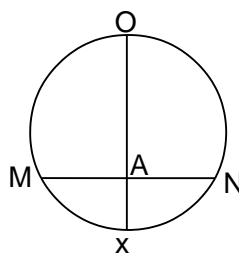

4. In the given figure, O is the center of the circle if OA⊥MN at a point A, MN = 24cm and OA =5cm, find the length of AX.

5. i) Can we construct a triangle having length 2cm, 5cm and 1cm? Write with reason.

(2cm, 5cm र1cm बाट एउटा त्रिभुज रचना गर्न सकिन्छ ? कारण सहित लेख्नुहोस् ।)

ii) What is the measure of each angles of right angled isosceles triangle?

(समकोणी समद्विबाहु त्रिभुजको प्रत्येक कोणको नाप कति हुन्छ ?)

Group 'B' [5×4=20]

6. समद्विबाहु त्रिभुजको आधारका कोणहरु बराबर हुन्छन् भनी प्रमाणित गर्नुहोस् ।

   (Prove that the base angles of an isosceles triangle are equal.)

7. समानान्तर चर्तुर्भुजको सम्मुख कोणहरु बराबर हुन्छन् भनी प्रयोगद्वारा सिद्ध गर्नुहोस् ।

   (Experimentally verify that the opposite angles of paralleogram are equal.)

8. दिइएको चित्रमा PT = 8cm, PQ = 12cm, PS = 10cm छन् भने

i) PR को मान निकाल्नुहोस् ।

ii) PR: PS को मान निकाल्नुहोस् ।

   (In the figure, PT = 8cm, PQ = 12cm and

   PS = 10cm then,

i) Find the length of PR

ii) Find the value of PR: PS
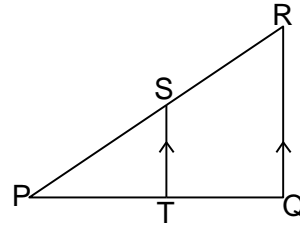
9. तलको चित्रबाट थाहा नभएको कोणको नाप निकाल्नुहोस्
   (Find the size of unknown angles from
   the figure given below.)

10. दिइएको चित्रमा o वृत्तको केन्द्रविन्दु र m जीवा PR को मध्यविन्दु भए om⊥PR हुन्छ भनि प्रमाणित गर्नुहोस् ।

    (In the given figure, o is

    the centre of circle and m

    is the mid point of the

    chord PR, prove that

    om⊥PR.)

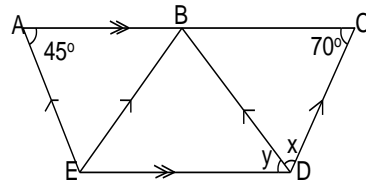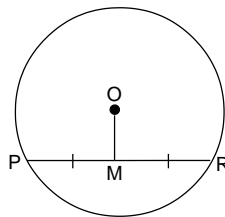## Score of pre-test

S.N.	Sym. No.	Score of Students in Experimental Group	Sym. No	Score of Students in Control Group
1	A7701	11	B7701	6
2	A7702	14	B7702	9
3	A7703	8	B7703	10
4	A7704	13	B7704	8
5	A7705	10	B7705	8
6	A7706	17	B7706	7
7	A7707	6	B7707	11
8	A7708	12	B7708	6
9	A7709	10	B7709	5
10	A7710	10	B7710	6
11	A7711	13	B7711	5
12	A7712	9	B7712	5
13	A7713	11	B7713	10
14	A7714	4	B7714	13
15	A7715	2	B7715	9
16	A7716	9	B7716	4
17	A7717	10	B7717	7
18	A7718	12	B7718	6
19	A7719	11	B7719	4
20	A7720	3	B7720	6
21	A7721	6	B7721	8
22	A7722	5	B7722	10
23	A7723	7	B7723	10
24	A7724	3	B7724	11
25	A7725	4	B7725	7
26	A7726	8	B7726	1
27	A7727	4	B7727	3
28	A7728	1	B7728	4
29	A7729	4	B7729	1
30	A7730	4	B7730	1
31		Total: 241	B7731	2
32			B7732	3
			Total: 206	
$N_1 = 30$, $\bar{x}_1 = 8.03$, $s_1^2 = 15.95$, $s_1 = 3.99$			$N_2 = 32$, $\bar{x}_2 = 6.44$, $s_2^2 = 9.59$, $s_2 = 3.1$	

