

**EFFECTIVENESS OF CONSTRUCTIVIST APPROACH ON THEOREM  
PROVING**

**A**

**THESIS**

**BY**

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**FOR THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR  
THE DEGREE OF MASTER OF EDUCATION.**

**SUBMITTED**

**TO**

**DEPARTMENT OF MATHEMATICS EDUCATION**

**CENTRAL DEPARTMENT OF EDUCATION**

**UNIVERSITY CAMPUS**

**T.U KIRTIPUR**

**KATHMANDU**

**NEPAL, 2015**



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**Letter of CERTIFICATE**

This is to certify that **Mr. Narayan Prasad Neupane**, a student of the academic year 2068/069, Exam roll No. 281702 and T.U. Regd. No. 9-2-1-1043-2007 has completed his thesis under my supervision during the period prescribed by the rules and regulation of T.U., Nepal. The thesis entitled "Effectiveness of Constructivist Approach on Theorem Proving" has been prepared based on the result of his investigation conducted during the period 2014/015 at the Department of Mathematics Education, Central Department of Education, University Campus, Tribhuvan University, Kirtipur, Kathmandu. I recommend and forward that his thesis be submitted for the evaluation for awarding the Degree of Master of Education.

(Mr. Abatar Subedi)

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**EFFECTIVENESS OF CONSTRUCTIVIST APPROACH ON THEOREM PROVING** has been Approved in Partial Fulfillment of the Requirements of the Master Degree in Mathematics Education.

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## ACKNOWLEDGMENT

I am delighted to express earnest gratitude and deepest appreciation to Mr. Abatar Subedi, My research supervisor, from Department of Mathematics Education for his providing valuable time, encouragement, suggestion, comments and continuous guidance during the preparation of this thesis.

I express my heart-felt gratitude to Mr.Laxmi Narayan Yadav, Head Department of Mathematics Education, for his valuable encouragement, suggestion, generous comments and continuous guidance during the preparation of this study.

I would like to express my sincere gratitude to Prof. Dr. Hari Prasad Upadhyay, Prof. Dr. Min Bhadur Shrestha and faculty members of mathematics education Department in the Central Department Education, University Campus Kirtipur for their co-operation in finalizing the title of this thesis and improving the format of the study report.

I am grateful to Mr. Surya B.C, founder and teacher of Suvakamana Boarding School and Mr. Mukesh Katuwal, teacher of Kathmandu Bern Hardt School. I am especially grateful to all the teachers and students for their active participation and co-operation extended to the researcher during the phase of data collection for this study.

Last but not least, I am thankful to all my friends who helped directly or indirectly to completing this thesis. I am deeply indebted to the authors that I consulted several books, thesis and papers on the period of this thesis preparation.

Finally, deep appreciation is felt for my parents Hari Prasad Neupane and Ambika Neupane for my brother Janak Neupane and my sisters Indira and Laxmi Neupane for their encouragement and support.

Narayan Prasad Neupane

### Abstract

The present study “Effectiveness of constructivist approach on theorem proving” was an experimental research. Especially, following research questions the investigator started this study i) Does the constructivist approach proving theorem of geometric is more effective than the traditional approach? ii) dose constructivist approach able to encourage the habit of self-learning and self- correcting?

A pre-test equivalent group design was adopted for the purpose of the study. The population of this study was 9<sup>th</sup> grade students of Kathmandu District in the academic year 2071. Researcher selects two schools i.e. Suvakamana Secondary Boarding School, Taudha, Kathmandu and Kathmandu Bern Heart H.S School, Bhalku Chowk, Kathmandu. Grade IX all the student of Suvakamana School and grade IX all student of the Bern Hardt Schools are the sample of this study. One school of above school was experimental group and another school was control group. Determination of experimental and control group was carried out by tossing a coin. In this study, Suvakamana School is experimental group and Bern Hardt School is control group. Thus, researcher was use constructivist approach in Suvakamana Shool and tradition approach use in Bern Hardt School.

The instrument adopted in this research was an achievement test in topic of geometric theorem proves. The items for achievement test were developed by the researcher himself. Experimental and control groups of students were made homogeneous as nearly as possible. Experimental and control group were taught the same topic of geometry (Triangle, parallelogram) by using constructivist approach and tradition approach respectively.

For the collection of data, the researcher developed ten objective type questions and eight subject type questions. Researcher was also noted daily students behavior and developed the observation note for the purpose of looking student’s behavior change.

At the end of instruction period, both groups were post-test with the same set of test items in each school. The result of the pre-test and post-test of both groups were analyzed using statistical devices such as mean, S.D, Variance and t-test. Then qualitative data were analyzed by using following steps Data, Coding, Memo-writing, Theoretical sample and interpretation.

Finally, researcher concluded that the achievement of students taught by constructivist approach of teaching improved significantly batter then the achievement of taught by tradition approach, Moreover, constructivist approach was able to encourage the habit of self-learning and self-correcting.

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## Chapter: I

### INTRODUCTION

#### Background of the Study

The word “Mathematics” has been derived from the ancient world. It is an exact Science which is related to measurement, calculation, covers relationships and deals with the problems of space. Mathematics has been developed to fulfill human needs. So, mathematics is the necessity of the civilization. Thus, in our daily life we must relate mathematics to History, Science, Logic, Philosophy, Social science, Art music, Literature and many other disciplines.

Mathematics is useful and necessary day to day of human life. It is more applicable due to the invention of science and technology because mathematics can be used all disciplines. Moreover mathematics is the key of all sciences. A lack of mathematics knowledge everything doors has been closes. So, mathematics and human life is the two sides of a coin. Without mathematics education the human life is meaningless.

Mathematics is aroused by the human activities and thiamin mathematics was reserved by each any field and every living thing which enclose after human activities human creation. So, the main steps of development mathematics are Recording or Protection period, Negligence period, and Rebirth of mathematics period. Sharma & Chettri (2067)

The English word ‘geometry’ developed by Greek world “Earth measure” means measure of earth or land. Geometry is born by measure of earth and calculates material’s length, breath, area and volume in ancient Babylonian civilization. In ancient period Babylonian used geometry mostly. Babylonian has the concept of geometry in the period of 2000 to 1600 B.C, which was the starting phase of geometry development. Area of rectangle ,Area of right and isosceles triangle, Area of trapezoid having one side perpendicular to the parallel side ,In the right angle triangle  $h^2= p^2+b^2$  ,Area of right circular cylinder = base altitude are developed by Babylonian civilization. Thales (Ca. 640- Ca. 546 B.C), Pythagoras (560 B.C- 480 B.C), Hippocrates (Ca.460- Ca.380 B.C) and Euclid (Ca.330-270 B.C) are important role to develop geometry. In this process non Euclidian geometry was born by challenging fifth postulate “parallel line” for Euclidian geometry. Anti-Euclidian geometry was the logical, intelligence, veteran achievement of the modern geometry. Saccharin, Lambert and Legendre are contributes

to developed Non-Euclidian geometry. Similarly, projective plane and projective geometry are developed in sixteen century and Analytical geometry established in seventeen century.

Theorem is the important part of mathematics development. Theorem is a result that has been proved to be true (using facts that were already known). Example, the “Pythagoras Theorem” proves that for a right angled triangle, where is right angle triangle already true fact.

Firstly, it should be known relation between Axioms, Theorem, Postulates, Corollaries and Hypothesis after the understanding theorem. A theorem is a logical consequence of the axioms. In Geometry, the ‘propositions’ are all theorems: they are derived using the axioms and the valid rules. A ‘Corollary’ is a theorem that is usually considered an easy consequence of another theorem. What is or is not a corollary is entirely subjective. Sometimes what an author thinks is a 'corollary' is deemed more important than the corresponding theorem. The same goes for ‘Lemma’s, which are theorems that are considered auxiliary to proving some other, more important in the view of the author, theorem. A ‘hypothesis’ is an assumption made. For example, "If  $x$  is an even integer, then  $x^2$  is an even integer" I am not asserting that  $x^2$  is even or odd; I am asserting that if something happens (namely, if  $x$  happens to be an even integer) then something else will also happen. Here, " $x$  is an even integer" is the hypothesis being made to prove it. Hence a theorem is a statement that has been proven on the basis of previously established statements, such as other theorems and generally accepted statements, such as axioms. The proof of a mathematical theorem is a logical argument for the theorem statement given in accord with the rules of a deductive system. The proof of a theorem is often interpreted as justification of the truth of the theorem statement.

The method is important for mathematics teachers and learners while teaching and learning in school education. Mathematics is a technical subject and exceptionally difficult for the learners. Its study requires special ability and intelligence and appraise teaching method should instigate the learners. The successful learning depends on the learning through active participation doing thing themselves. So, constructivism is the one of the students centered method. Constructivism is the new learning where students construct their own understanding for using pre-knowledge and pre-experiences. In this method, rather than being passively received knowledge is actively constructed by students. Constructivism theory was established in 1970 A.D in the field education and education psychology. Jean Piaget’s (1996-1980), Levesmenovic

Vygotsky(1896-1934) and John Dewey(1859-1952) have contribution to the development of constructivism. In this method teacher makes good teaching environment and student have the main role of the learning. The premises of constructivism are: rather than being passively received knowledge is active constructed by students, Mathematical knowledge is created by students as they reflect on their physical and mental actions. By observing relationship, identifying patterns and making abstractions and generalizations, students come to integrate new knowledge into their existing mathematical schemas and though engaging in the physical and social aspects of mathematics, students come to construct more robust understandings of mathematical concepts and process through processes of negotiation, explanation and justification.

In the context of Nepal, all the people think mathematics is the difficult subject. So, they think talent student only able to study mathematics. SLC result show that, mathematics' result was very low in Nepal moreover geometry achievement was also very low. Teachers as well as students feel difficulties to teach or study of the theorem prove in secondary level. Perhaps this problem can be occurs by using traditional approach to prove theorem. If we use the students centered method to prove theorem then we have solved the above problem. So, the constructivism is student centered methods were students construct their own understanding for using pre-knowledge and pre-experiences. Therefore, Researcher selected this topic to determine comparative effectiveness of constructivism approach with traditional approach to prove theorem in secondary level. Moreover, in mathematical teaching the research of constructivism was not used widely. In which to prove geometrical theorem the effectiveness of constructivism was not researched yet. So, researcher selected this topic to test the effectiveness of constructivist approach on Theorem Proving.

In this study, researcher tested effectiveness of constructivist approach to prove geometry theorem in secondary level. Researcher measured effectiveness between constructivist approach and traditional approach to teach secondary level theorem proves and researcher was to find out fact by experimentally.

## **Statement of the Problem**

The status of mathematics education results was not good as our expected. Every year SLC result shows that, the higher failure rate of mathematics in secondary level. Limited students were only pass mathematics and only few students were actively participant in mathematics class room. This problem can be occurs by using traditional approach, not use teaching material, not use child psychology etc to teach mathematics. The experience of Nepalese mathematics class are shows, above problem can be occurs to use tradition approach in mathematics class. So, it indicates urgent need of special treatment from our formal education. If we use the students centered method to teach mathematics hen we have solve the above problem. So, the purpose of the study was examining the effectiveness of constructivism approach to prove theorem in secondary level. The study was also determined which method was more effective to prove theorem in secondary level between constructivist approach and traditional approach. The following are the research question of this study:

- Does the constructivist approach prove geometric theorem is more effective than the traditional approach?
- Does the constructivist approach able to encourage the habit of self-learning and self-correcting?

## **Rational of the Study**

In the context of Nepal, all the people think mathematics is the difficult subject. So, they think talent student only able to study mathematics. Mathematics' result was very low in Nepal moreover geometry achievement was also very low. Teachers as well as students feel difficulties to teach or study of the theorem prove in secondary level. Perhaps this problem can be occurs by using traditional approach to prove theorem. If we use the students centered method to prove theorem then we have solve the above problem. So, the constructivism is a student centered method was students construct their own understanding for using pre-knowledge and pre-experiences. Therefore, Researcher selected this topic to determine comparative effectiveness of constructivist approach with traditional approach to prove theorem in secondary level. Moreover, in mathematical teaching the research of constructivism was not used widely. In which to prove geometrical theorem the effectiveness of constructivism was not researched yet.

So researcher selected this topic to test the effectiveness of constructivism on the Theorem Proving.

### **Objectives of the Study**

The objectives of the study are following

- To compare the achievement of the students to prove geometric theorem taught by constructivist approach with achievement of the students taught by traditional method.
- To find out the constructivist approach to encourage the habit of self-learning and self-correcting.

### **Research Hypotheses**

The hypothesis of this study was following at 0.05 levels of significance.

H<sub>1</sub>: There is significant difference of the student's achievement between pre test and post test.

H<sub>2</sub>: There is significant difference of the student's achievement taught by constructivist approach and traditional approach of teaching.

### **Significance of the Study**

The main problem or challenging question to the mathematics education is how a geometric theorem proof teacher can teach and students can learn effectively. The teacher cannot keep contact with the students individually then the class room convert crowded in the context of Nepal. So, the results of this study will help the mathematics teacher to adopt the effective teaching method.

Now a day's geometric theorem proof is taught by rote memorization without understanding the principles and their applications of mathematics, the teacher hands out rules precautions to the students. Then the students learn any aspect of geometric theorem proof better, if they are actually involved in learning. Hence the study helps to determine difficulties to teach theorem prove in secondary level. Moreover, significances of the study are following:

- It help to measured effectiveness of constructivist approach to teach theorem prove in secondary level.
- It help to find new learning strategy and to change learning strategy of teach theorem proves.

- This study would direct support the educational policy maker and curriculum framer for select the effective teaching approach in class-room activities.
- This study would provide one more instance to establish a new method of teaching in the Nepalese context.

### **Delimitations of the Study**

Delimitation of the study is most important part of the research. So this study has also delimitation. That are, the study is conduct for only 20 days in each school where one period is of 45 minutes. Lastly, this study concerned only with the effectiveness of constructivism to prove theorem in geometry. Moreover, following are the delimitation of this study.

- This study is delimited to the students of Kathmandu district. Only two secondary schools within Kathmandu metropolitan are included in the sample.
- The sample of the study is grade – IX students of selected schools.
- This study was delimited to 20 students in experimental group and 22 students in control group from each school.
- This study was delimited to the geometric theorem of compulsory mathematics at grade-IX. Moreover this study was delimited to only two units Triangle and Parallelogram of the grade-IX mathematics curriculum.
- This research only delimited secondary level geometry theorem prove.

### **Operational Definition of the Related Terms**

#### **Theorem**

Theorem is a statement that has been proven on the basis of previously established statement or theorem is a result that has been proved to be true(using facts that were already known).Example the “Pythagoras Theorem” proved that for a right angle triangle. Where Pythagoras theorem is the example of theorem and right angle triangle is already true statement. Moreover theorem was a statement that can be demonstrated to be true by accepted mathematical operations and arguments.

### **Constructivism Approach**

Constructivism is the one of the students centered method. Constructivism is the new learning where students construct their own understanding for using pre-knowledge and pre-experiences. In this method, rather than being passively received knowledge is actively constructed by students.

### **Traditional Approach**

Traditional approach is the one kind of the conventional method where students are only listening part but teacher role is veteran. In this method teacher focus how to provide knowledge and students centered only use to formula, solve the problem and ginning the answer.

### **Experimental Research**

An experimental is a scientific investigation in which the researcher manipulates one or more independent variables, controls and other relevant variables and observes the effect of the manipulations on the dependent variables. Khanal(2068)

## **Chapter: II**

### **REVIEW OF RELATED LITERATURE**

This chapter deals with the literature reviewed before and during the study period related to this study. The conclusions of various literatures which were studied before and during the period of my research are described in this chapter. In this chapter, research was review number of books, research papers, reports and other materials can be found that are concerned with curriculum, teaching materials, methods. But researcher could not find the literatures directly related to the research topics. Although researcher will review some disciplinary related and methodological related thesis.

#### **Reviews of the literature which are related to the theorem prove.**

Ghimire (2001) did an experimental research on “A study on the effectiveness of experimental verification in teaching the deductive proofs of geometric theorems at the secondary level.” The main purpose of the study was to study the effect of prior use of experimental verification in proving geometric theorems and the enhancement of understanding the facts, principles and concepts of geometric ideas. Pre-test and post-test in the experimental group and control group are the tool of data collection. Mean, S.D and variance were calculated for each set of achievement data and F-test used to test null hypothesis. He also analyzes the items from 27% upper and 27% lower scores of students. Researcher major finding are the mean score of students of experimental group is greater than the mean score of students of control group and the mean difference is significant statistically. Finally, researcher concluded prior experimental verification was significantly greater than the mean score of the achievement of the students taught without using experimental verification.

Kafle (2005) did a qualitative research “Error analysis of the proof of the theorem in geometry in grade x” which Newman’s technique of error analysis was the theoretical base of this study. The objectives of his study were to study the errors committed by the class ten students in the process of theoretical proof of the theorem in geometry. Test and In-depth interview are the tools of his research data collection. He analysis data to use ven Hieles spoke of levels 0 through 4 that are



- a. Level 0 : (basic level) : Visualization
- b. Level 1 : Analysis
- c. Level 2 : Informal Deduction
- d. Level 3 : Deduction
- e. Level 4 : Rigor

Finally, His research major finding insufficient experiences of geometry at lower level, excessive emphasis on formal two-column format proofs, Views and beliefs of both students and teachers towards geometry, less use of physical objects in proofs and problem are affects geometrics proof.

K.C(2005) did a survey research “Attitude of secondary level students towards the role of experimental verification for theoretical proof in geometry.” The main purposes of his study were to find out the students attitude towards the role of experimental verification for theoretical proof of theorem in geometry at secondary level and also to compare the boy’s and girl’s attitude on it. The opinionnaire is a tool of data collection.  $\chi^2$  test was used to test the significance of each statement of opinionnaire and t-test was used to compare the boy’s and girl’s attitude on it. His major finding of the study were there is a positive attitude of students towards the role of experimental verification for theoretical proof in geometry at secondary level and there is no gender wise difference in attitude towards the role of experimental verification for theoretical proof in geometry at secondary level. He also prefers the experimental verification for theoretical proof.

#### **Review of the literatures which are related to the constructivist approach.**

Upadhyay (2001, Ph.D) did his research entitled “Effect of constructivism on mathematics achievement of grade v students in Nepal.” The research was mainly conducted to explain the fact that whether the constructivism approaches produces better results than conventional approach or not. The study seeks to answer the question: can constructivism in mathematics be applied in Nepalese school situation? The main aim of the research was to adopt and advocate constructivism in mathematics teaching in Nepalese classroom. In the conclusion, the researcher found the possibility of constructivism in Nepalese school with significant differences in achievement in favor of constructivism approach that of than conventional method of teaching.

Basnet(2004) did an experimental research on “The effects of constructivism on achievements of grade iv students in mathematics.” The objectives of the study were to compare the achievement scores of students taught by constructivism method and traditional method and to explore the effectiveness of the constructivist method in mathematics at primary level. His research tool is achievement test than he was analysis data to use mean, S.D, T- test and bar graph. Finally, He conclude that constructivist method produces better result than traditional method in teaching mathematics and constructivist method is effective in teaching mathematics for “Four fundamental operations of numbers” At primary level.

