

Chapter I

Introduction

Geometry is subject in mathematics that focuses on the study of shapes, size, relative configurations, and spatial properties. Derived from the Greek word meaning "earth measurement," geometry is one of the oldest sciences. It was first formally organized by the Greek mathematician Euclid around 300 BC when he arranged 465 geometric propositions into 13 books, titled 'Elements'. Ancient Egyptians used geometry to solve many practical problems involving boundaries and land areas. Geometry is the branch of mathematics that defines and relates the basic properties and measurement of line segment and angles. The work of Greek scholar such as Thales, Eratosthenes, Pythagoras and Euclid for centuries provided the basis for the study of geometry in the western world. About 300 B.C., Euclid and his followers organized the geometry of his day into a logical system contained in thirteen books known today as Euclid's Elements (Gantert, 2008).

Oldknow&Taylor (2000) describes that the use of technology has had a huge impact on the world of education. Technology leads to effective teaching and learning by providing a medium for teachers and students to be continuously involved in the process, regardless of their levels. Integration of technology into the teaching and learning of mathematics also brings in new, innovative ideas, particularly when they are supported by appropriate software for both teachers and students. Teachers should have proper training in order to help improve their skills to the optimum level. Other than that, teachers should also be guided so that they can involve their students in the application of the latest technological devices in various types of mathematical problem solving (Oldknow& Taylor, 2000).

Papert (1994) state that “Not very long ago, young people would learn skill they could use in their work throughout life. Today, in industrial countries, most people are doing jobs that did not exist when they were born. The most important skill determining a person’s life pattern has already become the ability to learn new skill, to deal with the expected.” New applications of technology have the potential to support learning across the curriculum and allow effective communication between teachers and learns in ways that have not been possible before (Chrysanthou, 2008).

According to Fluck (2010), the future of Information, Communication and Technology (ICT) should play as a transformation role in education rather than integration into existing subject areas. The transformative view of ICT in education requires us to examine what new ways of pedagogies and curriculum are appropriate for a new generation working with new tools. Technology is integrated into mathematics teaching and learning in two forms: first, there are virtual manipulates which consist of specific interactive learning environment, secondly more flexibility and enabling both teacher and student to explore mathematics concept (Preiner, 2008).

According to Light and Blaye (1989), during the last 30 years, computer technology for mathematics classroom has experienced and explosive growth both in term of development as well as availability. Also according to Tomic (2013), there are four aspects that mathematical software can offer to the process of mathematics teaching and learning: multiple display options, experimental work, elementarisation of mathematical method and connectivity.

Teachers can choose from a variety of software available for mathematics education. One of them is GeoGebra. GeoGebra is free open-source dynamic software for mathematics teaching and learning that offers geometry and algebra features in a fully

connected software environment. It was designed to combine features of dynamic geometry software (DGS) and computer algebra systems (CAS) in a single, integrated, and easy to use system for teaching and learning mathematics (Hohenwarter, Jarvis, & Lavicza, 2009). This dynamic mathematics software program was created by Markus Hohenwarter and now has been translated to 40 languages. Users all over the world can freely download this software from the official GeoGebra website at <http://www.geogebra.org>. Digital device promote student-centered learning and active learning. Furthermore, it can enhance students' ability in visualizing the mathematical elements hence improving learning.

GeoGebra is an attempt to join two pillars geometry and algebra; it also designed for educational purpose and can help students to foster their mathematical learning (Hohenwarter and Preiner, 2007). GeoGebra is rapidly growing worldwide popularity. It allows educators to create interacting learning environment to foster experimental and discovery learning for students while visually interacting with geometry, algebra and calculus, graphing and statistics. It is a powerful teaching tool for mathematics teachers.

According to CDC Nepal (2007), mathematics is compulsory subject from grade I to X in Nepal. Mathematics is essential for solving the behavioral problem of human life. There are eight areas (Set, Arithmetic, mensuration, Algebra, Geometry, Trigonometry, Statistics, and Probability) in secondary level. Among these, geometry is one of the most important parts. Geometric part has also been included the different chapters, in this study researcher had taken triangle and parallelogram. This chapter (parallelogram and triangle) focuses on developing skill of students for solving the problem and proving the theorem.

Statement of the Problem

In Nepal, major investment in ICT has been implemented to achieve effective teaching and learning in the classroom. Technology can also help

students to furnish their visual images of mathematical ideas, organizing and analyzing data, and can compute efficiently and accurately. Technology can support students to investigate in every area of mathematics, such as geometry, statistics, algebra, measurement and number (NCTM, 2000).

According to the National Council of Teachers of Mathematics (NCTM, 2011), it is essential that teachers and students have regular access to technologies that support and advance mathematical sense making, reasoning, problem solving, and communication. Effective teachers optimize the potential of technology to develop students' understanding, stimulate their interest, and increase their proficiency in mathematics. When teachers use technology strategically, they can provide greater access to mathematics for all students (NCTM, 2011).

The use of content specific and content neutral technology tools in the classroom can support the learning of students. Choosing which tools are appropriate and effective is critical. "In mathematics education, content specific technology tools include: computer algebra systems, dynamic geometry environments, interactive applets, handheld computation, data collection, analysis devices, and computer-based applications" (NCTM, 2011). These tools support students in exploring and identifying mathematical concepts and relationships. Content neutral technology tools include communication and collaboration tools and web-based digital media. These technologies increase students' access to information, ideas, and interactions that can support and enhance sense making (NCTM, 2011).

It is believed that ICT is the most important factor for integrating the developing and developed countries. We cannot ignore the effect of worldwide web in our daily life even in developing countries. So, the ICT is being prominent all around the world especially in the field of education. But knowledge of using ICT in Nepal has a slow

progress in the field of education. The government of Nepal, ministry of education (2013), through national curriculum framework has introduced ICT as a subject as well as ICT as a tool for instruction in school education but technology has minimal to nonexistent role at school level in Nepal. Very few schools have access to technologies and among them few mathematics teachers will integrate technology in their teaching and learning at secondary level in Nepal (Shrestha, 2015). In fact, the school educational system is based on a traditional approach in Nepal.

Many software have been developed related to teaching learning mathematics, like: GeoGebra, Mathematica, Matlab, Graphing calculator etc. Among them GeoGebra is most familiar tool, easy to use and make geometry interesting by visualizing. In secondary level, few mathematics teachers only know about the GeoGebra but many of them do not know how to use GeoGebra in mathematics teaching in Nepal. Students are not satisfied in their achievement in geometry. They try to memorize the concept of geometry by rote learning. But Geometry needs visualization of concepts through pictures and graphs. The traditional method is not working in this 21st century. For this, ICT must be fruitful to build the conceptual understanding of geometry. Geogebra is one of the wonderful tools to construct this knowledge in more systematic way. Therefore, this research was address the following statements:

- Is the use of GeoGebra more effective than traditional method while teaching the theorem of triangle and parallelogram?
- What are the students' perceptions on GeoGebra software?

Objectives of the Study

The main objective of this study was to investigate the effectiveness of the use of GeoGebra on students' achievement in teaching parallelogram and triangle of geometry at grade IX. This was accomplished by the following objectives:

- To compare the achievement of the students taught by using GeoGebra and traditional method in triangle and parallelogram.
- To analyze the students' perceptions on towards the use of GeoGebra software.

Hypothesis of the Study

Hypothesis is the assumption or guess about the population involved (Pandit&Bhattarai,2073 B.S.). Such assumption that may or may not be true are called hypothesis. It relates an independent variable to some dependent variables. The two types hypotheses were formulated in this study, they are as follows:

Research Hypothesis

A research hypothesis is a tentative answer to a research question. In this study use of GeoGebra yields effective result of the achievement of the students as compared to traditional method while teaching theorems related to triangle and parallelogram of geometry.

Statistical Hypothesis

A statistical hypothesis is an ascertain or conjecture about the distribution of one or more variables on one or more population (Pandit& Bhattarai, 2073).

The null and alternative hypothesis was as follows:

- H₀**: There is no significance difference between the average achievement score of experimental and control groups i.e. $\mu_1=\mu_2$ on pre-test
H₁: The average achievement score of experimental group is not equal to the control group i.e. $\mu_1\neq\mu_2$ on pre-test
- H₀**: There is no significance difference between the average achievement score of experimental and control groups i.e. $\mu_1=\mu_2$ on post-test

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

Where μ_1 = Average achievement score of experimental group

μ_2 = Average achievement score of control group

Significance of the Study

Mathematics is a technical and practical subject. It is being taught as a compulsory subject in school education from grade I to X in Nepal. The existing curriculum is silence about the use of technology in teaching and learning mathematics at secondary level. As 21st century is the age of ICT, it should be a tool of educational transformation. The major significance of this study was to present the effectiveness of GeoGebra in learning achievement of geometric concepts.

- This study would be useful for teachers who are searching to improve teaching and learning geometry through ICT as well as Geogebra.
- It helps the students to learn mathematical knowledge by practical and interesting way.
- This software is very useful tool of teaching materials because a teacher can build dynamic demonstrations creating dynamic relationships between objects on the screen live in front of a class.
- Students can build their own dynamic GeoGebra files, being able to efficiently explore key mathematical ideas i.e. they could create figure for themselves.
- This study would be useful for mathematics teachers, schools, researchers, educator's curriculum designers and policy makers.