Note: N_1 and N_2 denote the number of students

$\overline{x_1}$ and $\overline{x_2}$ denote the mean

s_1^2 and s_2^2 denote the variance

s_1 and s_2 denote the standard deviation

Score of post-test

S.N.	Sym. NO.	Score of Students in Experimental Group	Sym. No.	Score of Students in Control Group
1	A7701	29	B7701	23
2	A7702	24	B7702	18
3	A7703	28	B7703	18
4	A7704	30	B7704	23
5	A7705	27	B7705	16
6	A7706	18	B7706	25
7	A7707	23	B7707	12
8	A7708	21	B7708	11
9	A7709	22	B7709	18
10	A7710	23	B7710	8
11	A7711	24	B7711	13
12	A7712	21	B7712	16
13	A7713	22	B7713	20
14	A7714	21	B7714	24
15	A7715	26	B7715	13
16	A7716	20	B7716	17
17	A7717	15	B7717	19
18	A7718	20	B7718	8
19	A7719	16	B7719	9
20	A7720	20	B7720	14
21	A7721	11	B7721	9
22	A7722	13	B7722	18
23	A7723	21	B7723	13
24	A7724	13	B7724	11
25	A7725	14	B7725	10
26	A7726	9	B7726	7
27	A7727	16	B7727	12
28	A7728	18	B7728	11
29	A7729	16	B7729	4
30	A7730	14	B7730	9
31		Total: 595	B7731	7
32			B7732	5
				Total: 441
	$N_1 = 30$, $\bar{x}_1 = 19.83$, $s_1^2 = 28.47$, $s_1 = 5.33$		$N_2 = 32$, $\bar{x}_2 = 13.78$, $s_2^2 = 31.64$, $s_2 = 5.62$	

Note: N_1 and N_2 denote the number of students
$\overline{x_1}$ and $\overline{x_2}$ denote mean
s_1^2 and s_2^2 denote variance
    s_1 and s_2 denote standard deviation

APPENDIX-IV

Students' Perception on Problem solving Method

Name: ....   Class: IX

Roll No.: ....   Subject: C. Mathematics

School: ....

S.N.	Items	Strongly agree	Agree	Undecided	Disagree	Strongly disagree	Total
1	Problem solving method helps to learn Mathematical concepts.						
2	At the beginning, I did not like problem solving method.						
3	I feel confident when the activities are performed by using problem solving method.						
4	Using problem solving method makes geometry more difficult for me.						
5	I prefer to learn Mathematics with problem solving method.						
6	Problem solving method helps solving the problems of geometry significantly.						
7	Problem solving method helps to increase my achievement in the geometry						
8	Problem solving method can help to make the learning more enjoyable.						
9	I am happy if the teachers apply problem solving method in teaching geometry.						
10	Problem solving method makes geometry class boring.						

Reliability of the test

S.N.	Scores on odd items (X)	Scores on even items (Y)	X^2	Y^2	XY
1	10	13	100	169	130
2	7	7	48	49	49
3	8	11	64	121	88
4	10	7	100	49	70
5	13	15	169	225	195
N = 5	$\sum X = 48$	$\sum Y = 53$	$\sum X^2 = 482$	$\sum Y^2 = 613$	$\sum XY = 532$

$$\text{Correlation Coefficient } (r_{oe}) = \frac{N\sum XY - \sum X \sum Y}{\sqrt{\left\{N\sum X^2 - (\sum X)^2\right\}\left\{N\sum Y^2 - (\sum Y)^2\right\}}}$$

$$= \frac{5 \times 532 - 48 \times 53}{\sqrt{106 \times 256}}$$

$$= \frac{116}{164}$$

$$= 0.71$$

$$\text{Reliability Coefficient } (r) = \frac{2r_{oe}}{1 + r_{oe}}$$

$$= \frac{2 \times 0.71}{1 + 0.71}$$

$$= \frac{1.42}{1.71}$$

$$= 0.83$$

APPENDIX -VI

Item analysis

S.N./Question Number	Difficulty Level	Selected/Rejected	Remarks
1. (1)	0.52	Selected	
2. (2i)	0.45	Selected	
3. (2ii)	0.55	Selected	
4. (3)	0.20	Rejected	Very Difficult
5. (4)	0.60	Selected	
6. (5i)	0.90	Rejected	Very Easy
7. (5ii)	0.5	Selected	
8. (6)	0.65	Selected	
9. (7)	0.5	Selected	
10. (8i)	0.6	Selected	
11. (8ii)	0.55	Selected	
12. (9)	0.4	Selected	
13. (10)	0.15	Rejected	Very Difficult