Adhikari (2005) did an experimental research on “Effect of constructivism in teaching mathematics at primary level.” The aim of researcher are to examine if constructivism increases the achievement level of students in mathematic than the comparison of traditional method and to advocate constructivism as the appropriate teaching method. The achievement test for both experimental and control groups are the tool of the data collection. Researcher analysis data by using mean, S.D, coefficient of variation, bar graph and t-test. The major of the study are the mean score of experimental group is more the control group and the students under constructivist method learn better then students under traditional method. Finally, researcher concluded that constructivist method of teaching is effective than traditional method of teaching mathematics in primary level.

Regmi (2006) did an experimental research “The effects of constructivist method on student’s achievement in mathematics classroom.” The objective of the study is to find out the differences in the achievement scores of experimental and control groups. Achievement test for both pretest and posttest is the tool of data collection. The researcher analyzed and interpreted the collected data by using mean, S.D and variance were calculated for both groups with their secured marks in the test and t-test can be use to compare mean achievement of the both group students. The finding of the researcher, constructivism method was greater than the students taught by using conventional method. Finally researcher concluded that the constructivism method is more effective than conventional method in teaching mathematics for “Fraction and Decimal at grade-vii.”

Kafle (2006) did an experimental research “Effectiveness of constructivism based class work in absence of homework on mathematics achievement of primary school students.”

The aim of the research is to examine if the instruction under constructivism in absence of homework increases the achievement level of students in mathematics satisfactorily in comparison to traditional method of instruction with homework. To fulfill the objective of the study, the researcher chooses the pre-test and posttest equivalent control group design. For that purpose, the researcher has developed teaching episodes each consisting three steps that are introducing task, exploration on their own or within group and summarizing. An achievement test is the tool of data collection. The collected data was analyzed and interpreted by using t-test for independent sample. The tabulated t-value was used at 1 percent level of significance for 30 degree of freedom. The researcher finding are constructivism based class work in absence of homework perform better result than the students who got traditional method of instruction in presence of homework. Finally researcher concluded overburden homework can be minimized if school time is used appropriately for practical and constructive class work for the instruction of mathematics at primary level.

#### **Review of the literatures which are related to the van- Hiele's level of thinking.**

Acharya (2011) did a survey type study on "A study on van- Hiele's level of thinking of primary school students in geometry." The main objectives of the study was to explore the van-Hiele's level of thinking of primary school students in geometry, to determine the level of basic skills of geometry of primary school and to compare boys and girls in the level of thinking. The population of the study was all the students who study primary level at grade v of the southern part of Baglung district. An achievement test with 45 items including five skills under three different levels of geometric thinking by P.M van-Hiele was the tool of data collection. Researcher collected qualitative data and organized, analyzed and interpreted that. Researcher also tabularized van-Hiele's level of geometric thinking. That are,

**Table 1. van-Hiele's level of thinking with their Stage and Characteristics**

| Level   | Stages             | Characteristics   |
|---------|--------------------|---|
| Level 0 | Visualization      | Students recognize the figures on the basis of their physical appearance. |
| Level 1 | Analysis           | Students analyze the component parts of figures.                          |
| Level 2 | Informal Deduction | Students can establish interrelationships of properties                   |

|         |           |   |
|---------|-----------|---|
|         |           | within figures.   |
| Level 3 | Deduction | Students seek to prove the fact deductively using postulates or axioms and definitions. |
| Level 4 | Rigor     | Students can work in a variety of axiomatic systems.                                    |

Finally, Researcher found the level of thinking in geometry was satisfactory. About 82%, 35% and 59% students had attained the basic skills of geometry of levels 0, 1 and 2 respectively.

Utrecht (2014) the work of two Dutch educators, Pierre van-Hiele and Dina van Hiele-Geldof, has given us a vision around which to design geometry curriculum. Through their research they have identified five levels of understanding spatial concepts through which children move sequentially on their way to geometric thinking. They are following

#### **Level 0: Visualization (Basic level)**

At this level, the focus of a child's thinking is on individual shapes, which the child is learning to classify by judging their holistic appearance. Children identify prototypes of basic geometrical figures (triangle, circle and square). These visual prototypes are then used to identify other shapes. A shape is a circle because it looks like a sun; a shape is a rectangle because it looks like a door or a box; and so on.

#### **Level 1: Analysis**

At this level, the shapes become bearers of their properties. The objects of thought are classes of shapes, which the child has learned to analyze as having properties. A person at this level might say, "A square has 4 equal sides and 4 equal angles. Its diagonals are congruent and perpendicular, and they bisect each other.

#### **Level 2: Abstraction (Informal Deduction)**

At this level, properties are ordered. The objects of thought are geometric properties, which the student has learned to connect deductively. The student understands that properties are related and one set of properties may imply another property. Students can reason with simple arguments about geometric figures. A student at this level might say, "Isosceles triangles are symmetric, so their base angles must be equal."

### **Level 3: Deduction**

Students at this level understand the meaning of deduction. The object of thought is deductive reasoning (simple proofs), which the student learns to combine to form a system of formal proofs. Learners can construct geometric proofs at a secondary school level and understand their meaning.

### **Level 4: Rigor**

At this level, geometry is understood at the level of a mathematician. Students understand that definitions are arbitrary and need not actually refer to any concrete realization. The object of thought is deductive geometric systems, for which the learner compares axiomatic systems.

Hence, the literatures studied before and during the period of my research were related to the teaching of mathematics, teaching the geometry, conclusion of discussion and interaction program and various researches on school mathematics curriculum. It is concluded here that as Upadhyaha(2004) stated students in secondary especially in SLC examination students feel very difficulty in making theoretical proof of the theorem. As seen above, many studies have been carried out to constructivism method is effective to teach mathematics at primary level. Hari Prasad Upadhyay, Tara Basnet, Home kumara Adhikari and Bibak Kafle researcher are centered only effectiveness of constructivism method to teach mathematics at primary level. Then Damoder Prasad Regmi's research centered effects of constructivist method in mathematics classroom at lower secondary level. Similarly, Pradip Raj Ghimire's research centered effectiveness of experimental verification in teaching the deductive proofs of geometric theorem at secondary level. Moreover, Bir Bhadur Kafle's research focus error analysis of the proof of the theorem in geometry in grade x and Pream K.C's research focus attitude of secondary level students towards the role of experimental verification for theoretical proof in geometry. Similarly, C.K Acharya's thesis "A study on van-Hiele's level of thinking of primary school students in geometry" were Centered only primary level students. So, the study of above research, researcher found that they were silent in effectiveness of constructivism approach to prove theorem in secondary level. The proving of theorem is a main problem to the secondary level student in geometry. For the better understanding of proving theorem the role of constructivism is very important. It has not been studied yet. So, researcher feel need of study on "Effectiveness of Constructivist Approach on Theorem Proving."

## **Theoretical Literature**

This topic presents the theoretical guidelines for the present study. Constructivism approach is the main technology of this study. Researcher measured effectiveness of constructivism approach to prove theorem in secondary level. Generally, presentation of problem, exploration in group and reflection are the basic steps of the experimental research.

Constructivism is a belief that one constructs knowledge from one's experiences. When the learners assimilate any subject matter they construct new knowledge without changing the scheme/frame of that subject matter. Then the knowledge gained by person from assimilation is reframed into their mind which is called Accommodation. It is used in new environment or they gained Zone of Proximal Development (ZPD).

Moreover, when the child develop subjective concept they tries to develop the relation of that subject matter and at the moment he/she does error. Then child gets more information when their developed schemes are less egocentric. He/she compares his/her experiences and corrects his/her errors or they developed new knowledge. In this process child's knowledge is inter-psychological in first phase and another phase is intra-psychological knowledge. Teacher must be More Knowledge Other (MKO) to teach in constructivist approach. The person who can develop the ZPD, scaffolding, collaborative teaching and whole learning can be MKO.

Jean Piaget, Jerome Bruner, Lev Vygotsky and John Dewey are important role of the developed constructivism. They develop different theoretical base of constructivism. They are following

In the constructivism, Jean Piaget developed cognitive stages of learning. Piaget believed that children were constructing new knowledge as they moved through different cognitive stages or scheme, building on what they already knew. Furthermore, Children interpret this knowledge differently as they progress through different stages. So the cognitive stages of Jean Piaget is

**Table 2. Jean Piaget Cognitive stages**

|                  |             |                                      |  |
|------------------|-------------|--------------------------------------|--|
| Sensorimotor     | 0-2 years   | Building concepts of reality world   | Building mental pictures of objects              |
| Preoperational   | 2-7 years   | Mentally represent event and objects | Engage in symbolic play                          |
| Concrete         | 7-11 years  | Problem solve for object             | Logical thoughts of object they can manipulation |
| Formal Operation | 11-16 years | Conceptual reasoning like an adult   | Logical thoughts of object without manipulation  |

So, the motivation for learning is the predisposition of the learner to adapt to his environment, hence to institute equilibrium between schemes and the environment. Continuous interactions among existing schemes, assimilation, accommodation and equilibrium create new learning.

In the constructivism, Discovery learning developed by Jerome Bruner. Discovery learning is a method of inquiry-based instruction, than it believes that it is best for learners to discover facts and relationships for themselves. Bruner focus learning is an active process in which the learner constructs new ideas or concepts based on his current or post knowledge. In this process learner selects and transforms information, constructs hypothesis and makes decisions, relying on a cognitive structure to do so. Cognitive structure (i.e schema, mental models) provides meaning and organization to experience. In the constructivism, Lev Vygotsky developed social cognition. Vygotsky introduced he social aspect of learning into constructivism. He defined Zone of proximal development (ZPD) which means students solve problems beyond their actual development level. Vygotsky believed learning influenced by social development. The key points of the Vygotsky's constructivism are ZPD, Collaborative learning, Scaffolding and open, free and flexible learning. Sharma & Sharma(2068).

John Dewey also believed that education was a social process. He focus on learning should engage and expand the experiences of the learners. He believed students learn by doing and should be allowed to construct, create, and actively inquire.

### **Role of Students in Constructivist Classroom**

In the Constructivist classroom, students are the center part of the teaching and learning process. Students are actively participant in constructivist classroom. In constructivist classroom students work in group, learn actively, collaborative, meaningful learning, open, free and flexible learning. The learner as an unique individual and responsible person in constructivism classroom. Students become more actively engaged with technology then in a normal classroom setting and can learn different things at the same time. Hutton, Warren & Scarborough (2014).

### **Role of Teacher in Constructivist Classroom**

In the constructivist classroom teacher play the role of facilitator not an instructor. Teachers role of constructivist classroom are facilitator, Co-operative role, role of guidance, Role of counselor, role of environments developer and role of discussion maker. Teacher in constructivist classrooms with technology can let students learn different things at the same time, increasing the Zone of Proximal Development. Teacher guide the students into adopting cognitive strategies such as self testing, articulating understanding, asking probing questions and reflection. Furthermore the role of the teacher in constructivist classrooms is to organize information around big ideas that engage the student's interest, to assist students in developing new insights and to connect them with their previous learning.

### **Conceptual Framework**

The conceptual framework explains the research in narrative form or graphically from. Conceptual framework is the short graphically plane of research which make by researcher. Researcher conceptual framework of this study is following with figure.

van-Hiele model of geometrical think is the most important level or steps of theorem proofs. In mathematics education, the van-Hiele model is a theory that describes how students learn geometry. A typical high school geometry course should be taught at level 3 (Deduction) of van-Hiele model. So, researcher was to bond to van-Hiele model and Constructivist approach. van-Hiele level 0 visualization connects into presentation problem of constructivist approach



where student understanding the geometric problem without their properties. van-Hiele level 1 analyses connects into simplify into smaller sub-tasks of constructivist approach where student able to discuss properties of the problem. van-Hiele level 2 informal deduction connects into exploration in group of constructivist approach where student try to deductively prove with group discussion. Finally, van-Hiele level 3 deduction connects into reflection where student able to prove geometric theorem with suitable reason. Then make a new teaching model to prove theorem in secondary level. That is following.

### **Step1: Presentation of problem**

In this step teacher presents the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem and students are able to understand the geometric problem without their properties. It develops the level 0 of van-Hiele's reasoning model.

### **Step2: Simplify into smaller sub-tasks**

In this step, problem can be simplify into smaller sub-tasks then discuss about properties of the problem and irrelevant features, such as size or orientation, become less important, as students are able to focus on all shapes within a class. After that they are concentrating on the related questions of the problem like: what are given, need any construction, what is to be found? It develops the level 1 of van-Hiele's reasoning

### **Step 3: Exploration in group**

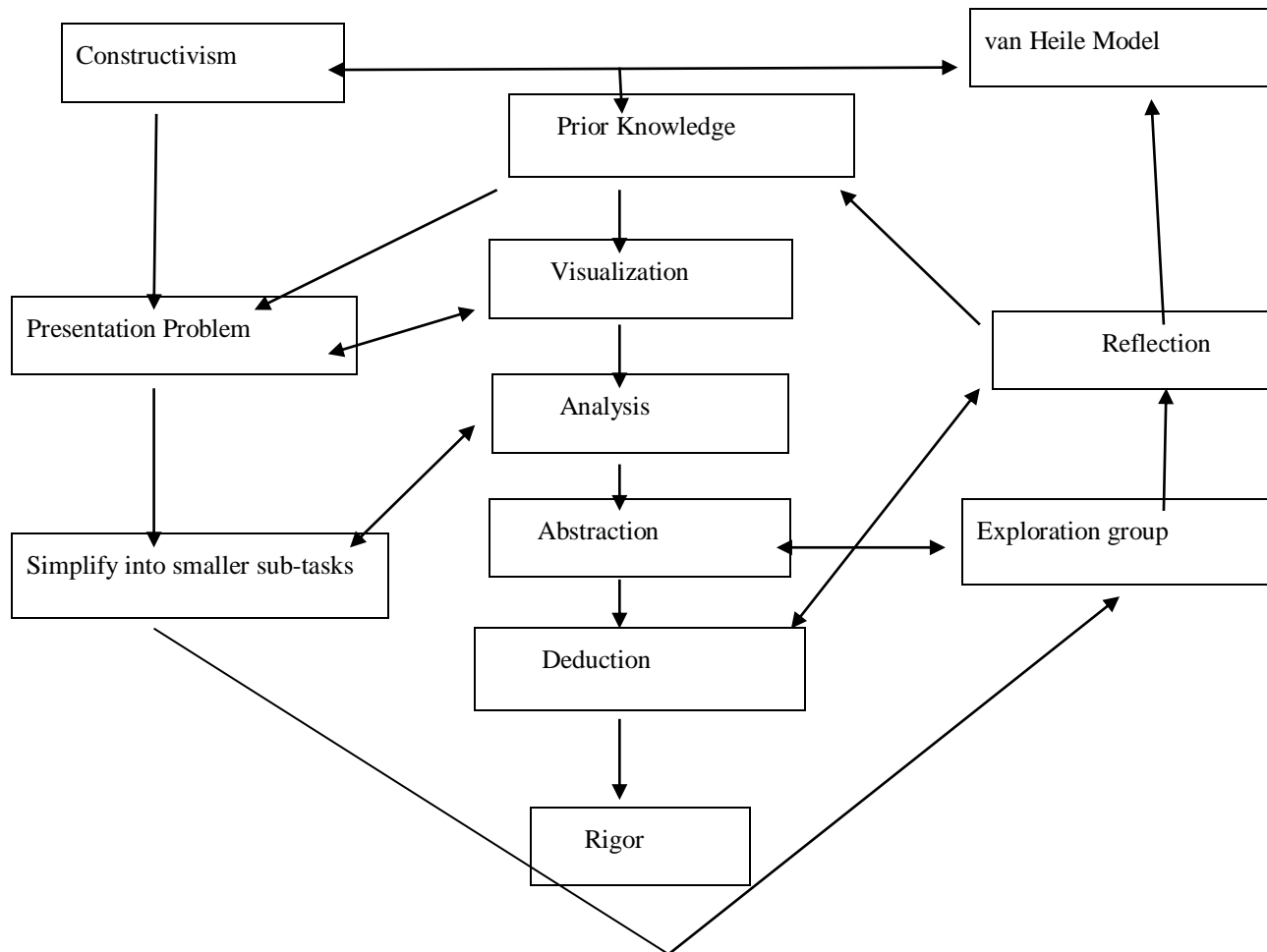
They order the properties of geometrical shapes and sizes with group discussion. They try to prove geometrical shapes and sizes in deductive way. The students understand that properties are related and one set of properties may imply another property. Students can reason with simple arguments about geometric figures. Like that, to solve the individual problem, first we give opportunity to the student. When student solve the individual problem their copies are exchanged within their group and make them to find the common solution. And teacher list each group solution on the white board. It develops the level 2 of van-Hiele's reasoning mode.

### **Step 4: Reflection**

In this step students are able to prove theorem with reason. Students understand the meaning of proof. The object of thought is deductive reasoning (simple proofs), which the above process and conclude the formula, statement or theorem. It develops the level 3 of van-Hiele's reasoning mode.

Above explanation and connection of van-Hiele's level of thinking and constructivist approach were present following chart.

**Chart: 1 Conceptual framework**



For the purpose of the moving experimental episode researcher developed the above chart himself. Above chart show that researcher connected steps of constructivist approach into van-Hiele's level of thinking. Researcher connected van-Hiele's level-0 into constructivist approach's step of presentation problem, van-Hiele's level-1 into constructivist approach's step of simplify into smaller sub-tasks, van-Hiele's level-2 into constructivist approach's step of explanation group and van-Hiele's level-3 into constructivist approach's step of reflection. Above chart also show teaching activities was circular process because teaching process was move cyclic form. Like that teaching activities start prior knowledge and presentation problem, simplify into smaller sub-tasks, exploration group and end into reflection after that restart from prior knowledge. Researcher was used above chart to developed experimental episode and connects van-Hiele's deductive thinking and constructivist approach.

### Chapter: III

#### RESEARCH METHODS AND PROCEDURES

This chapter includes research design, sample of the study, data collection instruments, reliability and validity of the research tool, data collection procedures and data analysis procedures. Those are following.

##### Research Design

The research design of this study was Experimental. An experimental is a scientific investigation in which the researcher manipulates one or more independent variables, controls and other relevant variables and observes the effect of the manipulations on the dependent variables. (Khanal, 2068). Generally, experimental research can be dividing into three parts that are quasi-experimental, true experimental and pre experimental. In this research, researcher was use quasi-experimental research design.

In this study constructivist approach was the independent variables then researcher manipulates that and student's achievement was the dependent variables where researcher search effects of independent variables. Exercise, homework, class work etc. are the other relevant variables which are researcher controls. Researcher was use constructivist approach into experimental group and traditional approach use to control group. This table also clears the research design.

**Table 3: Research Design**

| Group | Pretest        | Treatment               | Posttest       |
|-------|----------------|-------------------------|----------------|
| E     | T <sub>1</sub> | Constructivism Approach | T <sub>2</sub> |
| C     | T <sub>3</sub> | Traditional Approach    | T <sub>4</sub> |

Where, E = Experimental group,

C = Control group,

T<sub>1</sub> = Pre-test,      T<sub>3</sub>= Pre-test

$T_2 = \text{Post-test.}$        $T_{4=} \text{ Post-test}$

There are three models for proofs theorem. They are the two-column proofs, the flow proofs (flowchart proofs) and the paragraph proofs .In this study, Researcher was use two-column proofs because this model helps to clearly display each step in our argument, and helps to keep our ideas organized. In this model, two columns are presented where the first column contains a numbered chronological list of steps ‘statements’ leading to the desired conclusion. The second column contains a list of ‘reasons’ which support each step in the proof. These reasons are properties, theorems, postulates and definition.