Delimitations of the Study

This study was delimited under the following ways:

- The researcher of this study had utilized programme GeoGebra 5.0, that teaches theorem of geometry in particular chapter of triangle and parallelogram to the grade IX students.
- This study would be delimited to class IX.
- The study was delimited to the two government school of Nuwakot district.
- In experimental group 30 students of Shree Mahadev Secondary School were selected for the study. In which researcher was taught in experimental group by using GeoGebra software.
- In control group 32 students of Shree Shiladevi Secondary School were selected for the study. In which researcher was taught in control group by using traditional method.
- The experimentation period of this research was based on completion of targeted chapters.
- Tests were made by researcher himself with help of subject teacher, expert, and supervisor.

Operational Definition of the Key Terms

The key terms of this study were defined as below:

GeoGebra

GeoGebra is a Dynamic Mathematics Software (DMS) for teaching and learning mathematics from basic level through University level

ICT

Information And Communication Technology which includes any communication device or application, encompassing: radio, television, cellular phones, computer and network hardware and software, satellite systems and so on.

Experimental Group

The group of student taught by using GeoGebra while teaching parallelogram and triangle of geometry.

Control Group

The group of students taught by traditional method and without using GeoGebra while teaching parallelogram and triangle of geometry.

Achievement

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

Effectiveness

The measure of effect for this study includes the increase in the average achievement of students' in mathematics and students' positive view on GeoGebra in learning parallelogram and triangle of geometry.

Traditional Method

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

Chapter II

Review of Related Literature

A literature review is a scholarly paper, which includes the current knowledge including substantive findings, as well as theoretical and methodological contributions to a particular topic. Also it is a written summary of journal article, books, and other document that describes the past and current state of information on the topic of research study. With so much information available, searching and locating good literature on the topic of research study can be challenging (Creswell, 2012). The previous studies cannot be ignored because they provide the information to the present study. So, this chapter presents the empirical literature and theoretical as well as conceptual framework.

Review of Empirical literature

The researcher reviewed some national and international thesis, journal and article as empirical literature which are presented given below:

Chrysanthou (2008), conducted the research on “The use of ICT in primary mathematics in Cyprus: the case of GeoGebra”. The aim of this study was to investigate the potential and the implication of the implementation of GeoGebra for teaching primary mathematics. This research is based on a social constructivist view of learning and the methodology used is a case study. And research was conducted in Cyprus and involved a teacher with her class of 16 students. Data collection procedures was based upon classroom observation, teacher interview and students questionnaires. Findings of the research revealed that the use of GeoGebra can provide rich mathematical environments in which students are engaged in classroom activity.

Hohenwarter, Hohenwarter and Lavicza (2008), conducted the study entitled “Introducing dynamic mathematics software to secondary school teachers: the case of

GeoGebra". With describes a study aimed to identify most common impediments related to the introduction of an open-source mathematical software package GeoGebra. This study based on school teachers in Florida. And identified challenges participants face during workshops three week and evaluated the difficulty level of GeoGebra tool. Finding of the study, complexity criteria of software tool and commonly occurring difficulties, provided the basis for the development of several new mathematics assisting workshops activities and contributed to the improvement of introductory GeoGebra workshops.

Safdar, Yousuf, Parveen and Behlol (2011), conducted the study on "Effectiveness of ICT in teaching and learning mathematics at secondary level", with the purpose of this study was to determine the effectiveness of ICT as compared to the traditional method of teaching in the subject of mathematics at grade IX in Pakistan. In this study, students of sample school were divided into two equal groups i.e. experimental and control, each has 30 students. The students of experimental group were exposed to the teaching though ICT, whereas the students of control group were taught though traditional method of teaching in the subject of mathematics. This study shows that ICT was found effective as compared to traditional method of teaching in mathematics at secondary level.

Shadaan and Eu (2013), conducted a study entitled "Effectiveness of using GeoGebra on students' understanding in learning circles" in order to investigate the effectiveness of using GeoGebra on students understanding of circle as compared to the traditional approach and also analyse students perceptions about GeoGebra in learning of circle. The quasi-experimental study was adopted. The result indicated that students in the experimental group outperformed those in the control group. And analysis of the questionnaire responses indicated a positive overall perception of using GeoGebra in learning about circles.

Thambi and Eu (2013), studied on "Effect of students' achievement in fractions using GeoGebra". The purpose of this study was to investigate the effect of students' achievement in fractions using GeoGebra. A quasi-experimental research design was used to compare the achievement of two groups experimental and control of four primary school students. This study found that the student in experimental group performs better when using GeoGebra than the control group with the traditional learning method.

Acharya (2015), conducted the study on "Effectiveness of GeoGebra software on mathematics achievement", with objective to compare the achievement of the students in mathematics by using GeoGebra software with the achievement of students taught without using GeoGebra software and another objective to elicit students' perception in learning circles using GeoGebra software. Researcher used pre-test and post-test non-equivalent design of experimental research. The researcher chooses 28 students of grade X as experimental group and 25 students as control group. After one week of experiment research gathered data from mathematics achievement test and mathematics perception test. The result of this study indicated that students in the experimental group have better achievement than control group. And five point Likert type of scale was used to elicit students' perception on the use of GeoGebra. Result of the questionnaire response indicates a positive perception of using GeoGebra in mathematics learning.

Bhandari (2015), did a research on "Effectiveness of GeoGebra-assisted instruction in mathematics at secondary level", with objective to find the effectiveness of GeoGebra assisted instruction on the students' achievement in reflection and rotation at secondary level. The researcher chooses 25 students of grade IX as an experimental group and 23 students as a control group, after one week of experiment research gathered data. Also five point Likert type scale was applied for fostering students' motivation. This research shows that the students in the experimental group performed significantly better

than the students in control group and the students who were taught by GeoGebra-assisted instruction were more motivated towards the conventional study.

A study in Turkey conducted at Dicle University and Kahramanmaraş Sutcu Imam University involved 51, 10th grade students using GeoGebra to learn trigonometry, in particular, the graphing of trigonometric functions. The students' test scores showed that students who used the software learned the material better than students who did not use the software. Note that the treatment students were given a one hour introduction to the GeoGebra software prior to beginning the GeoGebra lessons. Students in both the treatment and control groups took a pre-test and post-test and both groups did better on the post test. However, there was a significant difference between the treatment and control groups with the treatment group scoring better on the post-test than the control group. This indicates that instruction with GeoGebra can be more effective than traditional teaching methods. As stated by the researchers, "computer assisted instruction as a supplement to constructivist instruction is more effective than constructivist teaching methods" (Zengin, Furkan, Kutluca, 2012). The findings in this study are consistent with the study by Ross and Bruce (2009), Reis (2010), and Tatar (2012) which found that the impact of utilizing mathematical learning software had a positive effect on enhancing student learning and understanding.

Denbel (2015), studied on "Students' learning experience when using a dynamic geometry software tool in geometry lesson at secondary school in Ethiopia". The study was investigated to what extent students are motivated to learn geometry with the support of dynamic geometry software. The research data was drawn from the used worksheets, classroom observation, and result of pre-test and post-test, a questionnaire and interview responded. The researcher used GeoGebra as a dynamic geometry software tool. The result showed that, the students are motivated in there

learning geometry and students understanding in learning were increased when using dynamic geometry software GeoGebra.

Kllogjeri (2015), did the research on “GeoGebra in teaching and learning mathematics in Albanian secondary school”. This research investigated the effectiveness of GeoGebra software in teaching and learning mathematics in the secondary school in Albanian. This study based on the comparing two groups where, one is taught in traditional way and other using GeoGebra. Kllogjeri’s study shows that mathematical course taught by using GeoGebra software is as effective as more traditional methods of instruction.

Acharya (2015), studied on “Effectiveness of Geogebra software on Mathematics Achievement”. The purpose of this study was to investigate the effectiveness of student’s achievement in circle using Geogebra. A quasi-experimental research design was used to compare the achievement of two groups experimental and control of two secondary schools. This study found that students in the experimental group have better achievement than control group.

Lammichhane (2017), conducted the research on “Effectiveness of Geogebra on Student’s Achievement at secondary Level”. This research investigated the effectiveness of Geogebra software in the Geometry. This research was based on the comparing two groups where one is taught in the traditional way and other using Geogebra software. This research shows that geometrical concept taught by using Geogebra is more effective than the traditional method.

From the above mentioned review of the literatures indicates that GeoGebra as teaching materials; which has positive impact on students’ achievement in learning mathematics at secondary level. It is also believed that knowledge, skill and

understanding of students can be enhanced with the use of dynamic mathematical software GeoGebra. GeoGebra is one of the open source mathematical software and it is beneficial for teachers. The using of GeoGebra in teaching and learning geometry is helpful for students and it increases the students' achievement. In addition, ICT is effective as compared to traditional method in secondary level for teaching mathematics. Therefore, using ICT in teaching and learning mathematics is as effective as more than traditional method. Similarly, use of GeoGebra in geometric construction may be beneficial to both students and teachers for better geometric construction and GeoGebra has motivational tool in learning geometrical lesson. Few number of researchers research on effectiveness of GeoGebra in the topic circle and parallelogram. Therefore, this study on the effectiveness GeoGebra software on students' learning achievement in geometry at secondary level would be conducted to see how it can be beneficial to improve the educational system in Nepal. And this study was concerned about the effectiveness of GeoGebra software in theorems related to triangle and parallelogram of geometry at grade IX.