APPENDIX - VII

Class Observation Form for Experiment Phase

Homework and Interest about Subject Matter: Check List

Date: ………………………………. Group:……………

Roll No.	Name of Students	Participation and Interest			Performance about Subject Matter		Attendance
		Active	Moderate	Passive	Classwork	Homework	
1							
2							
3							
4							
5							
6							
7							
8							
9							
…..							

Statistical formula used in data collection and analysis procedure

S.N.	Subject	Notation	Formula
1	Pooled Variance	S_P^2	$$\dfrac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$$
2	t - distribution	T	$$\dfrac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{S_P\sqrt{\dfrac{1}{n_1} + \dfrac{1}{n_2}}}$$
3	F-distribution	F	$$\dfrac{S_1^2}{S_2^2}$$
4	Degree of freedom	$d.f.$	$n_1 + n_2 - 2$
5	Pearsons's Correlation Coefficient	r_{oe}	$$\dfrac{N\sum XY - \sum X \sum Y}{\sqrt{\{N \sum X^2 - (\sum X)^2\}\{N \sum Y^2 - (\sum Y)^2\}}}$$
6	Reliability Coefficient	R	$$\dfrac{2\,r_{oe}}{1 + r_{oe}}$$
7	Coefficient of Variation	$c.v.$	$$\dfrac{\sigma}{\bar{x}} \times 100\%$$

APPENDIX - IX

Time Duration of Experimental Phase

	Control Group	Experimental Group
Pre-test	2077/08/25	2077/08/25
Experimental Phase	2077/09/01-2077/09/29	2077/09/01-2077/09/29
Post test	2077/10/04	2077/10/04
Student's Perception	- - -	2077/10/03
checklist	During in the experimental phase	

TEACHING EPISODE-1

Teaching Unit : Triangle   School's Name: Sangkosh Secondary school.

Teacher's Name: Ganesh Pathak   Time : 45 min.

Teaching Learning Process

i)   Teaching unit: Sum of the interior angles of triangles.

Experimental Verification:

1st Step: Start the lesson by asking the question about triangle and help them to find the answer if it is necessary. After this write the example on board related to the topic and ask that do you understand all the words given in the problem? Then,

teacher will display different shape and size of triangles on the board and ask students to draw these figures on their copy.

Fig.i   Fig.ii   Fig.ii
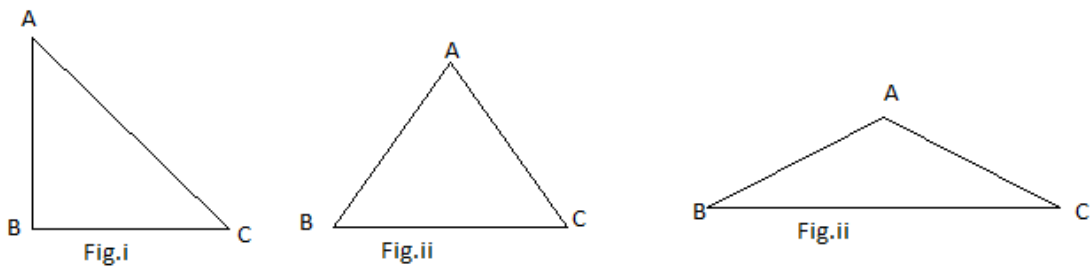
Divide the students into three groups and ask students to find the measure of $< A, < B$ and $< C$, fill as in the below table.

Figure	<A	<B	<C	Result
1				<A+<B+<C =
2				<A+<B+<C =
3				<A+<B+<C =

2nd step : If the students can't response appropriately then give them to consider and make them aware by asking some related questions. Teacher will guide to the students in group (not more than two or three minutes provides for each group) about how to measure the angles of triangles.

3rd step: In this section, questions will be asked to guide the students and think of the plan. If the students can't do it, the teacher will give some ideas.

Presentation of group report by students and discussion will be made about group report.