This study was mixed experimental design because researcher gathered both type data quantitative and qualitative in this study. Researcher analysis student’s achievement of pre test, post test and measure effects of constructivist approach to teach mathematical theorem prove. Qualitative data can be use understanding student’s behavior, change of student behavior and feeling of the students between constructivist approach and traditional approach. Then researcher developed following control mechanisms.

- a. There is not an interaction of the students between experimental and control groups.
- b. Control groups students are not provided the discussion method.
- c. Control group students are not provided to attain the tuition classes.

### **Sample of the Study**

Convenience sampling method should be used to collected data in this study. The sample of this study was the students of grade-IX from the area of the Kathmandu district. The researcher selected Subhakamana Academy Kritipur-15, Taudha and Kathmandu Bern Heartd H,S School . Researcher was choosing grade-IX all students of the Subhakamana Academy. There were 20 students at grade-IX in Subhakamana academy and researcher was also choosing grade-IX all students of Kathmandu Bern Heart H.S School. Researcher used constructivist approach into experimental group and traditional approach used in control group. Researcher also selected the treatment by using lottery method.

### **Tools for Data Collection**

In this study researcher developed two types of instruments. They are Test items, Observation notes and Interview.

## Test Items

The test was taken to find out current skills of the students to solve the mathematical theorem in secondary level. Researcher selected 18 theorem related question which are included in compulsory subject of secondary level. After the finish experimental class again selects 18 theorem related question then take post test.

For the purpose of specify research tool researcher developed specification chart. Specification chart was needed to select type of question, decided the number of question, representation all area of content, decided content validity etc. In the test items, researcher developed ten objectives types question per question one marks and eight subject types question per question five marks. They were based on the Triangle and Parallelogram with following chart. The set of the question was consist van-Hiele's level of thinking with following chart.

**Table 4: Specification chart of cognitive level**

| Unit/level of objectives | Cognitive Level |     |        |     |               |     |            |     |       |     |
|--------------------------|-----------------|-----|--------|-----|---------------|-----|------------|-----|-------|-----|
|                          | Knowledge       |     | Skills |     | Comprehension |     | Aplication |     | Total |     |
|                          | Obj             | Sub | Obj    | Sub | Obj           | Sub | Obj        | Sub | Obj   | Sub |
| Triangles                | 2               | 1   | 1      | 1   | 2             | 1   | -          | 1   | 5     | 4   |
| Parallelogram            | 1               | 1   | 1      | 1   | 2             | 1   | 1          | 1   |       | 4   |
| Total                    | 3               | 2   | 2      | 2   | 4             | 2   | 1          | 2   |       | 8   |

Above chart was developed by on the base of bloom model (1956). This chart is only present class nine two chapter's specification. This chart was centered only cognitive level.

In the geometric teaching, students should from the knowledge on the way of van-Heiles level of thinking. Therefore, research tool was needed to develop on the base of van-

Heiles level of thinking. So the researcher was developed following chart on the bases of van-Heiles level of thinking and which is used to making research tool.

**Table 5: Specification chart of van-Hieles level of thinking**

| van-Hieles level of thinking | Level-0 |      | Level-1 |          | Level-2 |           | Level-3  |           |
|------------------------------|---------|------|---------|----------|---------|-----------|----------|-----------|
|                              | Obj.    | Sub. | Obj.    | Sub.     | Obj.    | Sub.      | Obj.     | Sub.      |
| Triangle                     | 1(1)    | -    | 2(2, 3) | 2(11,13) | 2(4, 5) | 1(12)     | -        | 1(14)     |
| Parallelogram                | -       | -    | 1(6)    | -        | 2(7, 8) | 2(15, 16) | 2(9, 10) | 2(17, 18) |

### **Observation Form**

The Observation mean act of watching sb/sth carefully for a period of time, especially to learn sth. The secret of good observation is to create the unusual from out of the common place (Khanal, 2068). Observation is the supported data collection tool of this study. Researcher was daily note student's activities and behavior on his note book. Especially researcher observed students participant, motivation, and class room activities by using daily note and researcher observes effectiveness of constructivist approach by using observation questioner. Moreover researcher observed classroom activities, effectiveness of constructivist approach and changes of student behavior by using observation questioner which in Appendix-D.

### **Interview**

Researcher took interview for the purpose of finding constructivist approach to encourage the habit of self-learning and self-correcting. In this research, researcher used subject focused interview. All subject matters of interview are focused in effectiveness of constructivist approach to encourage the habit of self- learning and self-correcting.

### Reliability of Tools

Reliability refers to the consistency of measurement. That is, how consistent test scores or other assessment result are from one measurement to another. By reliability we mean that test takers would obtain the same score if they took an alternative form of the test, or took the same test at a different time or under different conditions. Ja.Ba.Ra, Shrestha & Rangitkar(2068). Ebel and Frisbe said that “The reliability co-efficient for a set of scores from a group of examinees is the coefficient of correlation between that set of scores and another set scores on an equivalent test obtained independently from members of the same group.” Basically, there are four methods of estimating reliability. Those are test-retest method, Alternative form method, Split-half method and Kuder-Richardson method. Out of these methods, the spilt-half method was applied to prove this research to make reliabial. The pilot test was taken in Ujjwal Vikash H.S School, Balaju, Kathmandu. In this method a test was divided into two equal parts. After that experiment of one time or twice then find out the co-relation of the both achievement of the test. In this study researcher divided test into odd and even group then find the reliability with using this formula which are show in appendix-H.

$$\text{Reliability of full test} = \frac{2 \times \text{Reliability on } \frac{1}{2} \text{ test}}{1 + \text{reliability on } \frac{1}{2} \text{ test}}$$

The calculate reliability value of the even and odd group were found 0.85 and 0.84 respectively. Since the reliability is always in -1 to +1. The greater value of the tool of measurement the greater the reliability of measure but the smaller value of the tool of measurement the smaller the reliability. Generally, reliability coefficient was interpretation following.

- 0- Completely not reliability
- ± (0.1-0.19) – strongly low reliability
- ± (0.20-0.39) - low reliability
- ± (0.40-0.59) – medium reliability
- ± (0.60-0.79) – high reliability
- ± (0.80-0.99) – strongly high reliability

$\pm 1$  – completely reliability

Therefore, calculated both reliability coefficient are in  $\pm$  (0.80-0.99). Thus, the measurement tool of the both group were strongly high reliability. It implies that this research tool was dependable, stable, consistent, predictable and accurate.

### **Validity of Tools**

Validity is an evaluation of the adequacy and appropriateness of the interpretation and assessment result. Validity is related to objectives. If a test measures what it intends to measure then the test is said to be valid. Validity is not all or non. It is a matter of degree. Validity is always specific to some particular use or interpretation. So, it is viewed as unitary concept based on various kinds of evidences. Freeman said that “An index which shows the degree to which a test measures what it purposes to measure.” There are four major considerations in Validation. Those are content consideration, construct consideration, and construct consideration, test-criterion relationship and consideration of consequences. The purpose of the prove research tool is valid; research should be used content consideration. The content validity was only fuscous how much objective of the curriculum can be included into test items.

Ten objectives type items and eight subjective type item were included in pre-test as well as post test. The entire questioner was included in triangle and parallelogram. Since, 5/5 objectives item were included in triangle and parallelogram respectively. Similarly, 4/4 subjective questioner was included in both topic. On the basis of van-Hieles level of thinking one question in level-0, five question in level-1, seven question in level-2 and five question in level-3. Similarly 1 question in level-0, 5 question in level-1, 7 questions in level-2 and 5 question in level-3. Moreover, on the basis of cognitive level three objective item and two subjective items was in knowledge level, two objectives items and two subjective items was in skills level, four objective items and two subjective items was in comprehension and one objective items and two subjective items was in application level. Thus the above explanation shows that each areas and scopes of the curriculum was included in both test. Therefore it said that both test was quiet valid.



### **Data Collection Procedures**

Data collection is the foundation of the research. In this study, Researcher collected primary data with following steps. Pre-experimental stages: In this study, researcher developed test items, observations form and interview. Researcher selected 18 theorem related question which are included in compulsory subject of secondary level on the base of cognitive level and van-Hieles level of thinking. Researcher taken pre test and stablish student's current skills of theorem prove. Researcher developed observation form for the purpose of finding students participant, motivation and class rome activites on both groups which in Appendix-D. Similarly, researcher developed subject focused interview for the purpose of finding constructivist approach to encourage the habit of self-learning and self-correcting. Experimental Stages: After that researcher divided student into two group. Then select two groups one is experimental and another is control group. Constructivist approach can be used in experimental group and traditional approach can be use another group. Post-experimental stages: After the few days' experimental class teaching or class observation take post test in both groups. Researcher also looked the student behavior with the support of the observation from and daily note. Researcher developed observation sheet for the purpose of measure change of student behaviors between constructivist approach and traditional approach. Appendix-D was the observation sheet of this study and researcher was also note student actives daily. After finished experiment episode student were fill the observation sheet. It's give qualitative data.

### **Data Analysis Procedures**

At the end of the instructional period, both groups take a post test with same question items. The result of pre test and post test of both group analyz using statistical devices such as mean, S.D, variance and t-test. The t-test was use at 0.05 level of significance. Similar process analyze achievement of student in constructivist approach and traditional approach. Finally make a desion Which method is better to teach secondary level theorem prove.

In this research, research was also analysis data using van-Hiele's level of thinking. Researcher made pre-test and post-test question on the basis van-hieles level of thinking. In the pre-test, one number question is in level-0 and 2,3,6,11,13 number question are in level-1. Similarly, 4,5,7,8,12,15,16 number question are in level-2 and 9,10,14,17,18 number question are in level-3. It has been taken out the report what percent of the students has given the right answer in pretest from each level. The mentioned report shows that to what extend the level of students

has been achieved by the students. In the post test also the same procedure has been adopted like in the pre test in order to find out the students' learning achievement in each level. After that the comparative study with an intention to find out the changes of students' knowledge has been done. In the same manner, it has been categorized that what difference came into exist among the successful students comparatively between Experimental and Control group of students.

In this research, researcher also gathered qualitative data by using daily note students activities, behavior, observation sheets and interview. The information's were collected from the observation then researcher analyzed by using three steps that are organization of data, summarizing the data and interpreting the data. Researcher explained the data and their perspectives according to the respondent's responses. In this research, researcher was analyzed data by using following steps.

- a. Gathering rich Data: Data are gathered in italic form which is responses of respondents.
- b. Coding: In this step, fact or data are read two and more than two times. After that writing impotents and valuable facts in short word or short paragraph.
- c. Memo writing; Memo writing means the process for reading the though and ideas of the researcher as they evaluation throughout the story. In this steps researcher explain his ideas and though about the story after the coding data.
- d. Theoretical sampling: Theoretical sampling is the needed person, event or behavior which is impotents to add for function of data analysis.
- e. Interpretations: The analysis of research variables with universal sentences in quantitative research is called Interpretations of data. This type of theory assumes emergent, multiple realities, indeterminacy, provisional and social life as processual.

## **Chapter: IV**

### **ANALYSIS OF DATA AND INTERPRETATION OF THE RESULTS**

The most important part of any study is the analysis of its collected data. The data collected in the form of large amount of information are to be reduced into desirable and simplified form or easily understood configurations. Then analysis the concise data enables the investigator to interpret data, draw conclusions and make generalizations. So, this chapter deals with the analysis and interpretation of the collected information.

The present study entitled, “Effectiveness of Constructivist Approach on Theorem Proving.” was an experimental study where involving pre-test and post-test as well as experimental and control group design. Since the objectives of this study was to compare the achievement of the study to prove geometric theorem taught by constructivist approach with achievement of the students taught by tradition approach and to find out the effective of constructivist approach to prove geometric theorem in secondary level students.

In this study researcher was experiment 20 episodes on both groups +experiment and control group. Then researcher gathered the quantitative data from take pre-test and post-test. Furthermore, researcher gathered qualitative data from observation sheet. So, quantitative as well as qualitative data on student’s achievement were obtained in this study.

The data were analyzed and interpreted by using statistical devices such as mean, standard deviation, variance and t-test for the difference between two means. Then qualitative data analyzed by using descriptive ways. In order to attained the objectives of this study, data were analyzed and interpreted systematically under the following major heading

- Analysis of pre-test results.
- Analysis of post-test results. (Comparison of Experiment and Control group results)
- Comparison of pre-test and post test results.
- Measure gain of van-Hiele’s deductive reasoning.
- Qualitative data analysis.

### Analysis of Pre-Test Result

To compare effectiveness of constructivist approach and tradition approach on experimental and control groups by using mean, standard deviation, variance and t-test for independent sample on pre-test. Researcher developed null hypothesis on pre-test “There is no signification difference between of experimental group and control group.” The pre-test’s means scores, standard deviation, variance and t-value of the scores obtained by experimental and control group of students are presented in Appendix-E and the summary of the mean, standard deviation, variance and t-value of pre-test score of both group are below

**Table 6. Summary mean, standard deviation, variance and t-value of pre-test.**

| School | Shuvakamana |          |      |       | Bern Heardt |         |      |       | Tabulated value of t-test | Calculate d value |
|--------|-------------|----------|------|-------|-------------|---------|------|-------|---------------------------|-------------------|
|        | Mean        | % scores | S.D  | Var   | Mean        | % score | S,D  | Var   |                           |                   |
|        | 22.1        | 44.2     | 5.71 | 32.59 | 22.9        | 45.82   | 6.57 | 43.17 | 1.68                      | 0.21              |

The above table show that the mean, standard deviation, variance and t-value of both groups on the basis of pre-test scores. Its table presents the mean score of the pre-test of Shuvakamana School and Bern Heardt School was 22.1 and 22.9 respectively. The mean different of the two group is 0.8. It implies that the mean achievement of both groups is not different very much. Than 44.2% students of experimental groups were solve the pre-test question and 45.82% students of control groups were solve pre-test question. It shows both groups are equivalent.

The standard deviation of the both groups was 5.71 and 6.57 respectively. Difference of S.D of the experimental and control group was 0.86. It implies those scores of the students of experimental and control group were approximately equally deviated from the respective mean scores.

The calculated t-value was 0.21 whereas tabulated t-value 1.684 at 0.05 level of significance and 40 degree of freedom. This indicates the calculated value 0.21 does not exceed the tabulated value 1.684. So, the null hypothesis was accepted. Since, there was no significance difference between of experimental group and control group. It concluded the skills of the students to prove geometric theorem of the both group was equivalent. Thus, the both group were homogeneous before the treatment.

### Comparison Experimental and Control Group on the Base of Post- Test

Researcher used mean, standard deviation, variance and t-test to compare experimental group and control group. Researcher order to test the hypothesis was no difference in achievement of control group and experimental group. The post-test's mean scores, standard deviation, variance and t-value of the scores obtained by experimental and control group of students are presented in Appendix-F and summary of mean, standard deviation, variance and t-value of post test was in below.

**Table 7. Summary mean, standard deviation, variance and t-value of post-test.**

| School | Shuvakamana(experimental group) |          |      |       | Bern Hardt(control group) |         |      |       | Tabulated value of t-test | Calculated value |
|--------|---------------------------------|----------|------|-------|---------------------------|---------|------|-------|---------------------------|------------------|
|        | Mean                            | % scores | S.D  | Var   | Mean                      | % Score | S.D  | var   |                           |                  |
| 1      | 36.85                           | 73.6     | 8.19 | 67.16 | 30.45                     | 60.9    | 6.64 | 44.06 | 2.021                     | 2.799            |

The above table shows that mean achievement of the experimental group (constructivist approach) and control group (tradition approach) were 36.85 and 30.45 respectively. The difference of mean achievement was found 6.13. Similarly, variance of experimental and control group was 67.16 and 44.06 respectively. The difference of variance was found 23.1. Then 73.6% students of experimental groups were solve post-test question but only 60.9% students of control

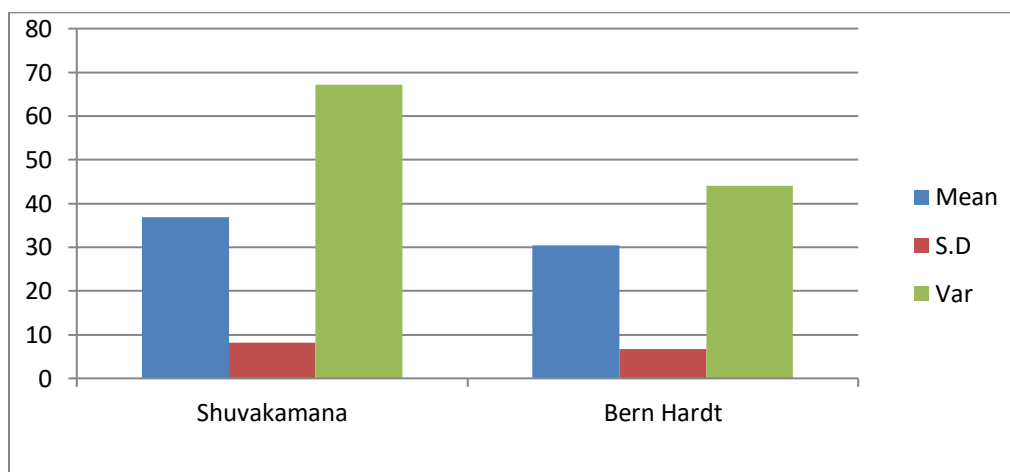
group were solve post-test question. It implies that the mean, variance and % score was vastly difference. In the pre-test mean achievement of both groups were equivalence but after the experimental treatment mean achievement of experimental group was grater then mean of the control group. Researcher used constructivist approach in experimental group and tradition approach in control group. It concluded that constructivist approach is more effectives to prove theorem than tradition approach in secondary level.

Now, the researcher descript of the t-test on the base of post-test. Researcher used t-test on two tail test at 0.05 level of significance and 40 degree of freedom. Since the calculated value t-value was 2.799 and the tabulated t-value was 2.021 at 40 degree of freedom. It implies that the calculated value 2.799 was greater than tabulated value 2.021. So the null hypothesis there is no significance difference between experimental group and control group was rejected. Thus, alternative hypothesis was accepted. It indicates there was significance difference between the achievement of experimental group and control group. Since achievement of experimental group was grater then achievement of control groups. Researcher used constructivist approach in experimental group and tradition approach use in control group. It concludes that constructivist approach was batter then tradition approach to prove geometric theorem in secondary level.

Moreover, following bar diagram was also clear the comparison of experimental groups and control groups in terms of their average achievement and standard deviation

**Fig No: 1**

**Comparison experimental and control group**



Finally, researcher conclude that the students who were taught prove geometric theorem with the use of constructivist approach was batter effective then students who were taught with the use of tradition approach.

### Comparison of Pre-Test and Post-Test

The summary of the average mean, standard deviations, variance and t-value of the pre-test and post test were presented by following table.

**Table 8. Comparison of pre-test and post test**

| Pre-Test |          |      |       | Post-test |          |       |       | Tabulated value | Calculated value |
|----------|----------|------|-------|-----------|----------|-------|-------|-----------------|------------------|
| Mean     | % scores | S.D  | Var   | Mean      | % scores | S.D   | Var   |                 |                  |
| 22.5     | 45.01    | 6.14 | 37.88 | 33.65     | 67.25    | 7.415 | 55.61 | 2               | 5.83             |

Above table show that average mean achievement of pre-test was 22.5 and average mean achievement of post test was 33.65. Since average mean difference between was 11.15. It indicates the average mean achievement of pre-test and post-test were difference. It implies that students was easy to understand geometric theorem prove with treatment than without treatment.