Theoretical Review

This study is based on the constructivist approach to learning. According to this theory "learning is an active process in which learners construct and internalize new concepts, ideas, and knowledge based on their present and past knowledge and experiences" (Cohen, Manion, & Morrison, 2013, p. 167). In addition, this theory emphasizes that knowledge is constructed by learners rather than received (Crowther, 1997). There are especially two types of constructivism: cognitive and social constructivism. But Cohen et al. (2013) avowed that both of them share common characteristics such as knowledge are constructed through reflective abstraction, through learner's cognitive structure and processing, through active and participative learning,

and through recognition. The impact of constructivist theorists' work in contemporary mathematics is seen as vivid since constructivism and its numerous versions have been taken by mathematics teachers in the classroom, curriculum writers in the curriculum, and researchers in their research setting. Jorgensen and Dole (2011, pp. 23-24) have emphasized that there are a number of different forms of constructivism, but underpinning all versions are three premises. First, knowledge is actively constructed by students rather than being passively received. It means that students in learning mathematics should have actively participated in learning activities for constructing new knowledge based on his present experiences. Second, mathematical knowledge is created by students as they reflect on their physical and mental actions. By observing relationships, identifying patterns and making abstractions and generalizations, students come to integrate new knowledge into their existing mathematical schemas. Third, learning mathematics is a social process where, through dialogue and interaction, students come to construct more refined mathematical knowledge. Through engaging in the physical and social aspects of mathematics, students come to construct more robust understandings of mathematical concepts and processes through processes of negotiation, explanation, and justification.

In the social constructivism approach of Vygotsky, the Zone of Proximal Development (ZPD) has been introduced which would be used in my study particularly in assessment of the students. In the learning of the theorems on triangle and parallelogram, more skilled students were able to assist their peers with information and manner of constructing diagrams and the more capable students were able to fill in gaps in their peers' knowledge or explanations they have missed. The peers then gain a different insight and develop a different manner of understanding the concept of triangle and parallelogram. In addition, when working in groups due to the differing ZPD of each

student, they may have differing view; therefore through interaction with peers they can achieve shared understanding. However, in a situation, there must be a balance in terms of the insights and ideas contributed by each group member; it is important to have shared views and justifications of opinions to reach mutual understanding. This enables all students apparent when new views and ideas are taken into the current cognitive state.

The study draws upon the constructivist theory of social interaction for cognitive development. The main principle was anchor on zone of proximal development (ZPD) and scaffolding. Students generally have challenges in understanding mathematical concepts; therefore in this study the Geogebra software was introduced as a scaffold to enhance students' understanding of the theorem of triangle and parallelogram.

Conceptual Framework

This study was used vygotsky's social constructivist theory for analyzing the effectiveness of using GeoGebra while teaching theorems of triangle and parallelogram of geometry at grade IX based on ACE teaching cycle. The conceptual framework of this study can be shown in the figure as follows:

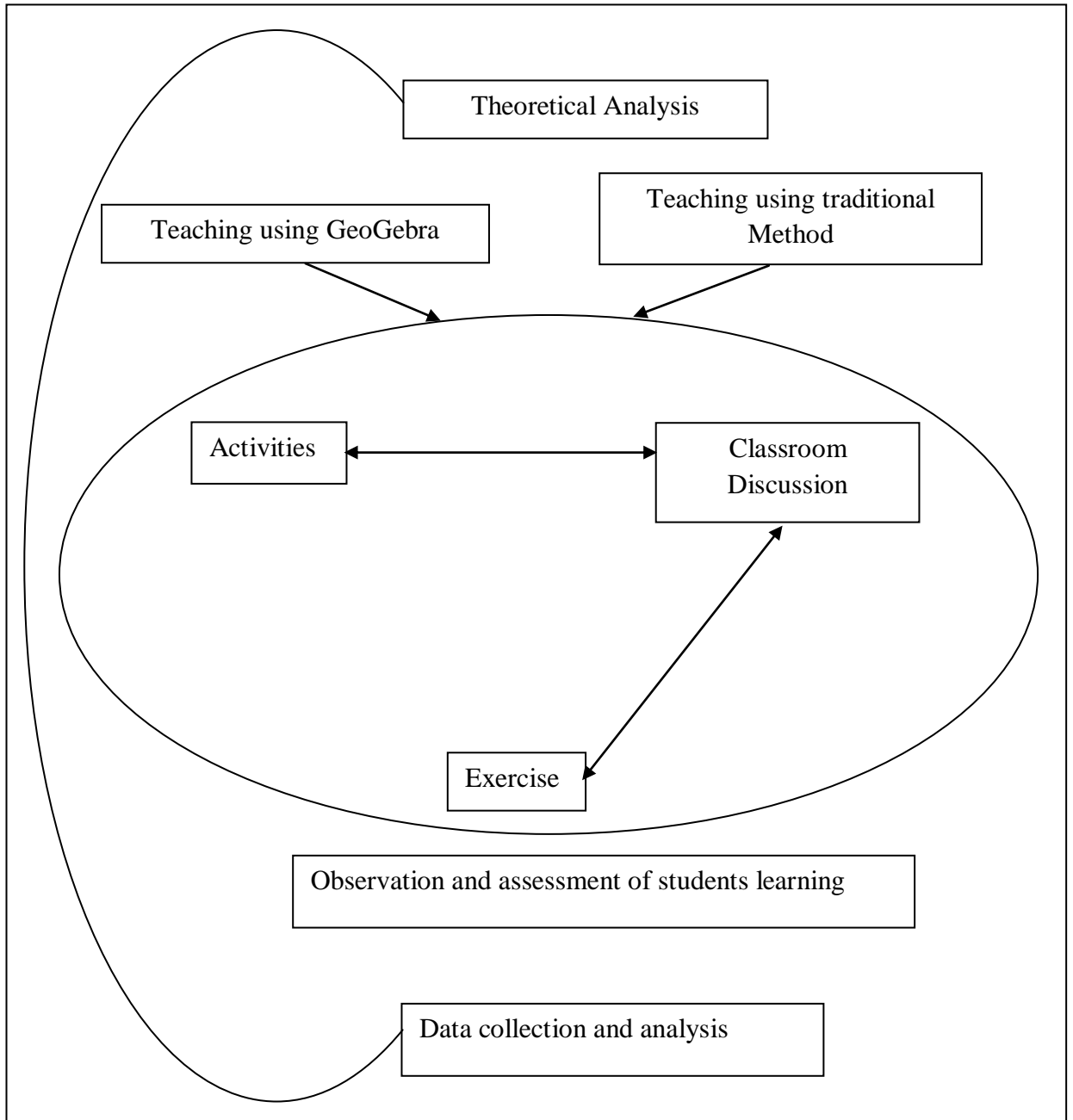


Figure 2.1: Conceptual Framework

Depending upon the Vygotsky's social constructivist perspectives, my research framework was based on: theoretical analysis, teaching by using GeoGebra and

traditional method, observation and assessment of students learning, and data collection and analysis with based ACE teaching cycle. Theoretical analysis derives from whole process of the research cycle. The both methods using GeoGebra and traditional method included the ACE teaching cycle: activities, classroom discussion, and exercise. In traditional method, teaching cycle based upon teacher centered activities and without using GeoGebra.

I had developed the teaching episode based on ACE teaching cycle. Activities, which constitute the first part of the teaching cycle, was based on the fulfillment of the objectives of this study. The classroom discussion, the second part of the teaching cycle, was involved instructor and students group. Activities and classroom discussion work gives students an opportunity to reflect on their work. As instructor guided the activities and discussion with provide definitions, explanations and presentation for control group using traditional method and for experimental group using GeoGebra software. Exercise, the third part of the teaching cycle, consist of fairly standard problems was designed to reinforce the activities and the classroom discussion. Exercise was guided to the students to apply what they learn and to consider related mathematical ideas. In this teaching cycle, instructor and students were work together interacting each other with collaborative dialogue. After completing the above teaching cycle, researcher collected the data from observation and assessment of students learning and data analysis was based upon method and procedures of this study.

Chapter III

Methods of Procedures

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

Research Design

Research design is the design of path about how is the research conducted. It is the detail path of the investigation. Thus, research design comprises the overall strategy that will be followed in collecting and analysing data (Gay, L.R., Mills, G.E., & Peter, W.A.,2012).To meet the objectives of the study, the researcher was used experimental design. According to Gay et al. (2012), in experimental research the researcher manipulates at least one independent variable, controls other relevant variables, and observes the effect on one or more dependent variables. It involved a comparison of two groups like experimental and control group.

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

Table 3.1: Design of Study

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

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

In this design, O_1 and O_2 represent the pre-test and post-test for experimental group, and O_3 and O_4 represents the pre-test and post-test for control group respectively. Both groups were given the same achievement test (pre-test) before treatment. Pre-test was used to assess similarities between groups. After pre-test, the experimental group of students were taught regularly by using GeoGebra software known as treatment T_1 . But the control group of students were taught regularly by using traditional method known as treatment T_2 . Here traditional method also includes teaching without using GeoGebra software. And their activities were noted by regular observation. At the end of the experimentation time, achievement test (post-test) was conducted to both group and their score were compared and analyzed. And the perception of students on GeoGebra software was conducted only experimental group and their perception were analyzed.

Population, Sample and Sampling Strategy

In this research, Nuwakot district was selected as a research site. Students of class IX of Nuwakot district were considered as population. Using purposive and convenience sampling two government schools of Nuwakot district were selected.

In particular, 30 students of Shree Mahadev Secondary School and 32 students of Shree Shiladevi Secondary School were the sample of this study as experimental and control group respectively. These two schools are located in Belkotgadhi-07, Nuwakot and Belkotgadhi-06, Nuwakot.