4th step: The teacher will give the students to examine for their inferred answer. The students will find out whether it has been solved by right way or not.

Teacher will give the conclusion as "sum of interior angles of a triangle is 180°

Post Learning Activities

Teacher will give some problems as post learning activities:

1. Find the value of x from the given figure;
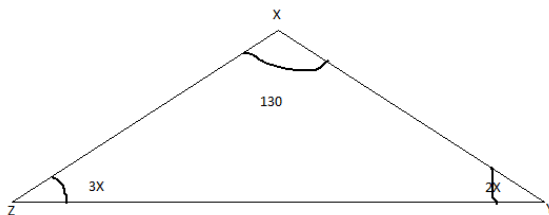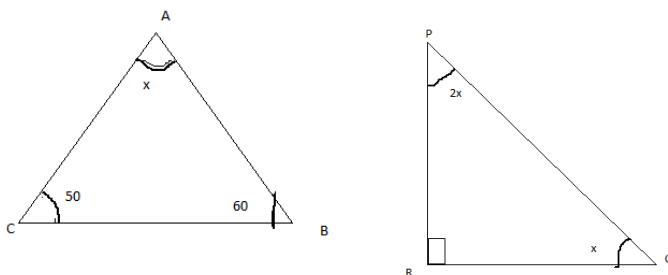
TEACHING EPISODE 2

Teaching Unit: Triangle   School's Name: Sangkosh Secondary School

Teaching Topic: Exterior angle of a triangle is equal to the sum of opposite interior angles.

Teaching Learning Process

Experimental Verification

1st Step

Teacher will draw different shape and size of triangle and produce a side to make an exterior angle on the board and ask students to draw these figures on their copy.
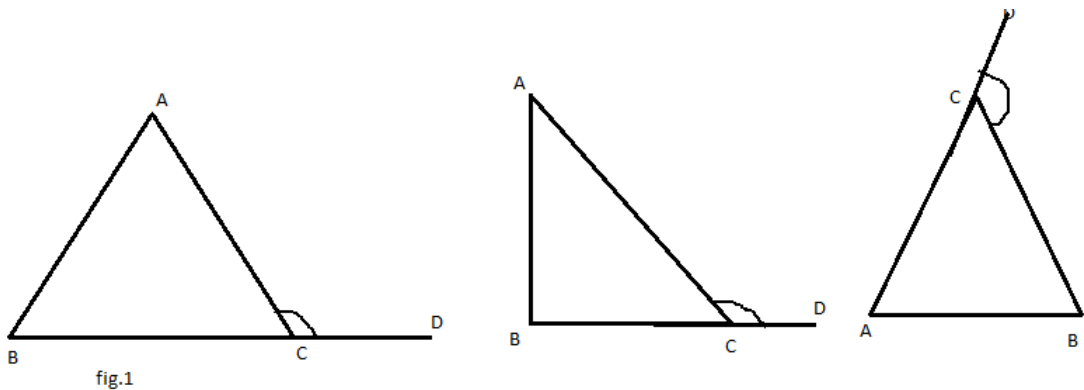
Teacher will give the below table as task for them from the above figures.

Figures	$< A$	$< B$	$< ACD$	Result
1				
2				
3				

2nd step

Teacher will instruct the students to fill the table in mass. Also he will guide some weak students about how to measure the interior and exterior angles and give feedback for others. Then, he will ask students to find relation between exterior angle and sum of two opposite interior angles.

3rd Step

Teacher will collect all different response from student and check their task and correct if necessary and give suggestion.
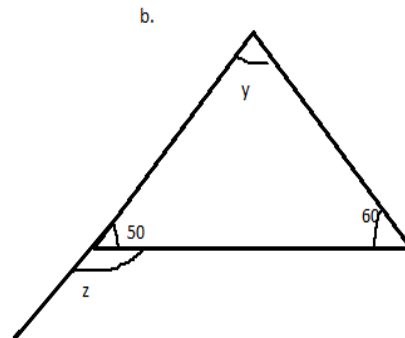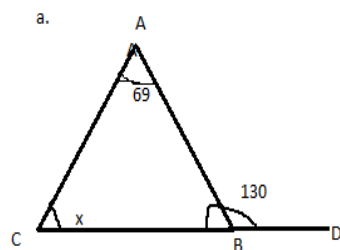
4th Step

Finally teacher will draw the conclusion as "the exterior angle of a triangle is equal to the sum of non adjacent interior angles."