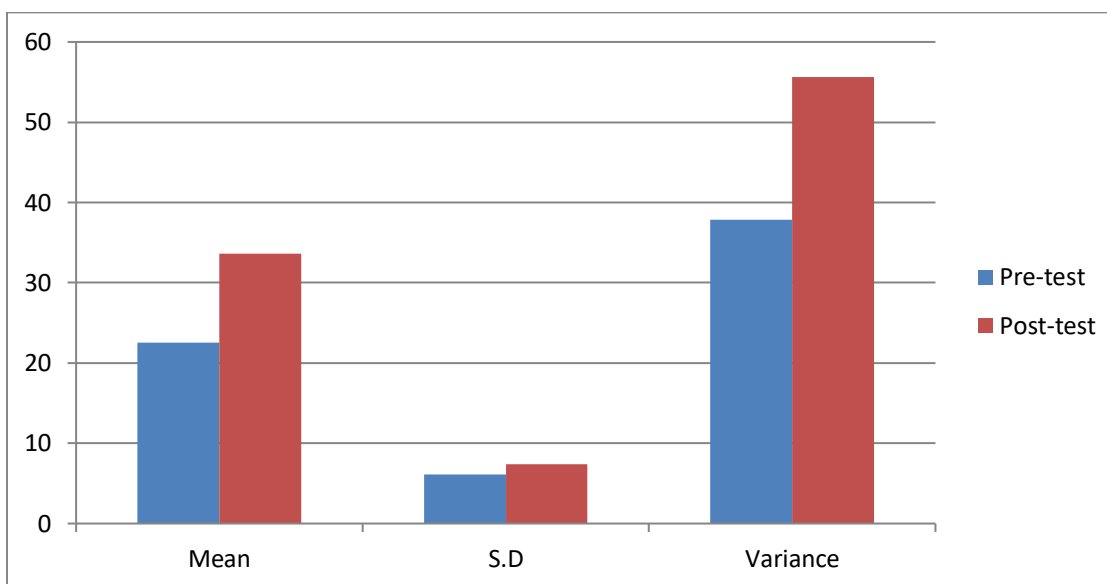
In pre-test mean achievement of the control group were 22.90 and after the treatment mean achievement of the control group were 30.45. Similarly, mean achievement of experimental group were 22.1 and after the treatment mean achievement of experimental group were 36.85. Since mean achievement difference of control group were 7.55 and experimental group were 14.75. It implies experimental groups students are obtund maximum marks than control group. Researcher use constructivist approach in experimental group and tradition approach use in control group. Thus, it concluded constructivist approach was more effectives to prove geometric theorem than tradition approach. Moreover, percent score of pre-test were only

45.01% but percent score of post-test were 67.25%. It indicates percent score of pre-test and post-test was vastly different.

The calculated t-value was 5.83 at 0.05 level of significance and 40 degree of freedom. Then the tabulated t-value was 2. Since the calculated t-value 5.83 was greater than tabulated t-value 2. Thus, the null hypothesis there is no significance difference between pre-post and post-test was rejected but alternative hypothesis was accepted. It implies that average mean of the post test was grater then pre-test. Finally, below bar diagram was compare effectively pre-test and post-test achievement. Then it support to prove constructivist approach is effectives to prove geometric theorem than tradition approach in secondary mathematics classroom.

**Fig No: 2**

**Comparison of mean, standard deviation between pre-test and post-test**



### **Measure Gain of van-Hiele's Deductive Reasoning**

van-Hiele's deductive reasoning was the most important part of geometric teaching and learning process. So, researcher made pre-test on the base of van-Hiele's level of thinking and teaching episode was also made on the base of van-Hiele's level of thinking. Similarly, researcher also made post-test on the base of van-Hiele's level of thinking. The researcher measured the level of students on van-Hiele's deductive reasoning for proving geometric



theorem on pre-test and measure which level gain after used constructivist approach to prove geometric theorem in secondary level. Since the summary achievement of the student of the students on pre-test for the van-Hiele's level of thinking are presented by below table.

**Table 9. Pre-test student's achievement on the base van-Hiele's level of thinking**

| van-Hiele's level | Question No:     | Experimental group |         | Control group |         |
|-------------------|------------------|--------------------|---------|---------------|---------|
|                   |                  | Student no:        | Percent | Students no:  | Percent |
| Level-0           | 1                | 20                 | 100%    | 22            | 100%    |
| Level-1           | 2,3,6,11,13      | 15                 | 75%     | 17            | 77.27%  |
| Level-2           | 4,5,7,8,12,15,16 | 11                 | 55%     | 11            | 50%     |
| Level-3           | 9,10,14,17,18    | 8                  | 40%     | 10            | 45.45%  |

Above table and appendix-A show that question no 1 was in level-0, question no 2,3,6,11,13 are in level-1, question no 4,5,7,8,12,15,16 are in level-2 and question no 9,10,14,17,18 are in level-3. Then 100% students are solving question no 1 of both group. It shows that all students could identify the visual properties of geometric figures of level-0. Similarly, 75% students of experimental group and 77.27% students of the control group were solved level-1 question. It shows that most of the students of both group in level-1. Similarly, 55% students of the experimental group and 50% students of control group was solved level-2 question. It implies 50% students are in this level of the both group. Similarly, 40% experimental group and 45.45% control group students are solved level-3 question. It shows that only few students are in level-3. Finally, researcher concluded that most of the students are in level-1 and level-2.

After the 20 days experimental episode researcher was take post-test on the basis of van-Hiele's level of thinking. The summary achievement was as following on the base of post-test.

**Table 10. Post-test student's achievement on the base van-Hiele's level of thinking**

| van-Hiele's level | Question No: | Experimental group |         | Control group |         |
|-------------------|--------------|--------------------|---------|---------------|---------|
|                   |              | Student no:        | Percent | Students no:  | Percent |

|         |                  |    |      |    |        |
|---------|------------------|----|------|----|--------|
| Level-0 | 1,6              | 20 | 100% | 22 | 100%   |
| Level-1 | 2,7,11,15        | 18 | 90%  | 18 | 81.81% |
| Level-2 | 3,4,8,9,12,16    | 17 | 80%  | 15 | 68%    |
| Level-3 | 5,10,13,17,14,18 | 15 | 75%  | 13 | 59.09% |

Above table and appendix-C show that question number 1, 6 are in level-0, question number 2, 7, 11, 15 are in level-1, question number 3, 4, 8, 9, 12, 16 are in level-2. Similarly, question number 5, 10, 13, 17, 14, 18 are in level-3. All of the students were solved level-0 question. It implies that all students of both groups could identify the visual properties of geometric figures on the base of level-0. Similarly 90% students of experimental groups were solved level-1 questions but 81.81% students of control group were solved level-1 questions. Similarly, 80% students of the experimental group were solved level-2 question but only 68% students of the control group were solved level-2 question. It indicates comparatively experimental group students were solved van-Hiele's level-2 than control group. Moreover, 75% students of experimental group are solving level-3 question but only 59.09% students of the control group are solve level-3 question. It implies students of the experimental group were gained more van-Hiele's level of thinking than students of the control group. Researcher used constructivist approach in experimental group and tradition approach in control group. So constructivist approach was effectives to prove geometric theorem at secondary level. Constructivist approach had support to gain van-Hiele's deductive learning. Thus researcher concludes that constructivist approach was effectives to prove geometric theorem on secondary level than tradition approach.

### **Qualitative Data Analysis**

Researcher developed observation note. Then take the responses of the students with used appendix-D and daily note and they were noted. Researcher used observation sheet note writing on both experimental group and control group. There was no limitation to responses for the respondents. They were able to express freely whatever they have in their mind. Thus, students feeling are difference to constructivist approach. Generally, researcher observed student's participant in mathematics class room, motivation, student's class activities and

Student's behavior change. Then they were noted and analyzed as a following with the using steps; gathering data, coding, memo writing, theoretical sampling and interpretation.

- a. Participant: Students took part in a teaching activities or teaching event.

*Response of control group; students are active to copy teacher's prove on note book.*

*Response of experimental group; Students are actively tried to solve problem with group discussion.*

- i. Coding: Copy on students note book, try to solve and group discussion
  - ii. Memo-writing: Control group students are only centered to copying teacher's activities. But experimental group students tried to solve problem and involved into group discussion.
  - iii. Theoretical sampling: If students are passive in class activities then it is called not participant. But if students try to understand problem, try to solve it and involved into group discussion then it called participant.
  - iv. Interpretation: Above explanation show that, control groups are not actively participant in class activities but the experimental group students are actively participant into class activities. It implies constructivist approach is effective to teach geometric theorem.
- b. Motivation: Motivation is the self interest or interest to class activities or try to solve problem themselves.

*Response of control group; mathematics class is boring class. I don't interest to participant there.*

*Response of experimental group; Students are not interest to earlier episode but after the six and seven episode student are interested into mathematics class room.*

- i. Coding: Not interested and interested
- ii. Memo-writing: Students of the control group are not interested in class activities but the students of the experimental group are interested in class activities.

- iii. Theoretical sampling: If students are not interested to teaching activities then it is called not motivated to class activity. But if students are interest to teaching activities then it is called motivation to class activities.
  - iv. Interpretation: Above explanation show that student of the control groups are not motivated to teaching learning activities but the experimental group students are motivated to teaching learning activities.
- c. Student's behavior change: Difference between earlier episode's behavior of the student and last episode's behavior of student is called student's behavior change.
- Response of control group; there was not change of behavior from earlier episode to last episode.*
- Response of experimental group; There was vastly change of behavior from earlier episode to last episode.*
- i. Coding: Behaviors not change and behaviors vastly change
  - ii. Memo-writing: Control group students behavior was not change from first episode to last episode but experimental group student's behavior was vastly difference from first episode to last episode.
  - iii. Theoretical sampling: If there is a change of behavior while using treatment it is positive behavior and if not it is constant behavior.
  - iv. Interpretation: From beginning to the end of the experimental episode, control groups students was only centered to copying teacher's solve and rote that. It means behavior of control group students are not change at the first episode to last episode. Experimental group students are not perfect to the steps of constructivist approach at the earlier episode. After six and seven episodes students are perfect to the steps of constructivist approach and their behavior was changed vastly. Students change copy writing and rote learning style into learning by group discussion way, learning by scaffolding to each other and collaborative learning.

Moreover the researcher had analyzed the student's responses as following with the support of Appendix-D. The question Do you like geometric subject? Fifty percent students asked geometric subject was like. It means 50% students don't like geometric. It implies half of

the students are feel geometric topic was difficult. The question do you think geometric problems are easier rather than the problems of other mathematics? Ninety five percent students think geometric problems are difficult than other mathematics problem. Similarly, the question is you satisfied your mathematics teacher? Around 60% students are satisfied their class teacher teaching method. About 13.08% students were expressing their feeling, confusion and problem about subject matter freely with their class teacher.

Response of student is show their class teacher didn't used teaching material at the class room activities. Regular class teacher should be used tradition approach in control group to teach prove geometric theorem. Again, the question, what do you think researcher teaching style? The students were give following response learning by doing, Discussion method, Students method, self doing method. Student clam that, there was vast difference between researchers used teaching approach and class teacher used teaching approach. The difference of teaching style were following according to students response, in the researcher style teacher was only environment maker, all the problem solve students itself and student are learned by using group discussion but in class teacher style teacher was center point of teaching activities, teacher do everything do, students were only receiver. It show researcher approach was batter effective then class teacher approach. So researcher use constructivist approach and class teacher use tradition approach. It implies that constructivist approach was batter effective to prove geometric theorem then tradition approach at secondary level.

Around 80% students are satisfied to researcher teaching approach and behavior. At the earlier episode of teaching episode students didn't interest to constructivist approach. So the researcher was feels difficult to use constructivist approach at class room activities. After the 7/8 teaching episode student should be perfect to constructivist approach's steps. So the researcher feels easier to use constructivist approach at class room.

The result of post test and response of students show, constructivist approach were support to the students to understanding prove geometric theorem. Moreover, student's response of the question "which method does you like between researcher method and class teacher method?" are 19% students asked both method was like, 56% students asked constructivist approach like and 25% students asked tradition approach like. It concludes that most of the

students were like constructivist approach. Finally, response of students conclude, most of the students believe that the concept of geometry can be learned by discussing with friends.

Above explanation show that constructivist approach was better to prove geometric theorem than tradition approach. More than 80% students were interest to constructivist approach's teaching activities. Above 80% students were able to prove geometric theorem themselves. Students were believed constructivist approach support to easier prove geometric theorem prove by using learning by doing and group discussion process. Thus, constructivist approach was support to developed students Zone of Proximal Development.

Finally, above explanation prove constructivist approach was able to encourage the habit of self-learning and self-correcting.

### **Encourage of Constructivist Approach to Self-Learning and Self-Correcting**

In this section, to address the second research question, "Does constructivist approach encourage the habit of self-learning and self-correcting?" which answer was found by using Interview and regular classroom observations.

#### **Students' opinion on self-learning**

After the interview had taken to the target student students and fill to the observation form, the researcher had found the following opinions:

The students said, "First, we studied the instructions clearly and to start solution, we observed the related example. It could not make us confident then we discussed among the group, consulted the reference text book, practices books".

When the researcher asked them whether they had any interaction concerning to the activities. Students replied, "As soon as the solution was found, we looked the answer key. Then we discussed to other groups in order to exchange the ideas and common techniques. The researcher adds another question if the students were satisfied students said, "in the beginning stage, we huddled but when we went on consulting the different resources one at after another, we really felt satisfaction.

Do you have any positive comment on self-learning method, the students added their opinions, and "we think one of the possible way of learning is self-practice. It makes the learner more active and we came to realize the team work is better.

### **Researcher's Views on Promoting Self-learning**

The researcher took an interview with the students who were studying in class IX and collected the reflections which are given below:

- The researcher found that the students had extremely attempted to consult the reference materials: example, spelling copy, practices books.
- When students began suffering from different confusions, they tried to come in contact with other groups in order to discuss.
- Ultimately, when they got the solution they were found to be satisfied and shared their somewhat innovative ideas to each other.

## **Chapter: V**

### **SUMMARY, FINDINGS, CONCLUSION AND RECOMMENDATION**

This study was an experimental whereas researcher developed two types teaching activates. Researcher was used constructivist approach in experimental group and tradition approach in control group. After the experimental episode take the achievement test on each group. Then the researcher obtained following summary, finding, conclusion and recommendation.

#### **Summary**

The nature of this study was experimental. The main purpose of the study was to measure effectiveness of constructivist approach to prove geometric theorem at secondary level. To full fill of this purpose researcher compared the achievement of the students to prove geometric theorem taught by constructivist approach with achievement of the students taught by traditional approach.

In this study researcher review seven research paper and two literatures which are related to constructivist approach and van-Hiele's deductive level of thinking. Then researcher associated constructivist approach and van-Hiele's level of thinking then the researcher made new conceptual framework which support to move teaching episode.

For the data collection of the study researcher choose two secondary schools from the area of Kathmandu district. Then researcher takes the pre-test for the purpose of group homogeneous. Researcher used constructivist approach in experimental group and tradition approach in control group. After that researcher take experimental episode and observe the class activities and students behavior. Then take post test. Both test consisted ten objectives multiple choice type item and eight subjective type item on the area of geometry from grade nine. Researcher also developed observation question for the purpose of learned student change behavior.

The researcher analyzed result of pre-test and post test of the both group by using statistical devices such as mean, S.D , variance and t-test on the bases of topics analysis of pre-test, comparison of experimental and control group, comparison of pre-test and post-test, measure gain of van-Hiele's deductive reasoning and qualitative data analysis respectively.



In this research, researcher also gathered qualitative data by using daily note students activities, behavior, observation sheets and interview. The information's were collected from the observation then researcher analyzed by using three steps that are organization of data, summarizing the data and interpreting the data. Researcher explained the data and their perspectives according to the respondent's responses.

### **Findings of the Study**

On the basis of analysis and interpretation of the data obtained from the achievement test which has been described in a chapter IV. Then the researcher was drawn following finding.

- Analysis of the mean, S.D, variance and t-test of the scores obtained by experimental group and control group students in pre-test showed two groups were equivalent or homogeneous before the treatment. It showed that there was no significance difference between mean achievement of experimental group and mean achievement of control group. It means the understanding level of two groups was equivalent or homogeneous before the treatment.
- The student's achievement of the post test was greater than student's achievement of the pre-test. It means both teaching approach was help to learn prove geometric theorem at secondary level. The difference of mean achievement between pre-test and post-test due to the provide treatment.
- Analysis of the post-test means scores between the experimental and control groups showed that there was significance difference to prove geometric theorem prove between both groups. The experimental group taught by constructivist approach perform was better than control group taught by tradition approach.
- On the basis of pre-test most of the student are in van-Hiele's deductive thinking level-0 and level-1. It means most of the students identify geometric figure and properties which are included in level-0 and level-1.
- On the basis of post test around 75% students are in van-Hiele's level of thinking level-2 and level-3. It implies that both treatment support to gain van-Hiele's level of thinking and easily level wise understanding to prove geometric theorem prove.
- Seventy five percent students of the experimental group were able to solve van-Hiele's level-3 test items but only 59% student of the control group were able to solve van-

Hiele's level-3 test items. Since researcher was used constructivist approach in experimental group and tradition approach was used in control group. It concludes that constructivist approach is better than tradition approach to prove geometric theorem at secondary level.

- Constructivist approach was one of the complete means to teach prove geometric theorem. Constructivist approach was support to complete teaching, collaborative learning, learn to discuss; scaffolding learning and use to learning by doing on field of geometric theorem prove.
- Researcher was found constructivist approach developed student's Zone of Proximal Development.
- Constructivist approach able to encourage the habit of self-learning and self-correcting.
- Finally, the main finding of this study was 'constructivist approach is effective to prove geometric theorem than tradition approach' at secondary level.

### **Conclusion**

On the basis of pre-test there was no significance difference between experimental group and control group. It means the performance of the both group in prove geometric theorem was same before the treatment. But on the basis of post test there was significance difference between pre-test and post-test mean achievement in prove geometric theorem. The achievement of the post-test was greater than pre-test. It was due to treatment.

The achievement of student taught by constructivist approach was significantly greater than the achievement of student taught by tradition approach. Thus, this study show that the constructivist approaches is more effective than the tradition approach of prove geometric theorem at secondary level.

The achievement of the post-test on the basis of van-Hiele's deductive reasoning show that 75% students of the experimental group was solve level-3 but only 59% students of the control group was solve level-3. It implies constructivist approach was support to gain van-Hiele's level of thinking. It means constructivist approach is better to develop students Zone of Proximal Development in prove geometric theorem at secondary level.

From beginning to the end of the experimental episode, control groups students was only centered to copying teacher's solve and rote that. It means behavior of control group students are not change at the first episode to last episode. Experimental group students are not perfect to the steps of constructivist approach at the earlier episode. After six and seven episodes students are perfect to the

steps of constructivist approach and their behavior was changed vastly. Students change copy writing and rote learning style into learning by group discussion way, learning by scaffolding to each other and collaborative learning. Finally, Constructivist approach was able to encourage the habit of self-learning and self-correcting.

### **Recommendations**

From the finding of this study the researcher suggest following recommendations for the better improvements to prove geometric theorem teaching and learning process at secondary level.