Table 3.2: Composition of Sample

Group of students	No. of students	Percentage
Experimental	30	48.39%
Control	32	51.61%
Total	62	100%

Variables

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

Different variables used in educational research. An independent variable is an attribute or characteristic that influences or affects an outcome or dependent variable. A dependent variable is an attribute or characteristic that is dependent on or influenced by the independent variable (Creswell, 2012). It means if one variable depends upon or is a consequence of the other variable, it is termed as a dependent variable, and the variable that is antecedent to the dependent variable is termed as an independent variable.

Variables that are not related to the purpose of the study, but may affect the dependent variable are termed as extraneous variables.

In this study, using GeoGebra software while teaching theorems of parallelogram and triangle of geometry was considered as independent variable. Similarly, students' score on mathematics achievement test (post-test) and students perception on GeoGebra in learning triangle and parallelogram of geometry were considered as dependent variables. Moreover, Selection of school, instructor/teacher, subject matter, group,

experimental time, test, scoring, student's labor and home environment were considered as extraneous variables in this study.

Controlled Variables

Two schools were selected in sample which is similar in status like socio-economic, facilities, result of student. Researcher himself was taught for the experimental and control group. In experimental period the chapter parallelogram and triangle of geometry of grade IX was taught for the both groups. Experimental and control group of students were made by naturally assembled. Researcher had provide equal time to both groups. Same test paper had conduct for the both groups before and after the time of experimentation. Researcher himself had given the score of students in test paper appeared by the students.

Extraneous Variables

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

Experimental stages

Experimental stage was categorised into three stages in this study, which as follows:

Pre-experimental stage

In the pre-experimental stage, the researcher had developed the test item and opinionnaires. The test item was related to the parallelogram and triangle of grade IX. In addition, test item included both objective and subjective questions. The questionnaire was related to five point Likert scales, which was based upon the student's perception about GeoGebra software. After developing test items, mathematics achievement test items were piloted on the group of students that are not included in sample for pre-test and post-test. And analysis was performed on the result of pilot test and the pre-test and post-test item of mathematics achievement test was selected. After selecting test item of mathematics achievement test, pre-test was administered among the students of experimental and control groups for the purpose of group comparison. The pre-test consisted of 10 objective questions and 6 subjective questions (Appendix-2).

Experimental stage

In this stage, researcher himself was taught for the experimental and control group regularly for two weeks. The experimental group of students were taught by using GeoGebra software but the students of control group was taught by using traditional method. In the experimental process, teaching episodes were developed for experimental group (Appendix-1). Also, the observation of students in both groups were done regularly during the time of experimentation.

Post-experimental stage

In post-experimental stage, the post-test was administered among both groups. The post-test consisted of 10 objective questions and 6 subjective questions. Also a set of opinionnaire was administered only on experimental groups. It consisted of 10 statements related to student's perception about GeoGebra software (Appendix-3).

After collecting the students answer and response, the data was analyzed.

Intervention

For the intervention, parallelogram and triangle of geometry at grade IX were planned to teach by using GeoGebra software to the experimental group. The researcher in the control group used the traditional teaching method. The intervention would be preceded by a pre-test, as a baseline (Appendix-2). After the pre-test the intended classroom activities were implemented. The classroom teaching, which was the main part of the intervention, researcher had covered parallelogram and triangle. The researcher taught one period per a day i.e 45 minutes. At the beginning of intervention, teacher prepared the teaching episode (Appendix-1).

In the first day, few minutes the teacher introduced to the dynamic mathematical software GeoGebra to the students in the experimental group, and researcher explained the theorem related to triangle with help of GeoGebra software. After that researcher and students were interacted each other and proved the theorem (Teaching episode-1). This theorem was taught by traditional method in the students of control group. By the similar way all theorems of triangle and parallelogram were taught by using Geogebra with the help of teaching episode (Appendix-1). At the end of the intervention, post-test (Appendix-2) was administered in both group and opinionnaire (Appendix-3) was administered only the experimental group. Thereafter, in order to evaluated the intervention.

Sources of Data

This study was based on experimental design. In order to carry out study, the following sources of data were adopted.

- i. **Primary source:** The primary source was based on test items and opinionnaires. The questionnaire was related to Likert scale.
- ii. **Secondary source:** The secondary source was based on articles, journals, previous research for analyzing data.

Data Collection Tools and Techniques

To succeed the research work within time, research tools and techniques were necessary and appropriate for particular research work. The researcher of this study used the achievement test and opinionnaire to collect the data.

Mathematics achievement test

The researcher himself with help of pilot test developed the achievement test. Pilot test was administered at Chandra Jyoti Secondary School ,Bidur-04, Nuwakot. The pre-achievement test was used to determine the achievement level of students in both groups. This test consisted of 10 objective and 6 subjective questions, where objective question were the weight of one mark, 2 subjective questions weight of two marks and 4 subjective questions weight of four marks. The tool was used as a pre-test for group comparison. This was administered before the experimentation process. At the end of experimental time, post-achievement test was administered for the purpose of this study. Post-test included same question as that of pre-test with same weight.

Opinionnaires

The questionnaire were related to five point Likert scales which was used to analyze the students perception on GeoGebra in learning parallelogram and triangle of geometry. In this study, the set of opinionnaire contained 10 statements using Likert scale of '1-Strongly disagree, 2-Disagree, 3-Undecided, 4-Agree and 5-Strongly agree' for positive statement and for negative statement the scoring process was reversed.

Validity and Reliability of Tool

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

Reliability of the test is very important of this study. For this purpose, every test item were piloted and reliability was checked before it was administered. In this study, the mathematics achievement test was piloted involving 5 students of grade X in Chandra Jyoti Secondary School, Bidur-4, Nuwakot. The response of the students were analyzed applying the split-half method and the reliability was determined. The test found $r = 0.98$ (Appendix-4). It indicated that the mathematics achievement test was highly reliable.

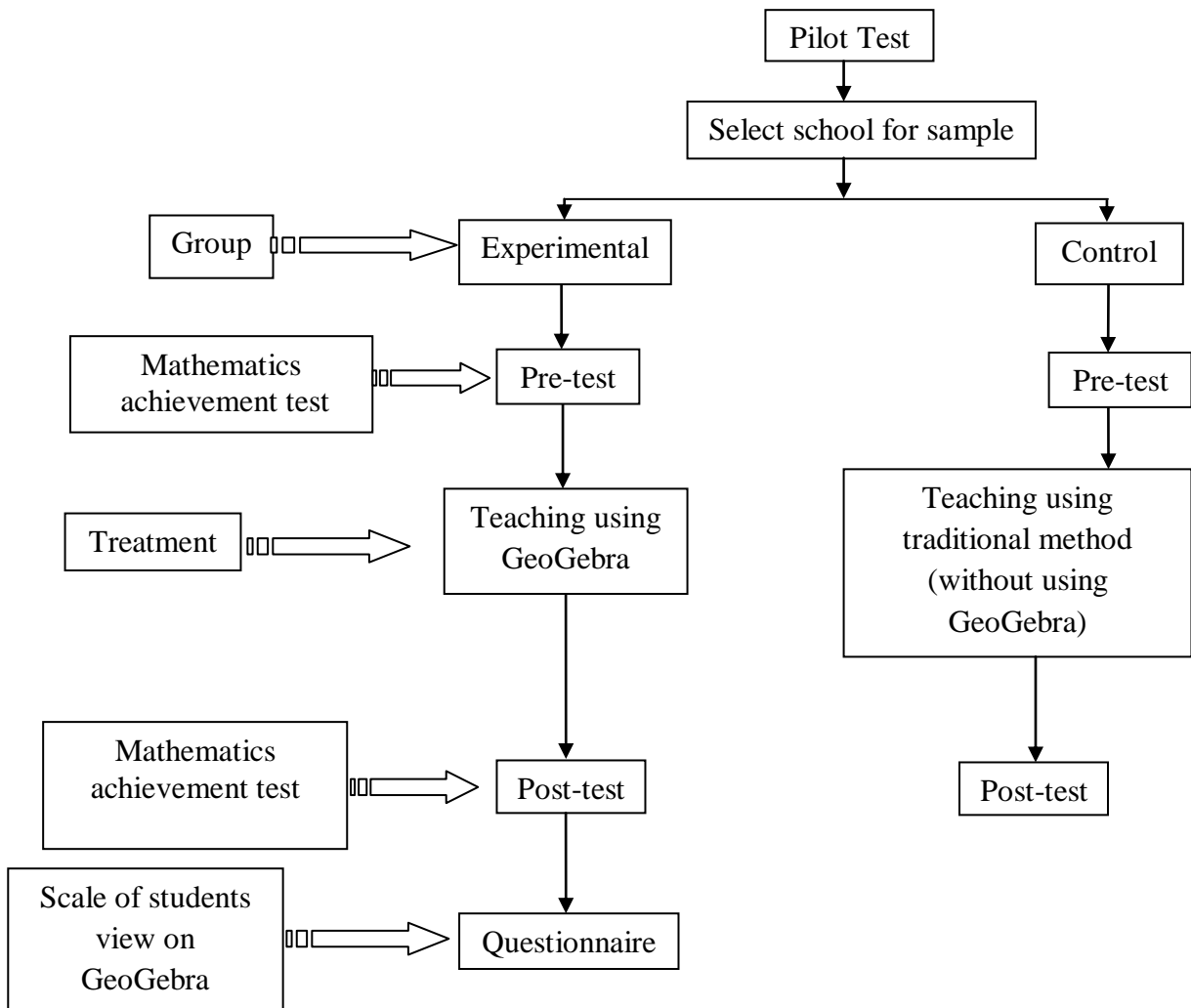
Data Collection Procedures

Data collection procedure is very important. The procedures of data collection describe how the relevant information gathered. This study was manly based on quantitative data obtained from mathematics achievement test and opinionnaire related to five point Likert scale. Before administering pre-test, pilot test was administered at Chandra Jyoti Secondary School. The researcher developed the test items and found the reliability of achievement test.