Post Learning Activities

Teacher will give the following problems for post learning activities;

1. Find the value of x, y and z from the adjoining figures
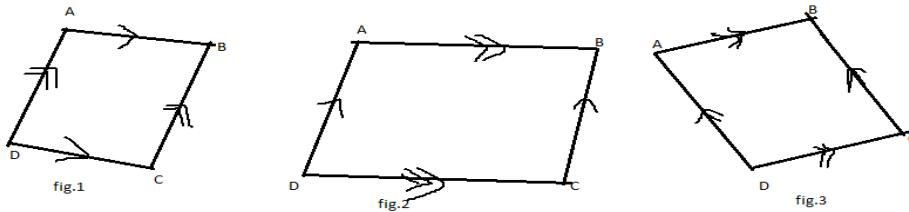
TEACHING EPISODE 3

Teaching Unit: Parallelogram

Teaching Topic: Opposite angles of parallelogram are equal

Experimental Verification

1st Step

Teacher will display different shape and size of the figures of parallelogram on the board and ask students to draw same figures on their copy.

Teacher will say to measure all angles of parallelogram and fill in the table.

Figures	<A	<B	<C	<D	Result
1					
2					
3					

2nd step

Teacher will guide some weak students about how to measure the angles of parallelogram.

Also, he asks students to take result from the obtained data and measurements.

For this he will ask, what is the relation between opposite sides?
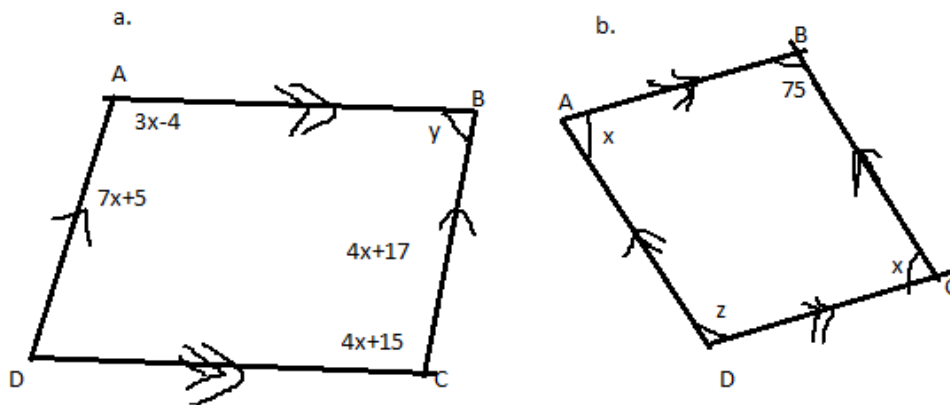
3rd Step

Teacher will check their task and correct if necessary and give suggestion for betterment.

4th step

At finally teacher will draw the conclusion as "opposite angles of the parallelogram are equal".

Post Learning Activities

Teacher will give following problems for post learning activities;

TEACHING EPISODE 4

Teaching Unit: Parallelogram

Teaching Topic: Diagonals of parallelogram bisect each other

Experimental Verification

1st Step

Teacher will display different shape and size of the figures of parallelogram with diagonals on the board and ask students to draw same figures on their copy. And let them to find relation between in the diagonals.

fig. 1   fig.2   fig.3
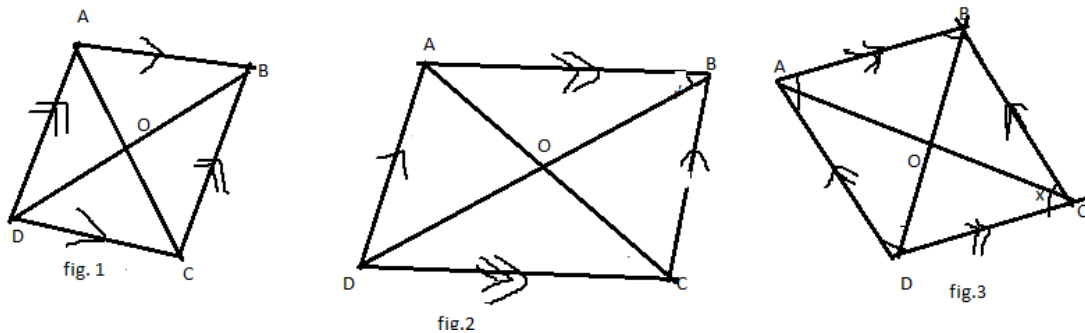
Teacher will say to measure the segment of diagonals and fill in the table.