- Constructivist approach should used to prove geometric theorem prove in secondary level.
- Students should be encouraged to participate actively in the classroom for constructivist activates.
- Mathematics teacher should be given training to using constructivist approach in classroom activities that could faster the potentially prove geometric theorem, conceptual development and create interest to learning prove geometric theorem.
- At least minimum facility of mathematics laboratory should be established in each and every school in order to practice constructivist approach.
- This study examined only effectiveness of constructivist approach to prove geometric theorem in secondary level. This research didn't tell physical facility, class environment, teacher's attitudes, knowledge and their teaching skill towards geometric. Thus, further researcher is need in this direction considering the mathematics laboratory which support to using constructivist approach, class and home environment, teacher's attitudes, knowledge and teaching skills to geometry.
- The writers of teacher's guide should emphasize on constructivist approach to giving the sample activities of prove geometric theorem in teaching and learning activities.
- The teacher training institutes should focus their attention on constructivist approach of teaching mathematics in the pedagogy course which is not yet introduced.
- Curriculum designer, textbook writer should emphasize on the constructivist approach.
- Such type of study can be carried out with a large sample and various schools of different parts of Nepal to initiate better prove geometric theorem learning activities, which may be more valid and reliable.
- This type of study should also be conducted at all level of school and in other subject as well.

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APPENDIX-A

Test-Items

Pre-Test

Class: 9

Full M: 10

Subject: C. Mathematics

Time: 10M

Students Name:

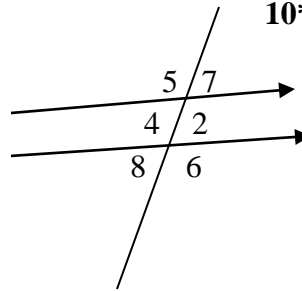
Students Roll No:

Group: A

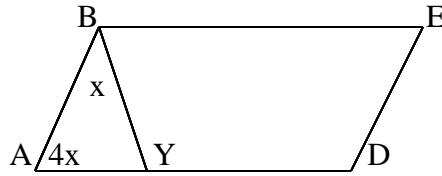
Objective Questions

10\*1=10

- Which angles is alternate angel?
  - 1 and 2
  - 5 and 3
  - 5 and 6
  - 4 and 2
- What are the properties of Co-interior Angles?
  - Equal to each other
  - Sum is 180
  - Subtraction is 180
- What are the properties of isosceles triangle?
  - Base angle are equal
  - All angle of the triangle are equal
  - Non of above
- Which is not a condition of congruent triangle?
  - S.A.S
  - S.A.A
  - Non of above
- Which statement is true?
  - A triangle which has any side equal to each other is scalene triangle.
  - A triangle in which any two sides are equal to each other is an isosceles triangle.
  - A triangle in which one of the angles is  $> 90^\circ$  is said to be an obtuse angled.
- The properties of parallelogram is
  - Alternative sides are equal
  - Alternative angles are equal
  - All of above
- Which is the area of Trapezium?
  - $\frac{1}{2}$  (sum of base)  $\times$  height
  - $\frac{1}{2}$  base  $\times$  height
  - Base  $\times$  height



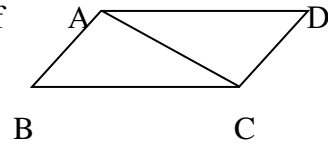
8. Which statement is true?
- In a quadrilateral, opposite side being equal and opposite angle is also equal.
  - In a quadrilateral, opposite side being parallel and opposite angle are equal.
  - In a quadrilateral, opposite angle are not equal but opposite side are parallel.
9. Find the value of Y if



- 80
  - 100
  - 20
10. What are the relation between  $\triangle ABC$  and  $\square ABCD$  if

- $\triangle ABC = \square ABCD$
- $\triangle ABC = 1/2 \square ABCD$

c. Non of above



**Test**

**Subject: C. Mathematics**

**Full M: 40**

**Class: 9**

**Times: 1hr 20m**

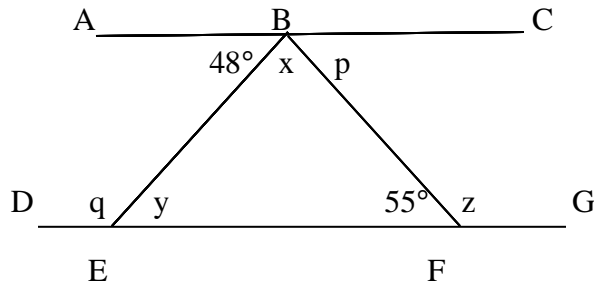
**Group: B**

**Subjective Question**

**8 × 5 = 40**

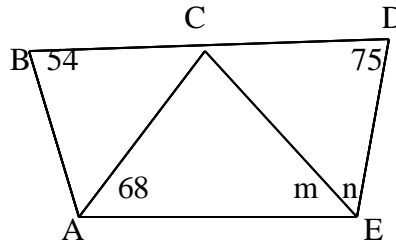
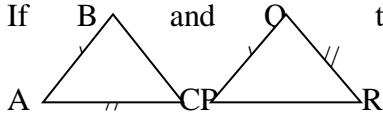
11. Write the five conditions of the congruent triangles with suitable figure.

12. Find the value of p,q,x,y and z if



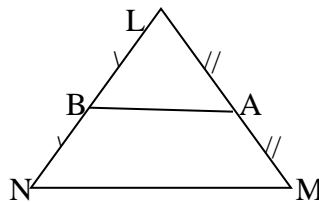
13. Define Alternate Angles, Isosceles triangle, Scalene Triangle, Obtuse Angle Triangle and Congruent triangles with figure.

14. If  $\triangle ABC$  and  $\triangle PQR$  are Congruent.



15. Find the value of m and n if

16. In the figure A and B are the mid-points of LM and LN line respectively then find the value of AB if NM=16cm



17. Prove that parallelogram's alternative sides are equal.

18. Define Trapezium, Parallelogram, Rectangle, Square and Kite with figure.



**APPENDIX-B**  
**Teaching Episode: 1**

**Shubhakamana Academy, Kirtipur-15, Taudha, Kathmandu**

**Class: 9**

**Times: 45 min**

**Chapter: Triangle**

**Topics:** The sum of interior angles of a triangle is equal two right angles.

**Objective:** After the completion of this episode student will be able to theoretical prove “the sum of interior angles of a triangle is equal two right angles.”

Researcher was add a one step prior knowledge in teaching episode and divide students into groups then each group consists equal students. Then with the following teaching episode model researcher will prove theorem in secondary classroom. In which theorem proofs style will be in two columns proof.

**Step 1: Prior Knowledge [5 min]**

Constructivists believe that prior knowledge impacts the learning process. In trying to solve novel problems, perceptual or conceptual similarities between existing knowledge and a new problem can remind people of what they already know. So, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach “the sum of the three angles in the triangle is two right angles.” Then we have review following topic and list on the white board. What are parallel lines? , What is alternate angle? , What is congruent triangle? , What are the properties of the congruent triangle?

**Step2: Presentation of problem [5 min]**

In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that “the sum of the three angles in the triangle is two right angles.” It develops the level 0 of Van Heile’s reasoning mode because in this step student visualize problem without their properties.

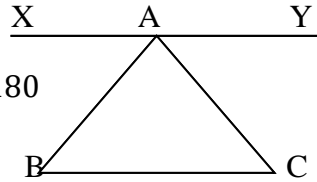
**Step3: Simplify into smaller sub-tasks [5 min]**

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what is internal angle of the triangle, what is the sum of the angle, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given: A triangle  $\triangle ABC$



Construction: Draw XY line on A.



To prove:  $\angle ABC + \angle BCA + \angle CAB = 180$

This step is developed van heile's level 1 because in this step student discusses about the properties of the problem.

**Step4: Exploration in group [20min]**

In this step the student understands that properties are related to the problem and one set of properties may imply another property. Students can reason with simple arguments about geometric figures and try to deductively prove. Like that, to solve the individual problem, first we give opportunity to the student. When student solve the individual problem teacher exchanged their copies within their group and make them to find the common solution with group discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties. So, this step is developed Van heile's level 2 because in this step student try to deductively prove the theorem.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts   | Reason                         |
|---|--------------------------------|
| I. $\angle XAB = \angle ABC$                      | I. XY//BC and Alternate angle  |
| II. $\angle YAC = \angle ACB$                     | II. XY//BC and Alternate angle |
| III. $\angle XAB + \angle BAC + \angle YAC = 180$ | III. Straight angle            |
| IV. $\angle ABC + \angle BCA + \angle CAB = 180$  | IV. Putting I and II in III    |

In this step students are able to prove theorem with reason. Students understand the meaning of proof. The object of thought is deductive reasoning (simple proofs), which the student learns to combine to form a system of formal proofs. Finally looking back of the above process and conclude the formula, statement or theorem. . It develops the level 3 of Van Heile's reasoning because in this step student prove theorem by deduction.

## Teaching Episode: 2

Shubhakamana Academy, Kirtipur-15, Taudha, Kathmandu

Class: 9

Times: 45 min

### Chapter: Triangle

**Topic:** When a side of a triangle is produced an exterior angle so formed, is equal to the sum of non adjacent interior angles of the triangle.

**Objective:** After the completion of this episode students will be able to prove “When a side of a triangle is produced an exterior angle so formed, is equal to the sum of non adjacent interior angles of the triangle”.

#### Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. For example, if we want to teach “When a side of a triangle is produced an exterior angle so formed, is equal to the sum of non adjacent interior angles of the triangle”. Then we have review following topic and list on the white board. What is exterior angle? , What is congruent triangle? , What are the properties of the congruent triangle?

#### Step2: Presentation of problem [5 min]

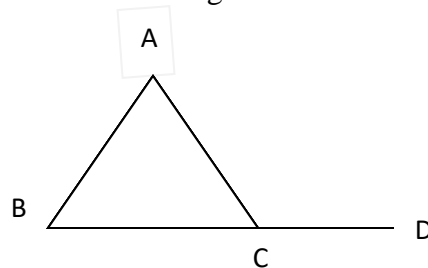
In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem.

#### Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what is exterior angle, what is adjacent angle or non adjacent angle, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it with suitable figure. Like that

Given: In  $\triangle ABC$ ,  $\angle BAC$  and  $\angle ABC$  are non-adjacent and interior angles. The side BC produced up to D so exterior  $\angle ACD$  is formed.

Prove:  $\angle BAC + \angle ABC = \angle ACD$



Construction: The line segment CX is drawn through C such that  $CX \parallel BA$

**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Like that, to solve the individual problem, first we give opportunity to the student. When student solve the individual problem teacher exchanged their copies within their group and make them to find the common solution with discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts                                     | Reason                             |
|---|------------------------------------|
| 1. $\angle ABC = \angle XCD$              | 1. Being corresponding angles.     |
| 2. $\angle BAC = \angle ACX$              | 2. Being alternate angles AB.      |
| 3. $\angle ACX + \angle XCD = \angle ACD$ | 3. Whole part axiom.               |
| 4. $\angle ABC + \angle BAC = \angle ACD$ | 4. From the statements 1, 2 and 3. |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.

### Teaching Episode: 3

Shubhakamana Academy, Kirtipur-15, Taudha, Kathmandu

Class: 9

Times: 45 min

Chapter: Triangles

Topic: Problem related triangles.

**Objective:** Students will be able to prove problem related congruent Triangles.

**Step 1: Prior Knowledge [5 min]**

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach problem related to congruent triangle. Then we have review following topic and list on the white board. What is parallel line? , What is congruent triangle? , What are the properties of the congruent triangle?

**Step2: Presentation of problem [5 min]**

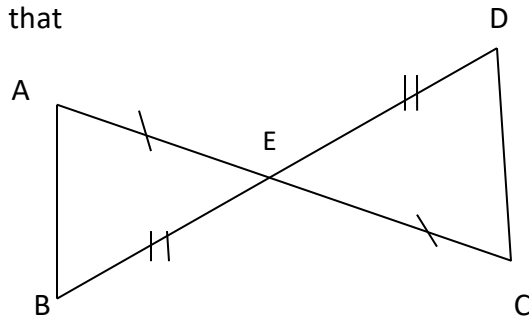
In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that If line segment AC and BD are bisected each other at E. Prove  $\triangle ABE \cong \triangle DEC$  and  $AB = CD$

**Step3: simplify into smaller sub-tasks [5 min]**

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given:  $AE = CE$  and  $BE = DE$

To prove:  $\triangle ABE \cong \triangle DEC$  and  $AB = CD$



**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Like that, Teacher wills emphasis the students to solve problem. When student solve the individual problem teacher provide few minutes to make them common

solution of the group with group discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts  | Reason   |
|--|--|
| <ol style="list-style-type: none"> <li>1. In <math>\triangle ABE</math> and <math>\triangle DEC</math> <ol style="list-style-type: none"> <li>a. <math>AE = EC</math> (S)</li> <li>b. <math>\angle AEB = \angle DEC</math> (A)</li> <li>c. <math>BE = ED</math> (S)</li> </ol> </li> <li>2. <math>\triangle ABE \cong \triangle DEC</math></li> <li>3. <math>AB = CD</math></li> </ol> | <ol style="list-style-type: none"> <li>1. ...           <ol style="list-style-type: none"> <li>a. Given.</li> <li>b. Vertically opposite angles.</li> <li>c. Given.</li> </ol> </li> <li>2. By SAS test of congruency.</li> <li>3. Corresponding side of the congruent triangles.</li> </ol> |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.

## Teaching Episode: 4

Shubhakamana Academy, Kirtipur-15, Taudha, Kathmandu

Class: 9

Times: 45 min

Chapter: Triangles

Topic: Problem related to the triangle

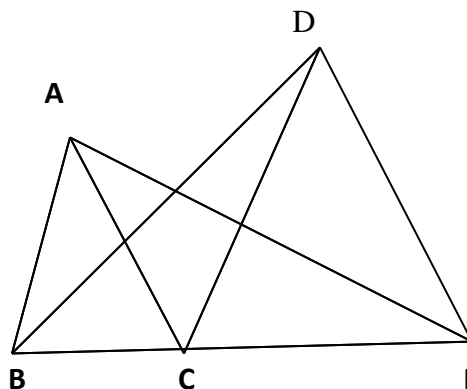
Objective: Students will be able to prove problem related to congruency.

Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach problem related to congruency. Then we have review following topic and list on the white board. What is parallel line? , What are the opposite angles and sides? , What is congruent triangle? , What are the properties of the congruent triangle?

Step2: Presentation of problem [5 min]

In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that, in the given figure, ABC and CDE are equilateral triangles. Prove that:  $AE = DB$ .



Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given: ABC and CDE are equilateral triangles.

To prove:  $AE = DB$

**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Like that, Teacher wills emphasis the students to solve problem. When student solve the individual problem teacher provide few minutes to make them common solution of the group with group discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts   | Reason   |
|---|--|
| 1. $\angle ACB = \angle DCE = 60$<br>2. $\angle ACB + \angle ACD = \angle DCE + \angle ACD$<br>Or, $\angle BCD = \angle ACE$<br>3. IN $\triangle ACE$ and $\triangle BCD$<br>a. $AC = BC$ (S)<br>b. $\angle BCD = \angle ACE$ (A)<br>c. $CE = ED$ (S)<br>4. $\triangle ACE \cong \triangle BCD$<br>5. $AE = BD$ | 1. Angles of equilateral triangles.<br>2. Adding $\angle ACD$ on both sides.<br>3. ....<br>a. Sides of equilateral triangles.<br>b. From the statement (2).<br>c. Sides of an equilateral triangle CDE.<br>4. By SAS test of congruency.<br>5. Corresponding sides of congruent triangles. |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.



## Teaching Episode: 5

Class: 9

Times: 45 min

### Chapter: Triangle

**Topic:** Theorem related to triangles.

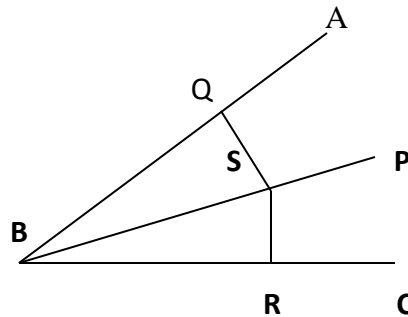
**Objective:** Students will be able to prove theorem related to congruency triangle.

#### Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach theorem related to congruency triangle. Then we have review following topic and list on the white board. What is parallel line? , What is the perpendicular line? , What is congruent triangle? , What are the properties of the congruent triangle?

#### Step2: Presentation of problem [5 min]

In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that in the figure, BP is bisector of  $\angle ABC$ ,  $SQ \perp AB$  and  $SR \perp BC$ . Prove that:  $QS = SR$ .



#### Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given: BP is bisector of  $\angle ABC$ ,  $SQ \perp AB$  and  $SR \perp BC$ .

To prove:  $QS = SR$

**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Teacher wills emphasis the students to solve problem. When student solve the individual problem teacher provide few minutes to make them common solution of the group with group discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts   | Reason   |
|---|--|
| 1. In $\Delta BQS$ and $\Delta BSR$<br>a. $\angle BQS = \angle BRS$ (A)<br>b. $\angle QBS = \angle SBR$ (A)<br>c. $BS = BS$ (S) | 1. ...<br>a. Given.<br>b. Given.<br>c. Common sides. |
| 2. $\Delta BQS \cong \Delta BSR$  | 2. AAS test of congruency.                           |
| 3. $QS = RS$  | 3. Corresponding sides of congruency.                |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.

## Teaching Episode: 6

Class: 9

Times: 45 min

Chapter: Triangle

Topic: Theorem related Triangle.

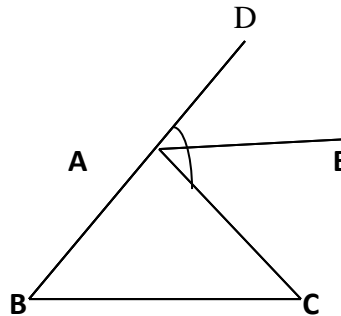
Objective: Students will be able to prove theorem related triangle.

Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach theorem related to triangle. Then we have review following topic and list on the white board. What is parallel line? , What are the bisectors? , What is congruent triangle? , What are the properties of the congruent triangle?

Step2: Presentation of problem [5 min]

In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that, prove that:  $AE \parallel BC$  if  $AE$  bisector of  $\angle DAC$ , and  $AB = AC$ .



Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given:  $AE$  bisector of  $\angle DAC$ , and  $AB = AC$ .

To prove:  $AE \parallel BC$

**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Teacher wills emphasis the students to solve problem. When student solve the individual problem teacher provide few minutes to make them common solution of the group with group discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts   | Reason   |
|---|--|
| 1. $\angle ABC = \angle ACB$  | 1. Base angles of an isosceles triangle.   |
| 2. $\angle ABC + \angle ACB = \angle DAC$                                   | 2. The sum of non adjacent interior angles of triangle is equal to exterior angle of the triangle. |
| 3. $\angle ABC + \angle ABC = \angle DAC$<br>Or, $2\angle ABC = \angle DAC$ | 3. From the statement 1 and 2.   |
| 4. $2\angle DAE = \angle DAC$   | 4. As AE is the bisector of $\angle DAC$   |
| 5. $\angle ABC = \angle DAE$  | 5. From the statement 3 and 4.   |
| 6. $AE = BC$  | 6. As $\angle ABC = \angle DAE$ .  |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.