In this study, after the standardization of the test, the collection of data from mathematics achievement test was done by following process. Before start experimentation, the researcher meet the principal and subject teacher and took permission for experimentation. After selection of sample school, the achievement test was administrated to IX grade students of sample school. In the examination, there were 30 students of Shree Mahadev Secondary School, which was experimental group and 32

students of Shree Shiladevi Secondary School, which was control group. Then the score of these students were tabulated. The pre-test was administered for group comparison.

After pre-test scores were tabulated, experimental group of students were taught regularly for two weeks by using GeoGebra software. The control group of students were taught regularly two weeks by using traditional method (without using GeoGebra). At the end of experimentation time an achievement test (post-test) was conducted to both groups and their score was tabulated. The post-test was administered for the purpose of comparing the achievement score. Additionally, a set of questionnaire related to five point Likert scale was administered only on experimental group and their perception was recorded. The set of opinionnaire was administered for purpose of analyzing the students' perception on GeoGebra software. The summary of the data collection procedures of this study given in the figure below:

Figure 3.1: A Summary of the Data Collection Procedures

Data Analysis Procedures

Data analysis procedures were based upon the data collection tools and techniques. Collected data was analyzed by using descriptive and inferential statistical analysis method. Descriptive statistical like: mean, variance and standard deviation were calculated with help of Microsoft Office Excel 2007. Mean, variance and standard deviation were calculated for both groups with their obtained marks in the pre-test and post-test. Also mathematics achievement test scores were analyzed using inferential statistics, specifically that t-test with two-tailed test at 0.05 level of significance value was used in comparison of pre-test result. Similarly, the t-test with one-tailed test at 0.05 level

of significance value was used in comparison of post-test result. For the comparison of both group in the pre-test, f-test were used. Additionally, to analyze the students perception about GeoGebra software, the opinionnaire related to five point Likert scale was used only on the students of experimental group. On the basis of students' response, mean, standard deviation and percentage were calculated by assigning 1 for strongly disagree, 2 for disagree, 3 for undecided, 4 for agree and 5 for strongly agree for all positive statement and for negative statement the scoring process was reversed. Finally, data was analyzed and interpreted.

Chapter IV

Analysis and Interpretation of Data

This chapter deals with the analysis and interpretation of data. An experimental research was done in concern to the topic “Effectiveness of GeoGebra on students’ achievement in geometry at grade nine”. The objectives of the study were ‘Comparing the achievement of the students taught by using GeoGebra and traditional method in parallelogram and triangle’ and ‘Exploring the students perception on GeoGebra software .A pre-test, post-test equivalent group design was adopted for the purpose of the study. A pre-test was taken to make the group comparable. Primarily, the achievement test of the students in post-test was taken to fulfil the first objective of the study. Then, for the second objective of the study, opinionnaire related to Likert scale was used. The score of the students were analyzed using statistical method with help of Microsoft Office Excel 2007 for mean, variance and standard deviation. And the students view on GeoGebra were analyzed using Microsoft Office Excel 2007 for mean and standard deviation with based on Likert scale analysis. To fulfill our objectives, the data are organized, tabulated, analyzed and interpreted as follows:

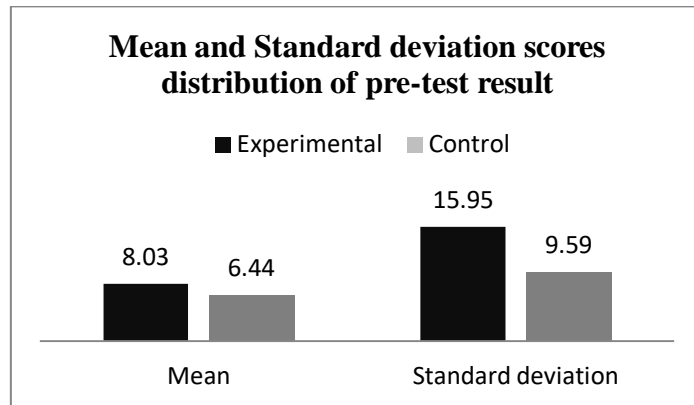
Analysis of Pre-test Result

In Appendix-5 the pre-test score of students of both groups are presented. The summary of statistical calculation for the experimental and control group on the pre-test is given in Table 4.1 and Figure 4.1 below.

Table 4.1: Result of Pre-test

Group	Number of students	Mean	Variance	Standard Deviation	F	Calculated t-value	Tabulated t-value
Experimental	$N_1 = 30$	$\bar{x}_1 = 8.03$	$S_1^2 = 15.95$	$S_1 = 3.99$	1.66	1.01	1.96
Control	$N_2 = 32$	$\bar{x}_2 = 6.44$	$S_2^2 = 9.59$	$S_2 = 3.1$			

The above Table- 4.1 shows that, there were 30 and 32 students in experimental and control group respectively. In pre-test, 30 marks of mathematics achievement test was administered (see pre-test questions in Appendix-2 and pre-test score of students in Appendix-5). The mean, variance and standard deviation of experimental group were 8.03, 15.95 and 3.99 respectively. Similarly, the mean, variance and standard deviation of control group were 6.44, 9.59 and 3.1 respectively. Since the calculated value of F is 1.66 and the tabulated value of F at 0.05 level of significance is 1.84 , so that two groups were homogeneous therefore t-test for pooled variance was applied. Here tabulated t-value at $\alpha = 0.05$ level of significance for two tailed test is 1.96 but calculated t-value was 1.01. Calculated t-value was not lying in critical region i.e $-1.96 < 1.01 < 1.96$. So H_0 is accepted. Hence, it could be concluded that there is no significance difference between the average achievement score of experimental and control groups students in pre-test. Thus, both groups were homogeneous.

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

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

Analysis of Post-test Result

The post-test score of students of experimental and control groups have been presented in (Appendix-6) and the summary of statistical calculation for the both groups on post-test is represented in the Table 4.2 and Figure 4.2 below.

Table 4.2: Result of Post-test

Group	Number of students	Mean	Variance	Standard Deviation	Calculated t-value	Tabulated t-value
Experimental	$N_1 = 30$	$\bar{x}_1 = 19.83$	$S_1^2 = 28.47$	$S_1 = 5.33$	2.51	1.645
Control	$N_2 = 32$	$\bar{x}_2 = 13.78$	$S_2^2 = 31.64$	$S_2 = 5.62$		

The above Table 4.2 shows that there are 30 and 32 students in experimental and control group respectively. In post-test, the mathematics achievement test of 30 marks was administrated (see post-test questions in Appendix-2 and Appendix-3 and post-test score of students in Appendix-6). The mean score of experimental and control group are 19.83 and 13.78 with variances 28.74 and 31.64 respectively. Here tabulated t-value at $\alpha = 0.05$ level of significance for one tailed test is 1.645. But, calculated t-value is 2.51. Here $2.51 > 1.645$, so that H_0 was rejected and H_1 was accepted i.e. it could be concluded that there is significance difference between average achievement scores of experimental and control groups. Hence, the average achievement score of experimental group is higher than the control group on post-test. Thus, the students who were taught by using GeoGebra learned more and so higher achievement than traditional method of teaching.