Figures	OA	OB	OC	OD	Result
1					
2					
3					

2nd step

Teacher will give hints to find the relation as, i.e. measure OA, OB, OC and OD of each figures.

3rd step

Teacher will check their task and collect the different result from students and discussion will be made to find the conclusion.
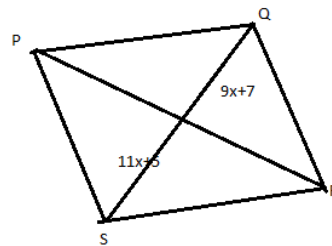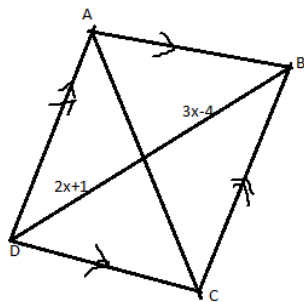
4th step

At last teacher will give conclusion as " Diagonals of a parallelogram bisect each other".

Post Learning Activities

Teacher will give following problems for the post learning activities.

1. Find the value of X from the given figures.

Subject: C. Mathematics   Duration of lesson: 45 minutes

Class: IX   Teacher: Ganesh Pathak

Topic: Similarity   School: Sangkosh Secondary School

1. Specific Objectives:

At the end of this class, the students will be able to find the value of unknown sides in similar triangles.
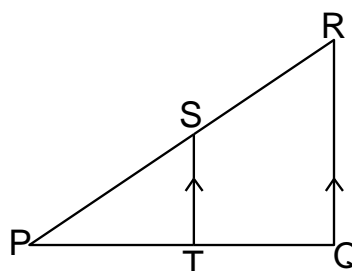
2. Teaching Materials:

Daily used teaching materials, Chart paper

3. Teaching Learning Activities:

Problem:

In the figure, PT = 16cm, PQ = 24cm and PS = 20cm then,

i) Find the length of PR

ii) Find the value of PR: PS

For 10 minutes:

i. Understanding the Problem:

Recall the previous lesson by giving question and help the students to find ratio if necessary. After this write an example on the board related to the topic. Ask them some questions such as:

a. Do you understand all the words in the problem?

b. What is given here?

c. What is to be found in the problem?

The students will see the problem and try to state it in their own words. If they can't response correctly, the teacher will give them time to consider and make them motivated by some questions and the teacher shows electricity bills and explains.

For 20 minutes:

ii. Thinking of a Plan and Carrying out Plan:

In this section, the teacher commands the students to -

a. What does similarity mean?

b. What does ratio of corresponding sides mean?

c. How can it be solved?

The teacher will guide the students to find the ratio between two triangles.

For 10 minutes:

iii. Looking Back:

In this step, the students will be given to examine the problem and the solution. The teacher will ask the following questions:

a. Can you examine each steps of the problem?

b. Are these steps correct?

c. Can you prove each step by appropriate reason?

d. Can you solve this problem by alternative method?

4. Homework:

Solve the problem from 1 to 5 given on exercise 15 of page number 157.

TEACHING EPISODE - 6

Class: IX   Duration of lesson: 45 minutes

Subject: C. Mathematics   Teacher: Ganesh Pathak

School: Sangkosh Secondary School

Topic: A perpendicular drawn from the centre of a circle to a chord, bisects the chord.

1. Specific Objective:

At the end of this class the students will be able to establish the relation that perpendicular drawn from the centre of a circle to a chord

2. Teaching Materials:

Daily used teaching materials, compass, drawing materials

3.Teaching Learning Activities

Firstly**,** teacher will motivate the students to make the discussion about definition of terms related to circle. (radius, arc, chord….) and make clear these concepts if the students will have any misunderstanding.

a) Understanding the problem: Teacher will ask them to try to understand the meaning each word and overall problems. (what are given and what are to be calculated)

b) Making the plan: Teacher will motivate the students to make overall plan to solve the problem.

c) Carry out the plan: Teacher will ask the students to perform the steps according as the plan and carry out the problem

    i)   Three circles with centre O and different radii are drawn.