## Teaching Episode: 7

Class: 9

Times: 45 min

### Chapter: Triangle

**Topic:** The angles at the base of an isosceles triangle are equal.

**Objective:** Students will be able to prove “the angles at the base of an isosceles triangle are equal”.

#### Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach “the angles at the base of an isosceles triangle are equal”. Then we have review following topic and list on the white board. What is isosceles triangle? , What are the properties of the isosceles triangle? , What is congruent triangle? , What are the properties of the congruent triangle?

#### Step2: Presentation of problem [5 min]

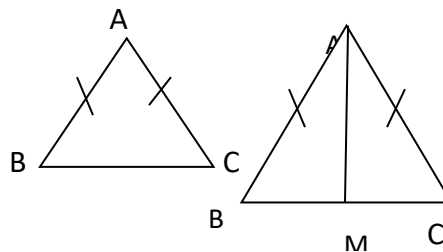
In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that “the angles at the base of an isosceles triangle are equal”.

#### Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what are the base angle of the triangles, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given: A triangle or  $\triangle ABC$

Construction: Draw AM line on BC.



To Prove:  $\angle ABM = \angle ACM$

**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Teacher wills emphasis the students to solve problem. When student solve the individual problem teacher provide few minutes to make them common solution of the group with group discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts                                     | Reason  |
|---|---|
| 1. In $\triangle AMC$ and $\triangle BMC$ | 1.  |
| a. $\angle AMC = \angle BMC$ (R)          | a. Both are $90^\circ$ by construction.           |
| b. $AC = BC$ (H)                          | b. Given.   |
| c. $MC = MC$ (S)                          | c. Common side.                                   |
| 2. $\triangle AMC \cong \triangle BMC$    | 2. By RHS test of congruency.                     |
| 3. $\angle ABM = \angle ACM$              | 3. Corresponding angle of the congruent triangle. |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.

## Teaching Episode: 8

Class: 9

Times: 45 min

### Chapter: Triangle

**Topic:** If two angles of a triangle are equal, then sides opposite to the angles are equal.

**Objective:** After the completion of this episode students will be able to prove “if two angles of a triangle are equal, then sides opposite to the angles are equal”.

#### Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach “If two angles of a triangle are equal, then sides opposite to the angles are equal.” Then we have review following topic and list on the white board. What is isosceles triangle? , What are the properties of the isosceles triangle? , What are the opposite sides of triangle? What is congruent triangle? , What are the properties of the congruent triangle?

#### Step2: Presentation of problem [5 min]

In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that “If two angles of a triangle are equal, then sides opposite to the angles are equal”.

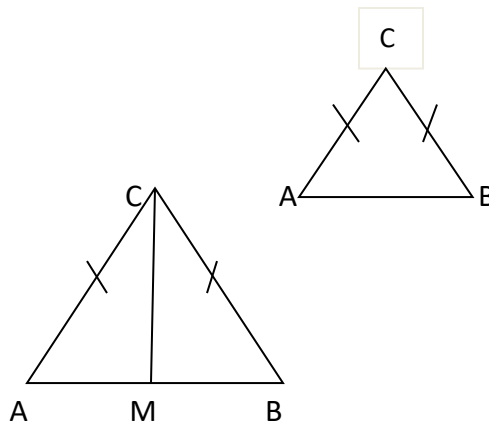
#### Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what are the base angle of the triangles, what are given, need construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given: A isosceles triangle or  $\triangle ABC$

Construction:  $CM \perp AB$  is drawn.

To Prove:  $CB=AC$



**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Teacher wills emphasis the students to solve problem. When student solve the individual problem teacher provide few minutes to make them common solution of the group with group discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts   | Reason  |
|---|---|
| 1. In $\triangle AMC$ and $\triangle BMC$<br>a. $\angle AMC = \angle BMC$ (A)<br>b. $\angle MAC = \angle MBC$ (A)<br>c. $MC = MC$ (S) | 1. ...<br>a. Both are $90^\circ$ by construction.<br>b. Given.<br>c. Common side. |
| 2. $\triangle AMC \cong \triangle BMC$  | 2. By AAS test of congruency.   |
| 3. $AC = BC$  | 3. Corresponding sides of congruent triangles.                                    |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.



## Teaching Episode: 9

Class: 9

Times: 45 min

### Chapter: Triangle

**Topic:** The bisector of vertical angle of an isosceles triangle is perpendicular to the base of the triangle.

**Objective:** After the completion of this episode students will be able to prove “The bisector of vertical angle of an isosceles triangle is perpendicular to the base of the triangle.”

#### Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach “the bisector of vertical angle of an isosceles triangle is perpendicular to the base of the triangle”. Then we have review following topic and list on the white board with discussion. What is isosceles triangle? , What are the properties of the isosceles triangle? , What are the opposite sides of triangle? , what is bisector? , What is congruent triangle? , What are the properties of the congruent triangle?

#### Step2: Presentation of problem [5 min]

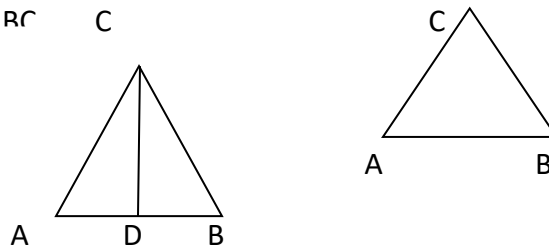
In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that “the bisector of vertical angle of an isosceles triangle is perpendicular to the base of the triangle”.

#### Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of problem. For example, what are the base angle of the triangles, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given: A isosceles triangle or  $\triangle ABC$   $AC = BC$

and  $CM$  is bisector of  $\angle ACB$ .



To Prove:  $AM = BM$  and  $\angle AMC = 90^\circ$

**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Teacher wills emphasis the students to solve problem. When student solve the individual problem teacher provide few minutes to make them common solution of the group with group discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts  | Reason  |
|--|---|
| 1. $\triangle AMC$ and $\triangle BMC$<br>a. $\angle ACM = \angle BCM$ (A)<br>b. $AC = BC$ (S)<br>c. $\angle MAC = \angle MBC$ (A)<br>2. $\triangle AMC \cong \triangle BMC$<br>3. $AM = BM$<br>4. $\angle AMC = \angle BMC$<br>5. $\angle AMC + \angle BMC = 180^\circ$<br>6. $\angle AMC + \angle BMC = 180^\circ$<br>Or $2\angle AMC = 180^\circ$<br>$\therefore \angle AMC = 90^\circ$ | 1. ...<br>a. Given.<br>b. Given<br>c. The base angle of an isosceles triangle.<br>2. BY ASA test of congruency.<br>3. Corresponding side of congruent triangles.<br>4. Corresponding angles of congruent triangles.<br>5. Angel in a straight line.<br>6. $\angle AMC = \angle BMC$ |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.

## Teaching Episode: 10

Class: 9

Times: 45 min

### Chapter: Triangle

**Topic:** Median from the vertex of an isosceles triangle is bisector of vertical angle and perpendicular to the base.

**Objective:** After the completion of this episode students will be able to prove “median from the vertex of an isosceles triangle is bisector of vertical angle and perpendicular to the base”.

#### Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. For example, if we want to teach “Median from the vertex of an isosceles triangle is bisector of vertical angle and perpendicular to the base.” Then we have review following topic and list on the white board. What is isosceles triangle? , What is congruent triangle? , What are the properties of the congruent triangle?

#### Step2: Presentation of problem [5 min]

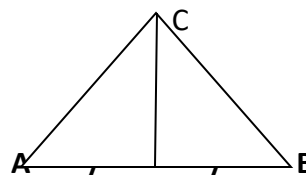
In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that “Median from the vertex of an isosceles triangle is bisector of vertical angle and perpendicular to the base.”

#### Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what is isosceles triangle? , what are given, need any construction, what is to be found? Then teacher as well as student both are lists it with suitable figure. Like that

Given: In an isosceles  $\triangle ABC$ ,  $AC = BC$  and  $AM = BM$ .

Prove:  $AM = BM$  and  $\angle AMC = 90^\circ$



#### Step4: Exploration in group [20min]

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Like that, to solve the individual problem, first we give opportunity to the student. When student solve the individual problem teacher exchanged their copies within their group and make them to find the common solution with discussion. And teacher list each group solution on the white board. In this step teacher facilitate student’s difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts  | Reason  |
|--|---|
| <ol style="list-style-type: none"><li>1. In <math>\triangle AMC</math> and <math>\triangle BMC</math><ol style="list-style-type: none"><li>a. <math>AC = BC</math></li><li>b. <math>AM = BM</math></li><li>c. <math>MC = MC</math></li></ol></li><li>2. <math>\triangle AMC \cong \triangle BMC</math></li><li>3. <math>\angle ACM = \angle BCM</math></li><li>4. <math>\angle AMC = \angle BMC</math></li><li>5. <math>\angle AMC + \angle BMC = 180^\circ</math></li><li>6. <math>\angle AMC + \angle AMC = 180^\circ</math><br/>or <math>2\angle AMC = 180^\circ</math><br/><math>\therefore \angle AMC = 90^\circ</math></li></ol> | <ol style="list-style-type: none"><li>1. ...<ol style="list-style-type: none"><li>a. Given.</li><li>b. Given.</li><li>c. Common side.</li></ol></li><li>2. By SSS test of congruency.</li><li>3. Corresponding angles of the congruent triangles.</li><li>4. Corresponding angles of the congruent triangles.</li><li>5. Angles in a straight line.</li><li>6. <math>\angle AMC = \angle BMC</math></li></ol> |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.

## Teaching Episode: 11

Class: 9

Times: 45 min

### Chapter: Parallelogram

**Topic:** The line segments which join the end points of two equal and parallel lines on the same side segments are equal and parallel.

**Objective:** Students will be able to prove “The line segments which join the end points of two equal and parallel lines on the same side segments are equal and parallel”.

#### Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach “the line segments which join the end points of two equal and parallel lines on the same side segments are equal and parallel”. Then we have review following topic and list on the white board. What is parallel line? , What are the properties of parallelogram? , What is congruent triangle? , What are the properties of the congruent triangle?

#### Step2: Presentation of problem [5 min]

In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that “the line segments which join the end points of two equal and parallel lines on the same side segments are equal and parallel”.

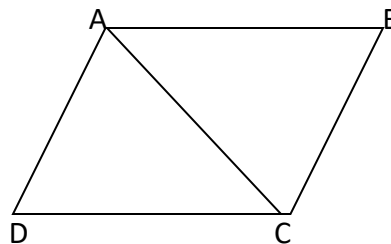
#### Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given:  $AB = DC$  and  $AB \parallel DC$  , the end points of  $AB$  and  $DC$  are joined with the line segments  $AD$  and  $BC$  on the same side

To prove:  $AD = BC$  and  $AD \parallel BC$

Construction: Join points  $A$  and  $C$



#### Step4: Exploration in group [20min]

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Like that, to solve the individual problem, first we give opportunity to the student. When student solve the individual problem teacher exchanged their copies within their group and make them to find the common solution with discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts   | Reason  |
|---|---|
| 1. In $\triangle ABC$ and $\triangle ADC$<br>a. $AB=DC$<br>b. $\angle BAC = \angle ACD$<br>c. $AC = AC$<br>2. $\triangle ABC \cong \triangle ADC$<br>3. $AD = BC$<br>4. $\angle ACB = \angle DAC$<br>5. $AD \parallel BC$ | 1. ....<br>a. Given<br>b. Being alternate angles<br>c. Common side<br>2. By SAS test of congruency.<br>3. Corresponding sides of congruent triangles.<br>4. Corresponding angles of congruent triangles.<br>5. From the statement (4) |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.

## Teaching Episode: 12

Class: 9

Times: 45 min

### Chapter: Parallelogram

**Topic:** The opposite sides and angle of a parallelogram are equal.

**Objective:** After the completion of this episode students will be able to prove “The opposite sides and angle of a parallelogram are equal.”

#### Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach “the opposite sides and angle of a parallelogram are equal”. Then we have review following topic and list on the white board. What is parallel line? , What are the properties of parallelogram? , What is congruent triangle? , What are the properties of the congruent triangle?

#### Step2: Presentation of problem [5 min]

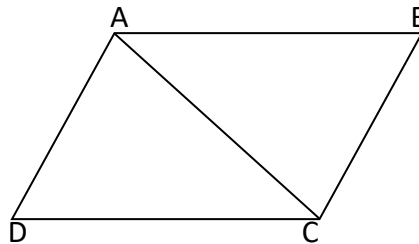
In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that “The opposite sides and angle of a parallelogram are equal.”

#### Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given:  $AB \parallel DC$  and  $AD \parallel BC$

Construction: Join points A and C



To prove:  $AB = DC$ ,  $AD = BC$  and  $\angle A = \angle C$ ,  $\angle B = \angle D$

**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Teacher will emphasize the students to solve problem. When student solve the individual problem teacher provide few minutes to make them common solution of the group with group discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts   | Reason   |
|---|--|
| <ol style="list-style-type: none"><li>1. In <math>\triangle ABC</math> and <math>\triangle ADC</math><ol style="list-style-type: none"><li>a. <math>\angle CAB = \angle ACD</math> (A)</li><li>b. <math>AC = AC</math> (S)</li><li>c. <math>\angle ACB = \angle DAC</math> (A)</li></ol></li><li>2. <math>\triangle ABC \cong \triangle ADC</math></li><li>3. <math>AB=CD</math> and <math>AD=BC</math></li><li>4. <math>\angle ADC = \angle ABC</math></li><li>5. <math>\angle DAB = \angle DCB</math></li></ol> | <ol style="list-style-type: none"><li>1. ...<ol style="list-style-type: none"><li>a. Being alternate angles.</li><li>b. Common sides.</li><li>c. Being alternate angles.</li></ol></li><li>2. By ASA test of the congruent.</li><li>3. Corresponding sides of the congruent triangles.</li><li>4. Corresponding angles of the congruent triangles.</li><li>5. AS above</li></ol> |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.



## Teaching Episode: 13

Class: 9

Times: 45 min

### Chapter: Parallelogram

**Topic:** The diagonal of parallelogram are bisecting each other.

**Objective:** After the completion of this episode students will be able to prove “the diagonal of parallelogram are bisecting each other”.

#### Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach “the diagonal of parallelogram are bisecting each other.” Then we have review following topic and list on the white board. What is parallel line? , What are the properties of parallelogram? , What is congruent triangle? , What are the properties of the congruent triangle?

#### Step2: Presentation of problem [5 min]

In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that “the diagonal of parallelogram a bisecting each other”.

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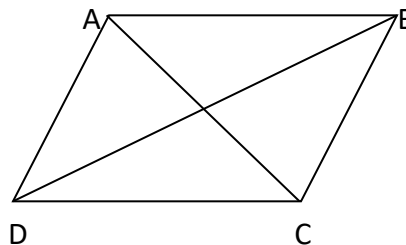
#### Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given: ABCD is parallelogram in which diagonals

and BD are intersected at point O.

To prove:  $AO = OC$  and  $OD = BO$



**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Teacher wills emphasis the students to solve problem. When student solve the individual problem teacher provide few minutes to make them common solution of the group with group discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts                                     | Reason                        |
|---|-------------------------------|
| 1. In $\triangle AOD$ and $\triangle BOC$ | 1. ...                        |
| a. $AD = BC$ (S)                          | a. Given.                     |
| b. $\angle DAO = \angle OCB$ (A)          | b. Being alternate angles.    |
| c. $\angle AOD = \angle BOC$ (A)          | c. Vertically opposite sides. |
| 2. $\triangle AOD \cong \triangle BOC$    | 2. By SAA test of congruency. |
| 3. $AO = OC$ and $OD = BO$                | 3. Corresponding sides        |

Finally looking back of the above process and conclude the formula, statement or theorem a ' repeated this process.

## Teaching Episode: 14

Class: 9

Times: 45 min

### Chapter: Parallelogram

**Topic:** The line segment which joins the mid points of two sides of triangles is parallel to third side and half of the third side.

**Objective:** Students will be able to prove “the line segment which joins the mid points of two sides of triangles is parallel to third side and half of the third side”.

#### Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach “The line segment which joins the mid points of two sides of triangles is parallel to third side and half of the third side.” Then we have review following topic and list on the white board. What is parallel line? , What are the properties of parallelogram? , What is congruent triangle? , What are the properties of the congruent triangle?

#### Step2: Presentation of problem [5 min]

In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that “the line segments which join the end points of two equal and parallel lines on the same side segments are equal and parallel”.

#### Step3: Simplify into smaller sub-tasks [5 min]

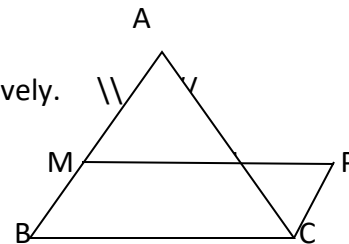
In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given: In  $\triangle ABC$ , M and N are midpoints of AB and AC respectively.

To prove:  $MN = \frac{1}{2} BC$  and  $MN \parallel BC$

Construction: A line segment is drawn through C and

parallel to AB, also MN is produced so they meet at P.



**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Teacher wills emphasis the students to solve problem. When student solve the individual problem teacher provide few minutes to make them common solution of the group with group discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts   | Reason  |
|---|---|
| <ol style="list-style-type: none"><li>1. In <math>\triangle AMN</math> and <math>\triangle NPC</math><ol style="list-style-type: none"><li>a. <math>AN = NC</math> (S)</li><li>b. <math>\angle ANM = \angle PNC</math> (A)</li><li>c. <math>\angle AMN = \angle NPC</math> (A)</li></ol></li><li>2. <math>\triangle AMN \cong \triangle NPC</math></li><li>3. <math>CP = BM, MN = NP</math></li><li>4. <math>MP = BC, MP \parallel BC</math></li><li>5. <math>MN + NP = BC</math></li><li>6. <math>MN + M = BC</math><br/>or, <math>2MN = BC</math><br/><math>MN = \frac{1}{2} BC</math></li><li>7. <math>MN = \frac{1}{2} BC, MN \parallel BC</math></li></ol> | <ol style="list-style-type: none"><li>1. ...<ol style="list-style-type: none"><li>a. Given.</li><li>b. Being vertically opposite angles.</li><li>c. Being alternate angles.</li></ol></li><li>2. By SAA test of congruency</li><li>3. Corresponding sides of congruent triangles.</li><li>4. As <math>MB = PC</math> and <math>MB \parallel PC</math></li><li>5. As <math>MP = MN + NP</math></li><li>6. As <math>MN = PN</math></li><li>7. From statements 4 &amp; 6</li></ol> |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.

## Teaching Episode: 15

Class: 9

Times: 45 min

### Chapter: Parallelogram

**Topic:** The line segments which passes through midpoint of a side of a triangles and parallel to another side bisects the third side.

**Objective:** Students will be able to prove “the line segments which passes through midpoint of a side of a triangles and parallel to another side bisects the third side.”

#### Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach “The line segments which passes through midpoint of a side of a triangles and parallel to another side bisects the third side.” Then we have review following topic and list on the white board. What is parallel line? , What are the properties of parallelogram? , What is congruent triangle? , What are the properties of the congruent triangle?

#### Step2: Presentation of problem [5 min]

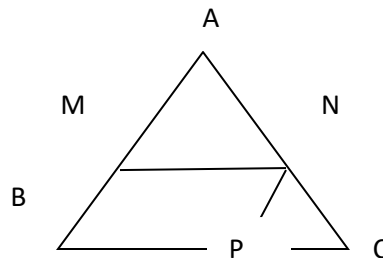
In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that “The line segments which passes through midpoint of a side of a triangles and parallel to another side bisects the third side.”

#### Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given: In  $\triangle ABC$ , M is midpoint of AB and  $MN \parallel BC$ .

To prove:  $AN = NC$



Construction: A line segment drawn through N which cuts BC at P such that  $AB \parallel NP$ .

**Step4: Exploration in group [10min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Teacher wills emphasis the students to solve problem. When student solve the individual problem teacher provide few minutes to make them common solution of the group with group discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts  | Reason   |
|--|--|
| <ol style="list-style-type: none"><li>1. BMNP is a parallelogram</li><li>2. <math>AM = BM</math></li><li>3. <math>BM = MP</math></li><li>4. In <math>\triangle AMN</math> and <math>\triangle NPC</math><ol style="list-style-type: none"><li>a. <math>AM = NP(S)</math></li><li>b. <math>\angle ANM = \angle PCP(A)</math></li><li>c. <math>\angle MAN = \angle PNC(A)</math></li></ol></li><li>5. <math>\triangle AMN \cong \triangle NPC</math></li><li>6. <math>AN = NC</math></li></ol> | <ol style="list-style-type: none"><li>1. As <math>AB \parallel NP</math> and <math>MN \parallel BC</math>.</li><li>2. Give.</li><li>3. The opposite sides of a parallelogram.</li><li>4. ...<ol style="list-style-type: none"><li>a. From the statements 2 and 3.</li><li>b. Being corresponding angles.</li><li>c. Being corresponding angles.</li></ol></li><li>5. By SAA test of congruency.</li><li>6. Corresponding sides of the congruent triangles.</li></ol> |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.

## Teaching Episode: 16

Class: 9

Times: 45 min

Chapter: Parallelogram

Topic: Exercise of parallelogram.

**Objective:** Students will be able to prove “Problem of question four”.

**Step 1: Prior Knowledge [5 min]**

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach “Problem of question four”. Then we have review following topic and list on the white board. What is parallel line? , What are the properties of parallelogram? , What is congruent triangle? , What are the properties of the congruent triangle?

**Step2: Presentation of problem [5 min]**

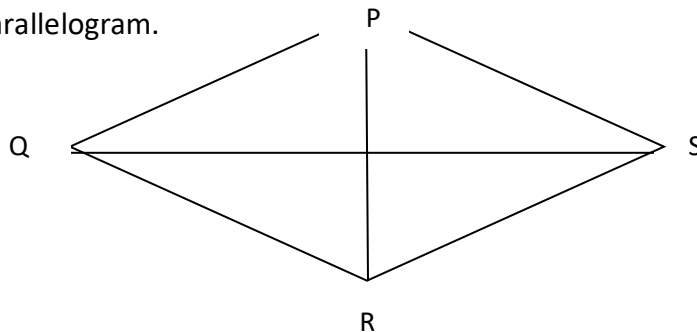
In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that “Problem of question numbers four”.

**Step3: Simplify into smaller sub-tasks [5 min]**

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given: PQRS is a parallelogram. The points M and N are point on diagonal PR such that  $PN = MR$ .

To prove: QNSM is a parallelogram.



**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Like that, to solve the individual problem, first we give opportunity to the student. When student solve the individual problem teacher exchanged their copies within their group and make them to find the common solution with discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts   | Reason  |
|---|---|
| 1. $PQ = QR$<br>2. $PN = MR$<br>3. $PO - PN = OR - MR$<br>Or, $NO = Mo$<br>4. $QO = OS$<br>5. QNSM is a parallelogram | 1. The diagonal of parallelogram are bisecting each other.<br>2. Given.<br>3. Statement 2 is subtracted from 3.<br>4. The diagonal of parallelogram are bisecting each other.<br>5. As the diagonal are bisecting each other. |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.



## Teaching Episode: 17

Class: 9

Times: 45 min

Chapter: Parallelogram

Topic: Problem of parallelogram.

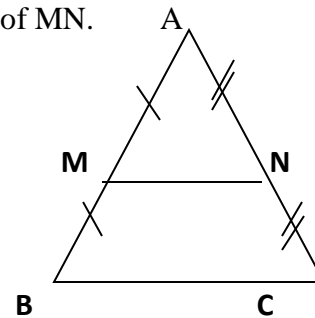
Objective: Students will be able to prove parallelogram related problem.

Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. Then we have review following topic and list on the white board. What is parallel line? , What are the properties of parallelogram? , What is congruent triangle? , What are the properties of the congruent triangle?

Step2: Presentation of problem [5 min]

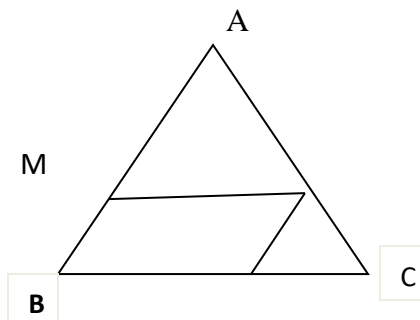
In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that In the figure alongside, M and N are mid points of AB and AC respectively and  $BC = 6\text{cm}$  find the size of MN.



Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given:  $AM = BM$  and  $AN = NC$  and  $BC = 6\text{cm}$ .



To prove:  $MN = ?$

**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Like that, to solve the individual problem, first we give opportunity to the student. When student solve the individual problem teacher exchanged their copies within their group and make them to find the common solution with discussion. And teacher list each group solution on the white board. In this step teacher facilitate student's difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion.

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.

## Teaching Episode: 18

Class: 9

Times: 45 min

### Chapter: Parallelogram

**Topic:** The line segments which join the end points of two equal and parallel lines on the same side segments are equal and parallel.

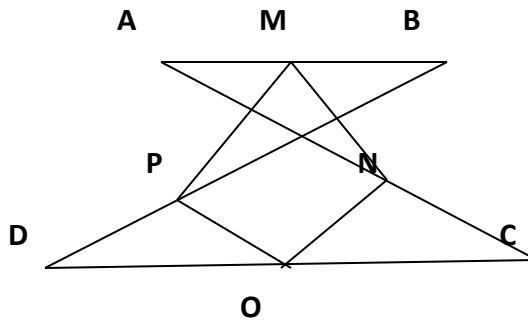
**Objective:** Students will be able to prove parallelogram related theorem.

#### Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. Then it also measure current skills of students. For example, if we want to teach theorem related to parallelogram... Then we have review following topic and list on the white board. What is parallel line? , What are the properties of parallelogram? , What is congruent triangle? , What are the properties of the congruent triangle?

#### Step2: Presentation of problem [5 min]

In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that In the figure, points M, N, O and P are the mid points of AB, AC, DC and BD respectively. Prove that MNOP is a parallelogram.



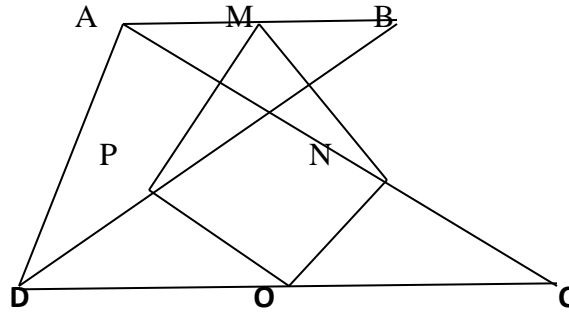
#### Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplify into smaller sub-tasks and discuss about properties of the problem. For example, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Give: points M, N, O and P are te mid points of AB, AC, DC and BD respectively.

To prove: MNOP is a parallelogram.

Construction: Join A and D.



**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Like that, to solve the individual problem, first we give opportunity to the student. When students solve the individual problem, they exchanged their copies within their group and made them to find the common solution with discussion. And the teacher lists each group solution on the white board. In this step, the teacher facilitates students' difficulties.

**Step5: Reflection [10 min]**

After listing each group solution, then discuss about what is the final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts   | Reason  |
|---|---|
| 1. In $\triangle ABD$ , $MP = \frac{1}{2} AD$ and $MP \parallel AD$ | 1. The line segment which joins the mid points of two sides of a triangle is parallel to the third side and half of the third side.   |
| 2. In $\triangle ACD$ , $ON = \frac{1}{2} AD$ and $NO \parallel AD$ | 2. Same as 1.   |
| 3. $MP = NO$ and $MP \parallel NO$                                  | 3. From the statement 1 and 2   |
| 4. $MN = PO$ and $MN \parallel PO$                                  | 4. The line segments which join the end points of two equal and parallel lines on the same side segments are also equal and parallel. |
| 5. MNOP is a parallelogram.   | 5. As opposite sides are equal and parallel.  |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.

## Teaching Episode: 19

Class: 9

Times: 45 min

Chapter: Parallelogram

Topic: Theorem related to parallelogram

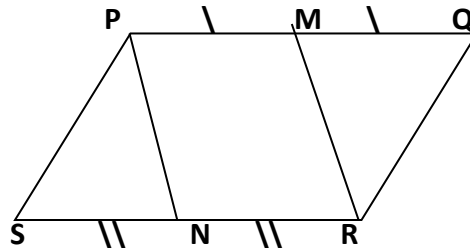
Objective: Students will be able to prove theorem related to parallelogram.

### Step 1: Prior Knowledge [5 min]

Firstly, discuss about prior knowledge which are related to problem. Then it also measures current skills of students. For example, if we want to teach theorem related to parallelogram. Then we have review following topic and list on the white board. What is parallel line? , What are the properties of parallelogram? , What is congruent triangle? , What are the properties of the congruent triangle?

### Step2: Presentation of problem [5 min]

In this step teacher present the problem to the students and they are provided free chance to understand problem and emphasizes to draw problem related figure which supported to Visualization of the problem. Like that PQRS is a parallelogram and M and N are mid points of PQ and SR respectively. Prove that PMRN is a parallelogram.



### Step3: Simplify into smaller sub-tasks [5 min]

In this step, problem can be simplified into smaller sub-tasks and discuss about properties of the problem. For example, what are given, need any construction, what is to be found? Then teacher as well as student both are lists it. Like that

Given: PQRS is a parallelogram and M and N are mid points of PQ and SR respectively.

To prove: PMRN is a parallelogram.

**Step4: Exploration in group [20min]**

In this step students can reason with simple arguments about geometric figures and try to deductively prove. Like that, to solve the individual problem, first we give opportunity to the student. When student solve the individual problem teacher exchanged their copies within their group and make them to find the common solution with discussion. And teacher list each group solution on the white board. In this step teacher facilitate student’s difficulties.

**Step5: Reflection [10 min]**

After the listed each group solution, then Discuss about what is final solution of the problem. Then find the common solution of each group with discussion. Like that

| Facts   | Reason   |
|---|--|
| 1. In $\Delta NPS$ and $\Delta MRQ$<br>a. $PS = QR$ (S)<br>b. $\angle PSN = \angle RQM$ (A)<br>c. $SN = MQ$ (S)<br>2. $\Delta NPS \cong \Delta MRQ$<br>3. $PN = MR$<br>4. $PN \parallel MR$<br>5. $PM = NR$<br>6. $PM \parallel NR$<br>7. $PMRN$ is a parallelogram | 1. ...<br>a. Opposite sides of parallelogram.<br>b. Opposite angles of parallelogram.<br>c. As $M$ and $N$ are mid points of $PQ$ and $SR$ respectively.<br>2. By SAS test of congruency.<br>3. Corresponding sides of congruent triangle.<br>4. From 3.<br>5. Given.<br>6. From statement 6.<br>7. By $PM = NR$ , $PM \parallel NR$ and $PN = MR$ , $PN \parallel MR$ |

Finally looking back of the above process and conclude the formula, statement or theorem and repeated this process.

## APPENDIX-C

### Post-Test

**Subject: C. Mathematics**

**F.M: 50**

**Class: Nine**

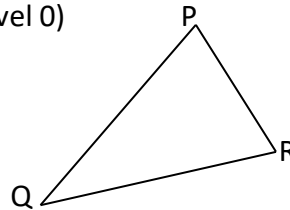
**Time: 1hr 30 m**

#### Group A

Objectives question.  $1 \times 10 = 10$

1. What is the name of the given triangle? (level 0)

- a. Isosceles Triangle.
- b. Acute Angle Triangle.
- c. Obtuse Angled Triangle.

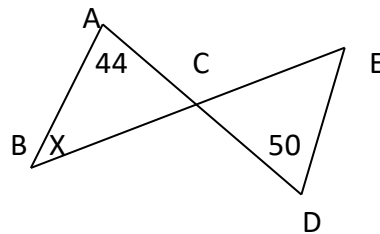


2. Which properties are not true? (level 1)

- a. The sum of interior angles of a triangle is equal to two right angles.
- b. The sum of the length of two sides of a triangle is less than the third side.
- c. The angles at the base of an isosceles triangle are equal.

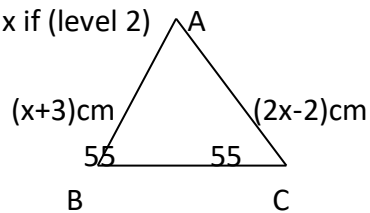
3. Find the value of  $x$  if (level 2)

- a. 30
- b. 47
- c. 50



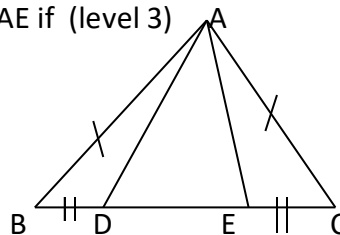
4. Find the value of  $x$  if (level 2)

- a. 5 cm
- b. 3 cm
- c. 6 cm



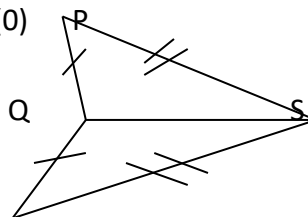
5. What is the relation between line  $AD$  and  $AE$  if (level 3)

- a.  $AD \geq AE$
- b.  $AD = AE$
- c.  $AD \leq AE$



6. What is the name of the given figure? (0)

- a. Kite
- b. Arrow
- c. Arrowhead



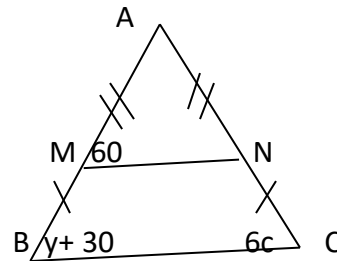
7. Which properties are true? (Level 1)
- The opposite sides of the parallelogram are equal but opposite angles are not equal.
  - The line segment which joins the mid points of two sides of a triangle is parallel to third side and equal of the third side.
  - The diagonal of parallelogram are bisecting each other.

8. Which is the area of parallelogram?(level 2)

- $\frac{1}{2}$  base  $\times$  height
- Base  $\times$  height
- $\frac{1}{2}$  (sum of the base)  $\times$  height

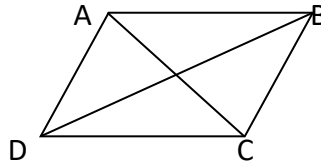
9. Find the value of x and y if (level 2)

- 3 cm and  $30^\circ$
- 6 cm and  $60^\circ$
- 4 cm and  $60^\circ$



10. What is the relation between  $\triangle ACD$  and  $\triangle ACB$  if  $\square ABCD$  is parallelogram?(level 3)

- $\triangle ACD \sim \triangle ACB$
- $\triangle ACD \cong \triangle ACB$
- No related to each other



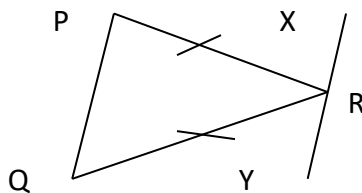
### Group B

Subjective Questions.

$8 \times 5 = 40$

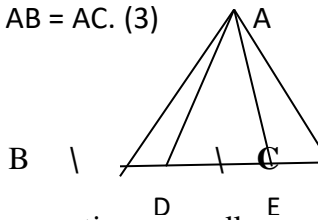
11. Define the congruent triangles with three properties.(level 1)

12. In the figure,  $PQ \parallel XY$  and  $\angle PQR = 45^\circ$ . Find the size of  $\angle PRX$  and  $\angle PRQ$ . (Level 2)



13. Prove two angles of a triangle are equal then sides opposite to the angles are equal.(3)

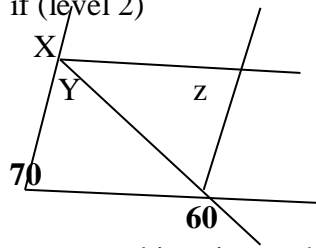
14. In the figure,  $AD = BD = EC$ . Prove that  $AB = AC$ . (3)



15. Define parallelogram and write the three properties of parallelogram?(level 1)



16. Find the value of X, Y and Z if (level 2)



17. Prove the diagonal of parallelogram are bisecting each other. (level 3)

18. Prove the line segment which joins the mid points of two sides of triangle is parallel to third

**APPENDIX-D (Qualitative Data Collection Tool)**

**Observation Sheet and Interview Questioner**

1. Do you like geometric subject?  
Ans .....
2. Do you think geometric problems are easier rather than the problems of other mathematics?  
Ans.....
3. Are you satisfied your mathematics teacher's behavior?  
Ans.....
4. Did you express your feeling, confusion, problems about subject matter freely with your teacher?  
Ans.....
5. Is mathematics class teacher use teaching material or not?  
Ans.....
6. Which of the method class teacher teach you?  
Ans.....
7. Is your mathematics teacher teaching as your interest?  
Ans.....
8. What do you think researcher teaching style?  
Ans.....
9. Is researcher teaching method and your mathematics teacher method differences?  
Ans.....
10. What are the difference between researcher teaching method and your mathematics class teacher?  
Ans.....
11. Are you satisfied to researcher behavior?  
Ans.....

12. Is researcher teaching as your interest?

Ans.....

13. Which of the method researcher teach you?

Ans.....

14. Do you support to understanding prove geometric theorem for researcher method?

Ans.....

15. Which method do you like between researcher and your mathematics teacher?

Ans.....

16. Do you believe that the concept of geometry can be learned by discussing with friends?

Ans.....

17. How did you begin the specific problem?

Ans.....

18. When you were in bit confusion, did you consult any reference?

Ans.....

19. Where you conformed when you got the answer?

Ans.....

20. Did you feel satisfaction after the task?

Ans.....

21. Is it possible to tackle the same categorical problems from the next time?

Ans.....

22. Which method do you consider more applicable regular teachers' guidance or self-practice?

Ans.....