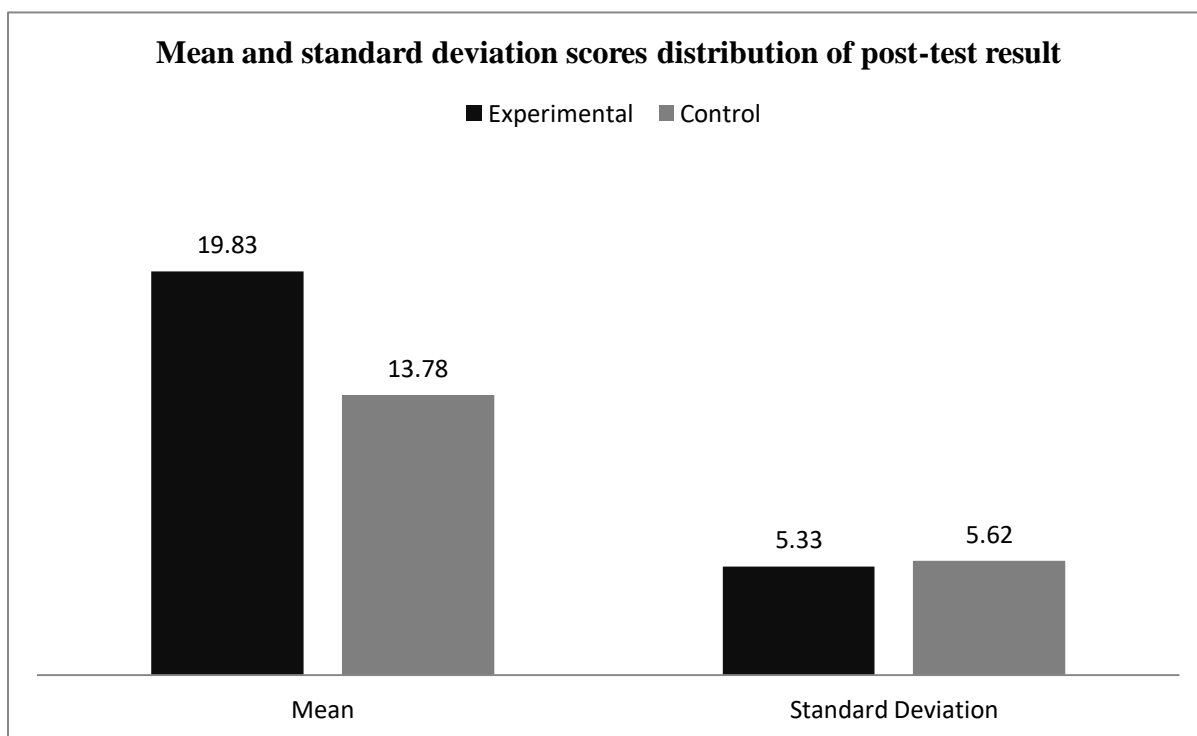


Figure 4.2: Mean and Standard Deviation Scores Distribution of Post-test Result

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

with respect to mean. This shows that there is a difference in achievement score between experimental group and control group on post-test. Since the difference between the mean, standard deviation on the post-test was 6.05 and 0.29 respectively. Therefore, the diagram (Figure 4.2) indicates that the teaching using GeoGebra software is more effective than traditional method in the content of parallelogram and triangle at grade IX.

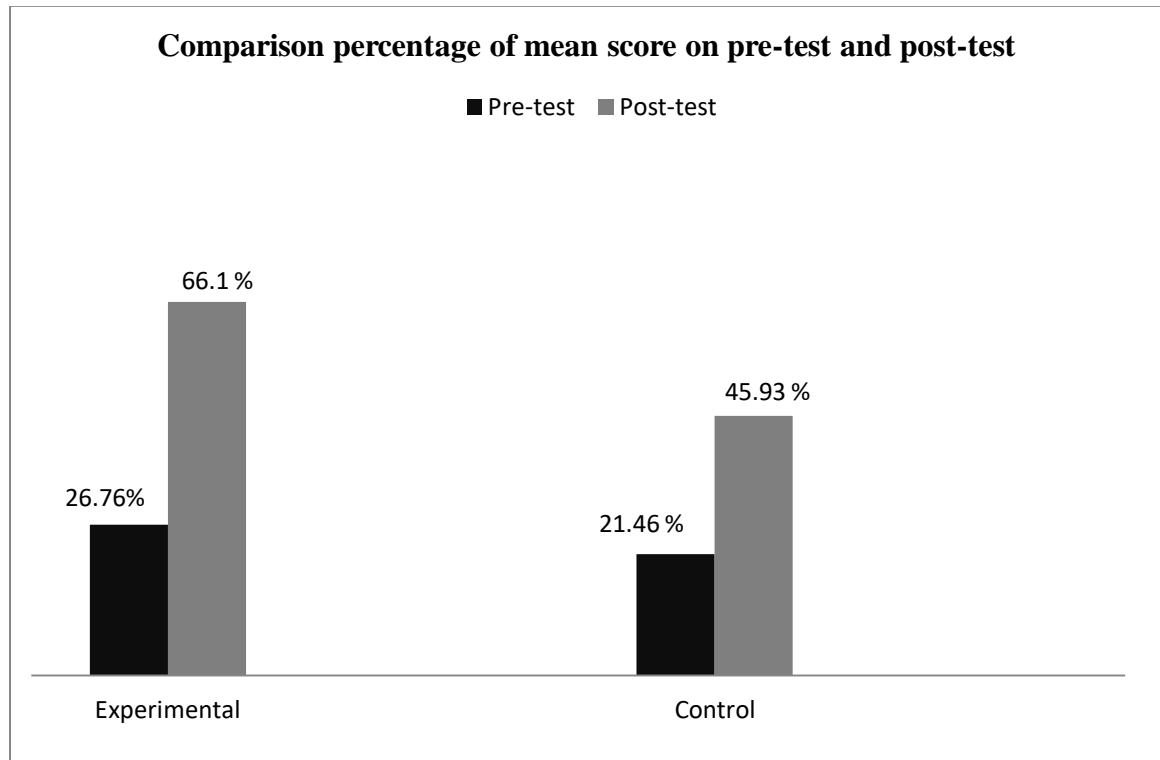


Figure 4.3: Percentage of Mean Score of Experimental and Control Groups

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

GeoGebra is more effective than traditional method in parallelogram and triangle of geometry at grade IX.

Analysis of Students Perception on GeoGebra Software

A opinionnaire related to students perception about GeoGebra software was administered to 30 students of experimental group only (see the statement in Appendix-3) whose response are tabulated, the quantitative data are provided in Table 4.3 (in Likert scale). 5, 4, 3, 2 and 1 indicated strongly agree, agree, undecided, disagree and strongly disagree respectively for positive statement. And 1, 2, 3, 4 and 5 indicated strongly agree, agree, undecided, disagree and strongly disagree respectively for negative statement.

Below the Table 4.3, the statements 'I prefer to learn Mathematics with GeoGebra software and GeoGebra makes geometry class boring' have the same mean score i.e. 4.8, which is the highest mean score. While the lowest mean was 2.93 which is obtained from the statement 'At the beginning, I did not like GeoGebra software. Other items mean were near about the highest mean. According to Denbel (2015) and Shadaan and KwanEu(2013), a mean score of 3.0 or higher indicates a positive feedback or opinionnaire about GeoGebra and the mean score lower than 3.0 indicates negative feedback or opinionnaire about GeoGebra in learning geometry. The result from overall mean 4.35 shows that students generally gave positive feedback about the GeoGebra software in learning parallelogram and triangle of geometry at grade IX.

Table 4.3: Result of Students Perception on GeoGebra Softwatre

S.N.	Statements		Strongly agree	Agree	Undecided	Disagree	Strongly disagree	Total	Weighted Mean	Perception Positive-P, Negative-N
1	GeoGebra software helps to learn Mathematics concepts.	fre.	21	9	0	0	0	30	4.7	P
		%	70	30	-	-	-	100		
2	At the beginning, I did not like GeoGebra software.	fre.	-	16	-	14	-	30	2.93	N
		%	-	53.3	-	46.7	-	100		
3	I feel confident when the activities are done by using GeoGebra software.	fre.	16	14	0	0	0	30	4.53	P
		%	53.3	46.7	-	-	-	100		
4	Using GeoGebra makes geometry more difficult for me.	fre.	0	0	2	7	21	30	4.6	N
		%	-	-	6.7	23.3	70	100		
5	I prefer to learn Mathematics with GeoGebra software.	fre.	27	2	0	0	1	30	4.8	P
		%	90	6.7	-	-	3.3	100		
6	GeoGebra software helps visualizing the problems of geometrical concept.	fre.	23	6	0	1	0	30	4.7	P
		%	76.7	20	-	3.3	-	100		
7	Geogebra software helps to increase my achievement in the geometry ..	fre.	3	23	0	4	0	30	3.83	P
		%	10	76.6	-	13.3	-	100		
8	GeoGebra software can help to make the learning more enjoyable	fre.	10	17	2	1	0	30	4.2	P
		%	33.3	56.6	6.7	3.3	-	100		
9	I am happy if the teacher uses the GeoGebra software in teaching Mathematics.	fre.	18	11	0	1	0	30	4.5	P
		%	60	36.7	-	3.3	-	100		
10	GeoGebra makes geometry class boring.	fre.	0	0	2	2	26	30	4.8	N
		%	-	-	6.7	6.7	86.6	100		
Overall Mean 4.35										
<p>Note: If the weighted mean is greater than 3, the perception is considered to be positive and if the weighted mean is less than 3 then the perception is considered to be negative.</p>										

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

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

Similarly, for the statement 8, the weighted mean is 4.2 where 10 students were strongly agree and 17 students were agree with this statements that means exactly 90 percent of the students feel that the software helps to make the learning more enjoyable. Similarly for the statement 9, 18 students were strongly agree and 11 were agree with the weighted mean 4.5 , the weighted mean shows that the students would be happy if the teacher uses the Geogebra software in teaching mathematics. Finally, for the negative statement 10, the weighted mean is 4.8 where all most all students rejected the statement

that means Geogebra does not make geometry class boring at all. The overall mean of the all 10 statements is 4.35 which represents that Geogebra software is more applicable in teaching geometry. If we apply the Geogebra software in the teaching geometry, students can learn geometrical concept in enjoyable and fruitful way.

Thambi and KwanEu (2013) also showed that students in experimental group performs better when using GeoGebra than the control group with the traditional learning method. During the period of experimentation, I found that students were interested to learn geometry with Geogebra. At that time, they were actively participated in the learning activities. They had made the classroom more interactive with discussing each other. When I started to teach by using Geogebra, they were came school regularly and gave great effort to learn geometrical proof of the related theorem.

Moreover, they got the idea to construct the figure in the Geogebra software then they feel easy to prove the theorem. There is a Chinese proverb, "I hear I forget, I see I remember, I do I understand". By this way in this research also student done the experiment themselves of every theorem by using Geogebra and made the concept how to prove them.

In the experimentation time, students were seen very interested and dedicated in their study with full of joyful environment. Among those students one students said that, "Please sir teach us another chapter also by using Geogebra software, I feel very confident in this topic " and another students told me that, "this software visualized the every concept of geometry , so I prefer this software very much". So, in my observation Geogebra software is very helpful and fruitful tools in teaching geometry.