    ii)   In each circle, a chord AB of different lengths is drawn.

    iii)   OP is perpendicular to AB is drawn in each circle.
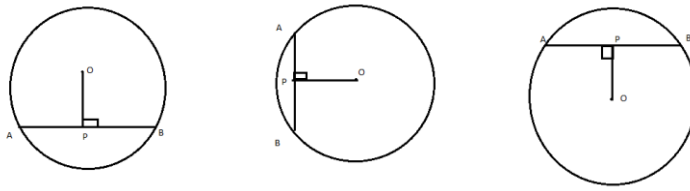
iv)   The lengths of AP and PB are measured and the result are tabulated.

Figure	AP	BP	Result
(i)			AP=BP
(ii)			AP=BP
(iii)			AP=BP

Conclusion: The perpendicular drawn from the centre of a circle to a chord, bisects the chord.

d) Looking back: Teacher will ask the students to review the solution, check the length and whether or not they have got the solution that the question has demanded.

After finding the solution of the problem, teacher will revise those steps that they followed while solving the problem i.e. understanding the problem, making a plan, carry out the plan and looking back. Finally, teacher will introduce that the students used problem solving method to find the solution and teacher will motivate the students to use this method to solve further problems.

4. Evaluation:

Teacher will give same statements and ask them to measure the length and let them to solve same type of questions.

5. Looking back:

Teacher will give same statements and tell them to verify by different name and size

TEACHING EPISODE - 7

Class: IX   Duration of lesson: 45 minutes

Subject: C. Mathematics   Teacher: Ganesh Pathak

School: Sangkosh Secondary School

Topic: Equal chords of a circle are equidistant from the centre.

1. Specific Objective:

At the end of this class the students will be able to establish the relation that Equal

chords of a circle and distance from the centre.

2. Teaching Materials:

Daily used teaching materials, compass, drawing materials

3.Teaching Learning Activities

Firstly**,** teacher will motivate the students by revising the terms related to circle. (

radius, arc, chord….)

a) Understanding the problem: Teacher will ask them to try to understand the meaning

each word and overall problems. (What are given and what are to be measured)

b) Making the plan: Teacher will motivate the students to make overall plan to solve

the problem.

c) Carry out the plan: Teacher will ask the students to perform the steps according as

the plan and carry out the problem

   i)   Three circles with centre O and different radii are drawn.

   ii)   Two equal chords AB and CD of different lengths are drawn in each circle,

   iii)   OP perpendicular to AB and OQ perpendicular to CD are drawn in each

           circle.

fig. i   fig. ii   fig. iii
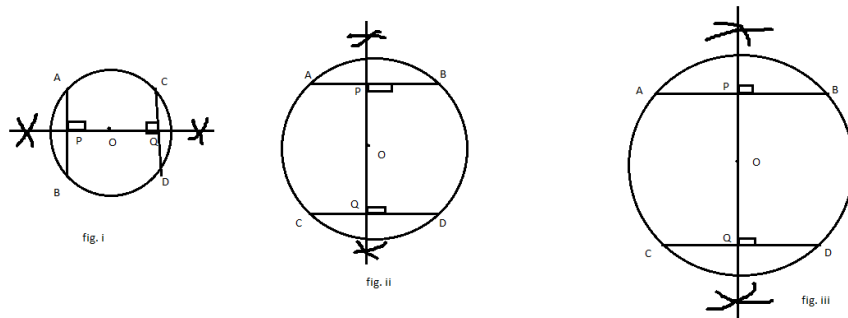
iv)   The lengths of OP and OQ are measured and the result are tabulated.

Figure	OP	OQ	Result
(i)			OP= OQ
(ii)			OP= OQ
(iii)			OP= OQ

Conclusion: Equal chords of a circle are equidistant from the centre.

d) Looking back: Teacher will ask the students to review the solution, check the length and whether or not they have got the solution that the question has demanded.

After finding the solution of the problem, teacher will revise those steps that they followed while solving the problem i.e. understanding the problem, making a plan, carry out the plan and looking back. Finally, teacher will introduce that the students used problem solving method to find the solution and teacher will motivate the students to use this method to solve further problems.

4. Evaluation:

Teacher will give same statements and ask them to measure the length and let them to solve same type of questions.

5. Looking back:

Teacher will give same statements and tell them to verify by different name and size.