## APPENDIX-E

Shuvakamana Academy, Kirtipur -16, Taudha,

Kathmandu, Nepal

Pre-Test' Mark

| S.N | Students Name       | Obj. | Sub. | Total(X)       | $X - 22.1$ | $X^2$              |
|-----|---------------------|------|------|----------------|------------|--------------------|
| 1   | Nischal Thapa Magar | 7    | 24   | 31             | 8.9        | 79.21              |
| 2   | Anish Nepal         | 7    | 28   | 35             | 12.9       | 166.41             |
| 3   | Bijay khadka        | 7    | 19   | 26             | 3.9        | 15.21              |
| 4   | Anish Basnet        | 5    | 13   | 18             | -4.1       | 16.81              |
| 5   | Hrisav Nepal        | 8    | 18   | 26             | 3.9        | 15.21              |
| 6   | Anjan Nepal         | 6    | 13   | 19             | -3.1       | 9.61               |
| 7   | Aakankshya Khadka   | 8    | 19   | 27             | 4.9        | 24.01              |
| 8   | Sachin Basnet       | 7    | 11   | 18             | -4.1       | 16.81              |
| 9   | Sankalpa Poudel     | 5    | 20   | 25             | 2.9        | 8.41               |
| 10  | Salim G.C           | 6    | 18   | 24             | 1.9        | 3.61               |
| 11  | Neha Maharjan       | 7    | 18   | 25             | 2.9        | 8.41               |
| 12  | Anupa Thapa         | 7    | 12   | 19             | -3.1       | 9.61               |
| 13  | Prashant Shrestha   | 5    | 14   | 19             | -3.1       | 9.61               |
| 14  | Rupesh K.C          | 5    | 12   | 17             | -5.1       | 26.01              |
| 15  | Nita Karki          | 6    | 21   | 27             | 4.9        | 24.01              |
| 16  | Rupen Maharjan      | 5    | 15   | 20             | -2.1       | 4.41               |
| 17  | Rojina Maharjan     | 6    | 9    | 15             | -7.1       | 50.41              |
| 18  | Deepika Thapa       | 5    | 19   | 24             | 1.9        | 3.61               |
| 19  | Arjan Khadka        | 5    | 6    | 11             | -11.1      | 123.21             |
| 20  | Kritika Bhagat      | 7    | 9    | 16             | -6.1       | 37.21              |
|     |                     |      |      | $\sum X = 442$ |            | $\sum X^2 = 651.8$ |

Total Number of Students (N) = 20

Total Obtained Marks  $\sum X = 442$

$$\text{Mean} = \frac{\sum X}{N} = \frac{442}{20} = 22.1$$

$$\text{Stander deviation (S.D or } \sigma) = \sqrt{\frac{\sum X^2}{N}} = \sqrt{\frac{651.8}{20}} = \sqrt{32.59} = 5.71$$

$$\text{Variance } (\sigma^2) = 32.59$$

**Kathmandu Bern Hard H. S School**

**Balkhu Chowk, Kathmandu**

**Pre-Test's mark**

| S.N | Name                | Obj. | Sub. | Total(X)       | $X - 22.1$ | $X^2$               |
|-----|---------------------|------|------|----------------|------------|---------------------|
| 1   | Abiskar Paneru      | 4    | 15   | 19             | -3.9       | 15.21               |
| 2   | Ajaya Das Chaudhary | 7    | 20   | 27             | 4.1        | 16.81               |
| 3   | Amit Maharjan       | 7    | 16   | 23             | 0.1        | 0.01                |
| 4   | Amogh Sharma        | 5    | 8    | 13             | -9.9       | 98.01               |
| 5   | Anisha Gautam       | 9    | 29   | 38             | 15.1       | 228.01              |
| 6   | Bibek Bohara        | 6    | 17   | 23             | 0.1        | 0.01                |
| 7   | Bishal Rauniyar     | 5    | 15   | 20             | -2.9       | 8.41                |
| 8   | Dikshya Lama        | 7    | 21   | 28             | 5.1        | 26.01               |
| 9   | Ishan K.C           | 4    | 14   | 18             | -4.9       | 24.01               |
| 10  | Ishan Tandukar      | 6    | 18   | 24             | 1.1        | 1.21                |
| 11  | Lishu Maharjan      | 4    | 19   | 23             | 0.1        | 0.01                |
| 12  | Manshu Shrestha     | 6    | 13   | 19             | -3.9       | 15.21               |
| 13  | Pranish Tuladhar    | 6    | 17   | 23             | 0.1        | 0.01                |
| 14  | Prashant Sing       | 5    | 13   | 18             | -4.9       | 24.01               |
| 15  | Rajkumar Magar      | 4    | 15   | 19             | -3.9       | 15.21               |
| 16  | Rieza Shrestha      | 6    | 12   | 18             | -4.9       | 24.01               |
| 17  | Roshni Rauniyar     | 7    | 15   | 22             | -0.9       | 0.81                |
| 18  | Rusali Kapali       | 5    | 8    | 13             | -9.9       | 98.01               |
| 19  | Sabiba Khatun       | 5    | 12   | 17             | -5.9       | 34.8                |
| 20  | Shiksha Thapa       | 8    | 26   | 34             | 11.1       | 123.21              |
| 21  | Soniya Shrestha     | 7    | 23   | 30             | 7.1        | 50.41               |
| 22  | Sujan Tuladhar      | 9    | 26   | 35             | 12.1       | 146.41              |
|     |                     |      |      | $\sum X = 504$ |            | $\sum X^2 = 949.81$ |

Total Number of Students (N) = 22

Total obtunded Marks = 504

Mean =  $504/22 = 22.90$

Standard deviation (S.D or  $\sigma$ ) =  $\sqrt{\frac{\sum X^2}{N}} = \sqrt{949.81/22} = \sqrt{43.17} = 6.57$

Variance ( $\sigma^2$ ) = 43.17

T-test of Pre-Test (for group homogeneity)

Steps- 1: Null Hypothesis

There is no significance difference between means of first group and second group.

Steps- 2: Level of significance; 0.05 or 5%

Steps- 3: Degree of freedom

$$N_1+N_2-2= 22+20-2= 40$$

Steps-4: Computation

Here,  $\bar{X}_1 = 22$ ,  $\bar{X}_2 = 20$ ,  $S_1^2 = 43.17$ ,  $S_2^2 = 32.59$ ,  $N_1=22$ ,  $N_2= 20$

$$t = (\bar{X}_1 - \bar{X}_2) / \sqrt{\frac{((N_1-1)S_1^2 + (N_2-1)S_2^2)}{N_1+N_2} \cdot \left(\frac{1}{N_2} + \frac{1}{N_1}\right)}$$

$$t = 0.42$$

Steps- 5: Conclusion

The tabulate value of t is 1.684 where level of significance 0.05 or 5% and degree of freedom 40. The value of t=0.42 is less then tabulated value 1.684. Thus null hypothesis is accepted.

## APPENDIX-F

Shuvakamana Academy, Kirtipur -16, Taudha,

Kathmandu, Nepal

Post-Test' Mark

| S.N | Students Name       | Obj. | Sub. | Total(X)       | $\chi = X - 22.1$ | $\chi^2$               |
|-----|---------------------|------|------|----------------|-------------------|------------------------|
| 1   | Nischal Thapa Magar | 10   | 39   | 49             | 12.15             | 147.62                 |
| 2   | Anish Nepal         | 9    | 36   | 45             | 8.15              | 66.42                  |
| 3   | Bijay khadka        | 10   | 38   | 48             | 11.15             | 124.32                 |
| 4   | Anish Basnet        | 8    | 36   | 44             | 7.15              | 51.12                  |
| 5   | Hrisav Nepal        | 9    | 37   | 46             | 9.15              | 83.72                  |
| 6   | Anjan Nepal         | 8    | 37   | 45             | 8.15              | 66.42                  |
| 7   | Aakankshya Khadka   | 9    | 36   | 45             | 8.15              | 66.42                  |
| 8   | Sachin Basnet       | 8    | 34   | 42             | 5.15              | 26.52                  |
| 9   | Sankalpa Poudel     | 7    | 31   | 38             | 1.15              | 1.32                   |
| 10  | Salim G.C           | 8    | 30   | 38             | 1.15              | 1.32                   |
| 11  | Neha Maharjan       | 7    | 27   | 34             | -2.85             | 8.12                   |
| 12  | Anupa Thapa         | 6    | 21   | 27             | -9.85             | 97.02                  |
| 13  | Prashant Shrestha   | 9    | 25   | 34             | -2.85             | 8.12                   |
| 14  | Rupesh K.C          | 7    | 24   | 31             | -5.85             | 34.22                  |
| 15  | Nita Karki          | 8    | 28   | 36             | -0.85             | 0.72                   |
| 16  | Rupen Maharjan      | 6    | 22   | 28             | -8.85             | 78.32                  |
| 17  | Rojina Maharjan     | 7    | 24   | 31             | -5.85             | 34.22                  |
| 18  | Deepika Thapa       | 6    | 23   | 29             | -7.85             | 61.62                  |
| 19  | Arjan Khadka        | 5    | 19   | 24             | -12.85            | 165.12                 |
| 20  | Kritika Bhagat      | 5    | 17   | 22             | -14.85            | 220.52                 |
|     |                     |      |      | $\sum X = 736$ |                   | $\sum \chi^2 = 1343.2$ |

Total Number of Students (N) = 20

Total Obtained Marks  $\sum X = 736$

Mean =  $736/20 = 36.85$

Standard deviation (S.D or  $\sigma$ ) =  $\sqrt{\frac{\sum \chi^2}{N}} = \sqrt{736/20} = \sqrt{67.16} = 8.19$

Variance ( $\sigma^2$ ) = 67.16

Kathmandu Bern Hard H. S School

Balkhu Chowk, Kathmandu

Post-Test's mark

| S.N | Name                | Obj. | Sub. | Total(X)       | $X$<br>$= X - 30.45$ | $X^2$               |
|-----|---------------------|------|------|----------------|----------------------|---------------------|
| 1   | Abiskar Paneru      | 5    | 20   | 25             | -5.45                | 29.70               |
| 2   | Ajaya Das Chaudhary | 9    | 26   | 35             | 4.55                 | 20.70               |
| 3   | Amit Maharjan       | 7    | 22   | 29             | -1.45                | 2.10                |
| 4   | Amogh Sharma        | 7    | 17   | 24             | -6.45                | 41.60               |
| 5   | Anisha Gautam       | 10   | 37   | 47             | 16.55                | 273.90              |
| 6   | Bibek Bohara        | 6    | 25   | 31             | 0.55                 | 0.30                |
| 7   | Bishal Rauniyar     | 7    | 24   | 31             | 0.55                 | 0.30                |
| 8   | Dikshya Lama        | 9    | 28   | 37             | 6.55                 | 42.90               |
| 10  | Ishan K.C           | 6    | 21   | 27             | -3.45                | 11.90               |
| 11  | Ishan Tandukar      | 7    | 26   | 33             | 2.55                 | 6.50                |
| 12  | Lishu Maharjan      | 5    | 25   | 30             | -0.45                | 0.20                |
| 13  | Manshu Shrestha     | 7    | 16   | 23             | -7.45                | 55.50               |
| 15  | Pranish Tuladhar    | 7    | 23   | 30             | -0.45                | 0.20                |
| 16  | Prashant Sing       | 7    | 20   | 27             | -3.45                | 11.90               |
| 17  | Rajkumar Magar      | 6    | 19   | 25             | -5.45                | 29.70               |
| 18  | Rieza Shrestha      | 8    | 16   | 24             | -6.45                | 41.60               |
| 20  | Roshni Rauniyar     | 8    | 19   | 27             | -3.45                | 11.90               |
| 21  | Rusali Kapali       | 7    | 13   | 20             | -10.45               | 109.20              |
| 22  | Sabiba Khatun       | 7    | 19   | 26             | -4.45                | 19.80               |
| 23  | Shiksha Thapa       | 10   | 31   | 41             | 10.55                | 111.30              |
| 24  | Soniya Shrestha     | 9    | 29   | 38             | 7.55                 | 57.01               |
| 25  | Sujan Tuladhar      | 10   | 30   | 40             | 9.55                 | 91.20               |
|     |                     |      |      | $\sum X = 670$ |                      | $\sum X^2 = 969.45$ |

Total Number of Students (N) = 22

Total obtunded Marks = 969.45

Mean =  $670/22 = 30.45$

Standard deviation (S.D or  $\sigma$ ) =  $\sqrt{\frac{\sum X^2}{N}} = \sqrt{969.45/22} = \sqrt{44.06} = 6.64$

Variance ( $\sigma^2$ ) = 44.06



## T-test of the Post Test

Steps- 1: Null Hypothesis and alternative Hypothesis

$H_0$ = Mean achievement of experimental group is not higher than the mean achievement of control group.

$H_1$ = Mean achievement of experimental group is higher than the mean achievement of control group.

Steps- 2: Level of significance; 0.05 or 5%

Steps- 3: Degree of freedom

$$N_1+N_2-2= 22+20-2= 40$$

Steps-4: Computation

Here,  $\bar{X}_1 = 36.85$ ,  $\bar{X}_2 = 30.45$ ,  $S^2_1 = 67.16$ ,  $S^2_2 = 44.06$ ,  $N_1 = 20$ ,  $N_2 = 22$

$$t = (\bar{X}_1 - \bar{X}_2) / \sqrt{\frac{((N_1-1)S^2_1 + (N_2-1)S^2_2)}{N_1+N_2} \cdot \left(\frac{1}{N_2} + \frac{1}{N_1}\right)}$$

$$t = 2.799$$

Steps- 5: Conclusion

The tabulate value of t is 2.021 where level of significance 0.05 or 5% and degree of freedom 40. The value of  $t=2.799$  is greater than tabulated value 2.65. Thus null hypothesis is accepted.

## APPENDIX-G

### T-test of the Post Test and post test

Steps- 1: Null Hypothesis and alternative Hypothesis

Ho= Mean achievement of Post-Test is not higher than the mean achievement of Pre-Test.

H<sub>1</sub>= Mean achievement of Post-Test is higher than the mean achievement of Pre-Test.

Steps- 2: Level of significance; 0.05 or 5%

Steps- 3: Degree of freedom

$$N_1+N_2-2= 22+20-2= 40$$

Steps-4: Computation

Here,  $\bar{X}_1 = 22.5$ ,  $\bar{X}_2 = 33.65$ ,  $S^2_1 = 37.88$ ,  $S^2_2 = 55.61$ ,  $N_1=42$ ,  $N_2= 42$

$$t= (\bar{X}_1 - \bar{X}_2) / \sqrt{\frac{((N_1-1)S^2_1 + (N_2-1)S^2_2)}{N_1+N_2} \cdot \left(\frac{1}{N_2} + \frac{1}{N_1}\right)}$$

$$t= -5.83$$

Steps- 5: Conclusion

The tabulate value of t is 2 where level of significance 0.05 or 5% and degree of freedom 40. The value of t=5.83 is grater then tabulated value 2. Thus null hypothesis is rejected.

## APPENDIX-H

### Reliability and Validity of the Test item

#### Reliability of experimental groups achievements

| Roll No | Mark of even(X <sub>1</sub> ) | Mark of odd(X <sub>2</sub> ) | $X = X_1 - A$ | $y = X_2 - A$ | $x^2$            | $y^2$            | $xy$            |
|---------|-------------------------------|------------------------------|---------------|---------------|------------------|------------------|-----------------|
| 1       | 24                            | 25                           | 5             | 7             | 25               | 49               | 35              |
| 2       | 21                            | 24                           | 2             | 6             | 4                | 36               | 12              |
| 3       | 25                            | 23                           | 6             | 5             | 36               | 25               | 30              |
| 4       | 24                            | 20                           | 5             | 2             | 25               | 4                | 10              |
| 5       | 23                            | 23                           | 4             | 5             | 16               | 25               | 20              |
| 6       | 23                            | 22                           | 4             | 4             | 16               | 16               | 16              |
| 7       | 22                            | 23                           | 3             | 5             | 9                | 25               | 15              |
| 8       | 21                            | 21                           | 2             | 3             | 4                | 9                | 6               |
| 9       | 22                            | 16                           | 3             | -2            | 9                | 4                | -6              |
| 10      | 20                            | 18                           | 1             | 0             | 1                | 0                | 0               |
| 11      | 18                            | 16                           | -1            | -2            | 1                | 4                | 2               |
| 12      | 10                            | 17                           | -9            | -1            | 81               | 1                | 9               |
| 13      | 15                            | 19                           | -4            | 1             | 16               | 1                | -4              |
| 14      | 14                            | 17                           | -5            | -1            | 25               | 1                | 5               |
| 15      | 17                            | 19                           | -2            | 1             | 4                | 1                | -2              |
| 16      | 16                            | 12                           | -3            | -6            | 9                | 36               | 18              |
| 17      | 17                            | 14                           | -2            | -4            | 4                | 16               | 8               |
| 18      | 15                            | 14                           | -4            | -4            | 16               | 16               | 16              |
| 19      | 12                            | 12                           | -7            | -6            | 49               | 36               | 42              |
| 20      | 12                            | 10                           | -7            | -8            | 49               | 64               | 56              |
| Total   |                               |                              |               |               | $\sum x^2 = 399$ | $\sum y^2 = 369$ | $\sum xy = 288$ |

$$r_{12} = \frac{\sum xy}{\sqrt{\sum x^2 \sum y^2}} = \frac{288}{\sqrt{399 \times 369}} = 0.75$$

$$r_{tt} = 2 r_{12} / (1 + r_{12}) = 2 \times \frac{0.75}{1 + 0.75} = 0.85$$

### Reliability of Control groups achievements

| Roll No | Mark of even(X <sub>1</sub> ) | Mark of odd(X <sub>2</sub> ) | $x = X_1 - A$ | $y = X_2 - A$ | $x^2$            | $y^2$            | $xy$            |
|---------|-------------------------------|------------------------------|---------------|---------------|------------------|------------------|-----------------|
| 1       | 15                            | 10                           | 0             | -5            | 0                | 25               | 0               |
| 2       | 17                            | 18                           | 2             | 3             | 4                | 9                | 6               |
| 3       | 13                            | 16                           | -2            | 1             | 4                | 1                | -2              |
| 4       | 12                            | 12                           | -3            | -3            | 9                | 9                | 9               |
| 5       | 24                            | 23                           | 9             | 8             | 81               | 64               | 72              |
| 6       | 16                            | 15                           | 1             | 0             | 1                | 0                | 0               |
| 7       | 14                            | 17                           | -1            | 2             | 1                | 4                | -2              |
| 8       | 21                            | 16                           | 6             | 1             | 36               | 1                | 6               |
| 9       | 14                            | 13                           | -1            | -2            | 1                | 4                | 2               |
| 10      | 14                            | 19                           | -1            | 4             | 1                | 16               | -4              |
| 11      | 15                            | 15                           | 0             | 0             | 0                | 0                | 0               |
| 12      | 12                            | 11                           | -3            | -4            | 9                | 16               | 12              |
| 13      | 16                            | 14                           | 1             | -1            | 1                | 1                | -1              |
| 14      | 15                            | 15                           | 0             | 0             | 0                | 0                | 0               |
| 15      | 12                            | 13                           | -3            | -2            | 9                | 4                | 6               |
| 16      | 11                            | 13                           | -4            | -2            | 16               | 4                | 8               |
| 17      | 12                            | 15                           | -3            | 0             | 9                | 0                | 0               |
| 18      | 12                            | 8                            | -3            | -7            | 9                | 49               | 21              |
| 19      | 12                            | 14                           | -3            | -1            | 9                | 1                | 3               |
| 20      | 22                            | 19                           | 7             | 4             | 49               | 16               | 28              |
| 21      | 18                            | 20                           | 3             | 5             | 9                | 25               | 15              |
| 22      | 20                            | 20                           | 5             | 5             | 25               | 25               | 25              |
| Total   |                               |                              |               |               | $\sum x^2 = 283$ | $\sum y^2 = 274$ | $\sum xy = 204$ |

$$r_{12} = \frac{\sum xy}{\sqrt{\sum x^2 \sum y^2}} = \frac{204}{\sqrt{283 \times 274}} = 0.73$$

$$r_{tt} = 2 r_{12} / (1 + r_{12}) = 2 \times \frac{0.73}{1 + 0.73} = 0.84$$