Statistical result of this study indicates that there is significant difference between the average achievement score of experimental and control group in post-test. Also above

result shows, that GeoGebra is very helpful for teaching and learning geometry. By the development of technology tools GeoGebra increases the students' achievement in their learning geometry. Hence, teaching using GeoGebra is more effective than traditional method in parallelogram and triangle of geometry at grade IX. Moreover, students gave positive response about the GeoGebra softwar.

Chapter V

Summary, Findings, Conclusions and Implications

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

Summary of the Study

The research entitled “Effectiveness of GeoGebra on students' achievement in geometry” was intended to investigate the using GeoGrbra is more effective than the traditional method and also analyse the students perception on GeoGebra software.

For the data collection of this study, pilot test was conducted on 5 students of the school Chandrajyoti Secondary School, Bidur-4, Nuwakot. The researcher developed and tested the reliability of achievement test before their administration. The pilot test consisted of 10 objective (multiple choice) and 6 subjective type items on the area of parallelogram and triangle of geometry from grade IX. The reliability coefficient of achievement test was found to be 0.98 (Appendix-4). It indicated that the mathematics achievement test was highly reliable.

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

After teaching two week in Shree Mahadev Secondary School by using GeoGebra software, researcher collects data from mathematics achievement test and students Perception on GeoGebra by using opinionnaire related to Likert scale of this experimental

group. Also teaching two week in Shree Shiladevi Secondary School by using traditional method, researcher collects the data from mathematics achievement test of this control group. The experimental group contained 30 students and control group contained 32 students.

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

In this study teaching using GeoGebra more effective than the traditional method in triangle and parallelogram of geometry at grade IX. The result highlighted that students in the experimental group performed better using GeoGebra than the control group that uses the traditional method. In addition, students view about GeoGebra was analysed through a set opinionnaire based on Likert scale consists of ten items. This opinionnaire was distributed to only experimental group and result shows that students gave positive feedback or perception about GeoGebra software in learning parallelogram and triangle of geometry.

Findings of the Study

Accepting or rejecting the significance of null hypotheses constructed for the study determined the effectiveness of GeoGebra software as compared to traditional method and opinionnaire related to Likert scale constructed for the analysing students perception on GeoGebra software in teaching parallelogram and triangle of geometry at grade IX. The findings of the study were observed from the calculated and tabulated t-

value recorded in table for hypotheses to achieve the objectives of the study. Also mean and standard deviation recorded in table for analyzed students perception on GeoGebra.

Following were the findings of the study:

- There was no significant difference between the average achievement score of experimental and control groups on pre-test.
- There was significant difference between the average achievement score of these groups on post-test i.e. the average achievement score of experimental group was higher than that of control group.
- The teaching using GeoGebra was more effective than traditional method in parallelogram and triangle of geometry.
- The geometrical thinking of the students was improved by the use of GeoGebra in teaching geometry.
- The students were able to use different sorts of activities that are useful to improve geometrical thinking.
- The results show that students gave positive feedback or perception about the GeoGebra software in learning parallelogram and triangle.
- 87% of students of experimental group gave positive response on GeoGebra software which have enhanced students learning and understanding in geometry lesson. And GeoGebra was essential and important for the teaching geometry.
- The result shows that GeoGebra makes geometry class interesting, fruitful, meaningful and enjoyable.

Conclusions

In this study, the teaching and learning of parallelogram and triangle of geometry using GeoGebra has been effective. This was shown through the improved score of the students in experimental group. The finding highlighted that students in experimental group performed better using the GeoGebra than the control group that uses the traditional method. Students in the experimental group performed better in the post-test compared to the control group. Students generally gave positive feedback or response about the GeoGebra software in learning geometry. In addition, the GeoGebra software enhanced students learning and understanding of the parallelogram and triangle of geometry. Also GeoGebra software is essential and important for the teaching geometry and it makes geometry class interesting and enjoyable.

The use of GeoGebra not only increases students' scores in mathematics but also helps students to become more creative, independence as well as to improve their visual thinking (Bist, 2017). Thus, the use of GeoGebra in geometry provides an ample opportunity to each individual for unlocking geometrical thinking step by step through active participation. More importantly, it up-rises students' geometrical thinking because GeoGebra helps students to reconstruct their existing state of knowledge and enforces them to engage in enquiry based activities such as searching application of construction (Bist, 2017). Furthermore, the use of GeoGebra in geometry lesson enables students to use existing cognitive and visual skills to develop efficiency, experiences, autonomy and hence confidence in their verbal problem-solving. Thus, it is necessary to encourage the use of GeoGebra gradually into school geometry for the purpose of improving higher order thinking skills of students.

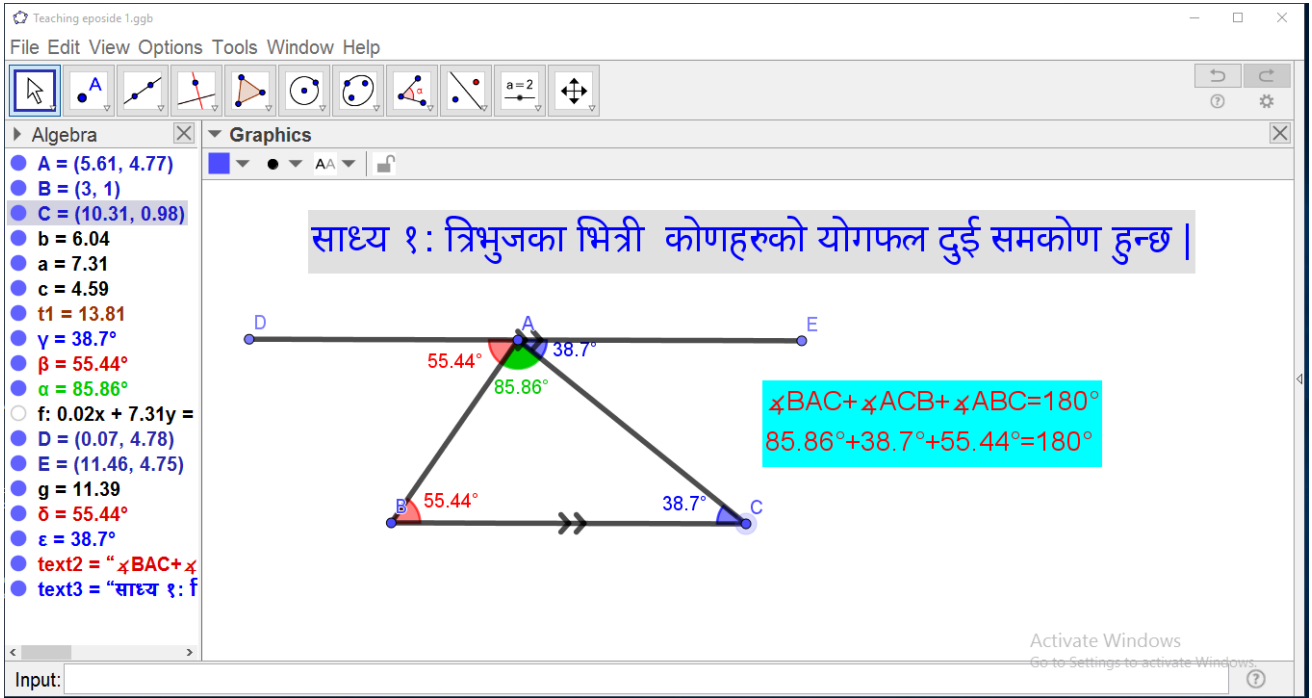
Implications

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

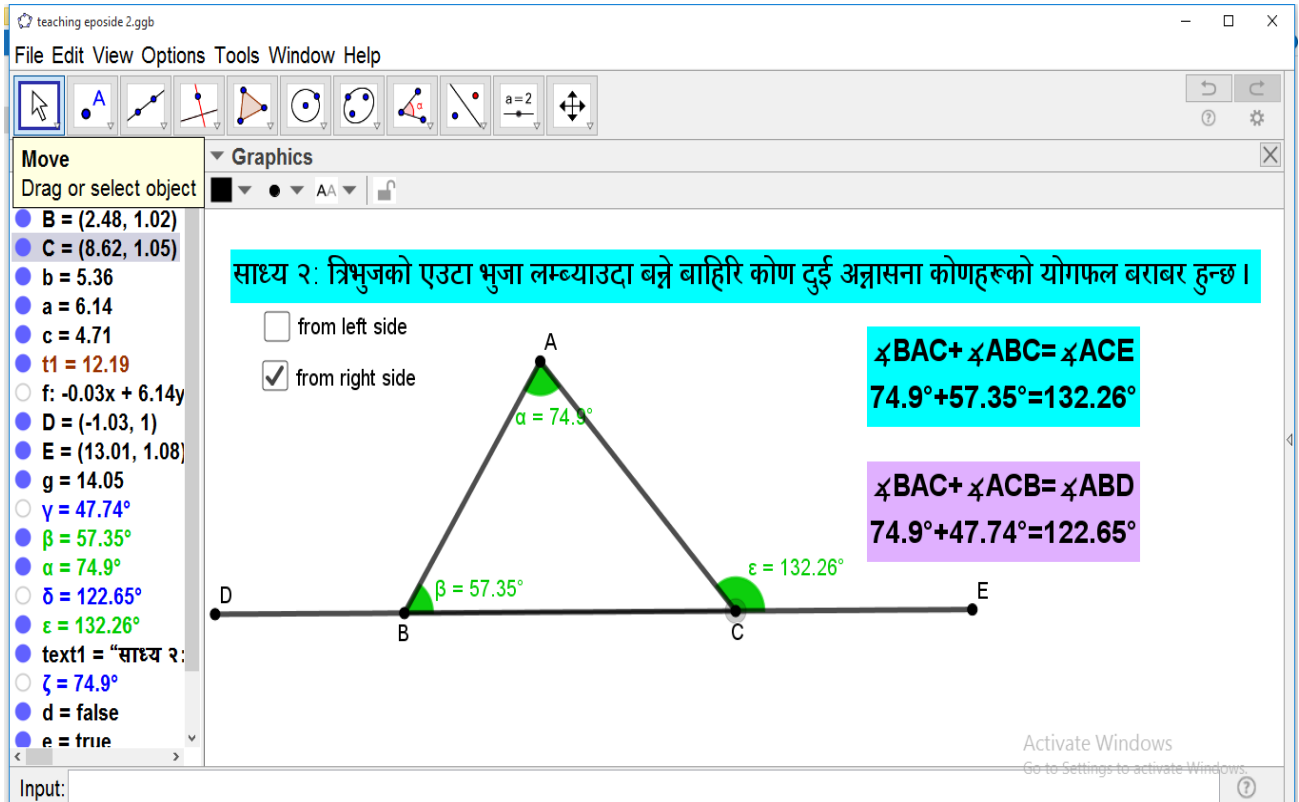
- If GeoGebra is going to become an established part of the curriculum it is important to continue to address the following issues: the general impact of GeoGebra activity on mathematics learning, gender differences while using GeoGebra, the use and developing understanding of mathematical ideas and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

Appendix-1

Related to teaching Episode-1



Related to teaching Episode-2



Related to teaching Episode-3

teaching episode 3 & 4.ggb

File Edit View Options Tools Window Help

Move Drag

- B = (12.33, 4.13)
- f = 9.05
- g: -9.04x + 0.23
- C = (7.91, 8.4)
- a = 6.14
- c = 9.05
- b = 6.14
- t1 = 18.78
- $\gamma = 42.54^\circ$
- $\beta = 42.54^\circ$
- $\alpha = 94.92^\circ$
- D = (7.81, 4.25)
- h = 4.15
- d = true
- i = 6.14
- j = 6.14
- distanceAC = 6.
- TextAC = "AC =
- distanceCB = 6.

Angle
 line

साध्य ३ : समद्विबाहु त्रिभुजका आधारका कोणहरु बराबर हुन्छन् ।
साध्य ४: (साध्य ३ को विलोम) : कुनै त्रिभुजका दुई कोणहरु बराबर छन् भने ती कोणका सम्मुख भुजाहरु बराबर हुन्छन् ।

Side AC= Side BC
6.14=6.14

$\sphericalangle CAB = \sphericalangle CBA$
42.54°=42.54°

Activate Windows
Go to Settings to activate Windows.

Input:

Related to teaching Episode-4

teaching episode 5 & 6.ggb

File Edit View Options Tools Window Help

Algebra Graphics

- A = (4, 1)
- B = (12, 1)
- f = 8
- g: -8x = -61
- C = (8, 6)
- a = 6
- c = 8
- b = 6
- t1 = 19
- D undefined
- E = (8, 1)
- h = 5
- W = 38°
- X = 38°
- text1 = "साध्य ५: र
- Z = 90°
- Y = 90°
- text2 = "साध्य ६: |
- distanceAE = 4
- TextAE = "AE = 4
- distanceEB = 4
- TextEB = "EB = 4

length
 Angle

साध्य ५: समद्विबाहु त्रिभुजको शीर्षकोणको अर्धक आधारमा लम्ब हुन्छ र यसले आधारलाई समद्विभाजन गर्दछ ।
साध्य ६: (साध्य ५ को विलोम) : समद्विबाहु त्रिभुजमा आधारको लम्बाधारकले शीर्षकोणलाई आधा गर्छ ।

Side AE = Side BE
4 = 4

$\sphericalangle AED = \sphericalangle BEC$
90° = 90°

$\sphericalangle ACE = \sphericalangle BCE$
38° = 38°

Activate Windows
Go to Settings to activate Windows.

Input:

Related to teaching Episode-5

teaching episode 7.ggb

File Edit View Options Tools Window Help

Algebra Graphics

Angle

- P = 61°
- Q = 36°
- R = 119°
- S = 119°
- W = 61°
- X = 83°
- Y = 36°
- Z = 83°

Boolean Value

- a = false
- b = false

Line

- g: $0x + 10y = \dots$
- i: $-5x + 3y = -\dots$

Point

- A = (3, -3)
- B = (13, -4)
- C = (6, 2)
- D = (16, 2)

Input:

साध्य १ : समानान्तर चतुर्भुजका सम्मुख भुजाहरु र सम्मुख कोणहरु बराबर हुन्छन्।

compound Angle

Compound angle

$\angle CAB = \angle CDB$
 $61^\circ = 61^\circ$

$\angle ACD = \angle ABD$
 $119^\circ = 119^\circ$

SIDE AC = SIDE BD
6 = 6

SIDE CD = SIDE AB
10 = 10

Related to teaching Episode-6

teaching episode 8.ggb

File Edit View Options Tools Window Help

Algebra Graphics

Angle

- $\alpha = 55^\circ$
- $\beta = 55^\circ$
- $\gamma = 125^\circ$
- $\delta = 125^\circ$

Boolean Value

- a = false
- b = true

Line

- g: $y = 6$
- i: $-5x + 4y = -\dots$

Point

- A = (2, 1)
- B = (9, 1)
- C = (6, 6)
- D = (13, 6)

Segment

- f = 7

Input:

साध्य २: (साध्य १ को विलोम) सम्मुख भुजाहरु बराबर भएको चतुर्भुज समानान्तर चतुर्भुज हुन्छ।

साध्य ३: (साध्य १ को विलोम 'ख') सम्मुख कोणहरु बराबर भएको चतुर्भुज समानान्तर चतुर्भुज हुन्छ।

LINE L

ANGLES

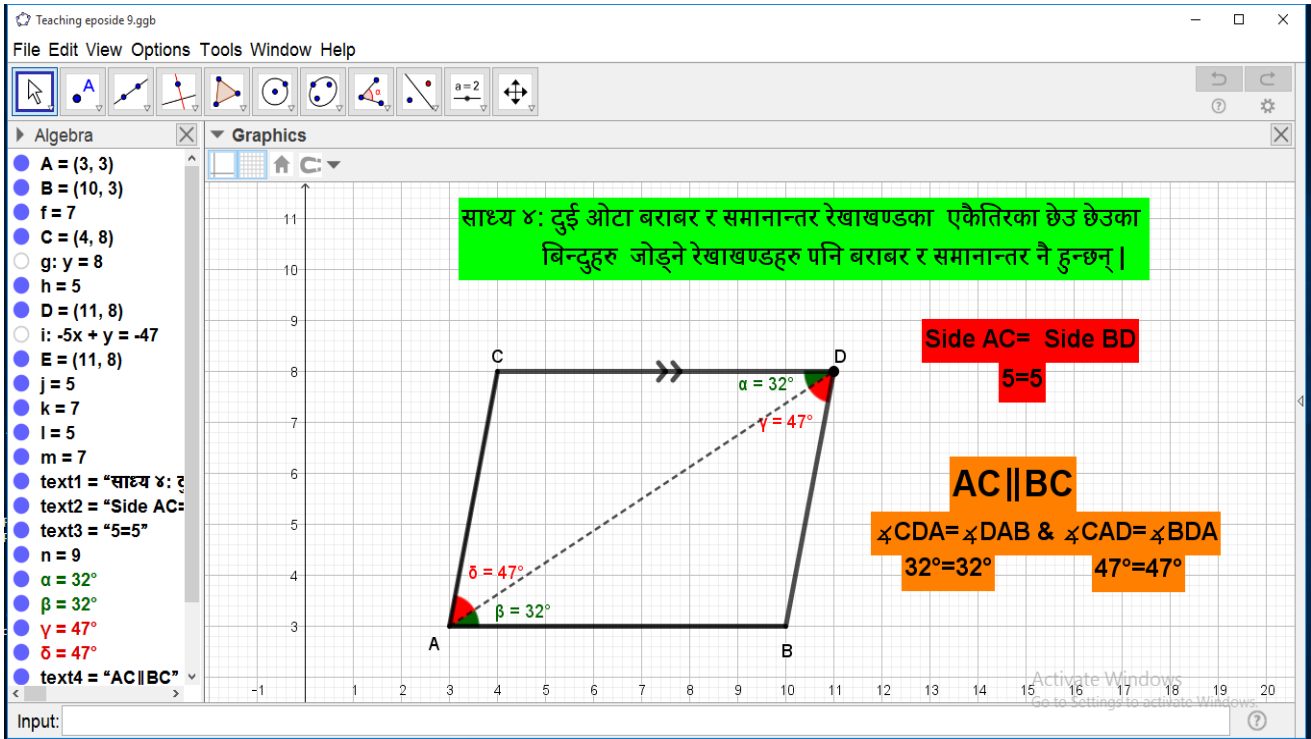
$\angle CAB = \angle CDA$
 $55^\circ = 55^\circ$

$\angle ACD = \angle ABC$
 $125^\circ = 125^\circ$

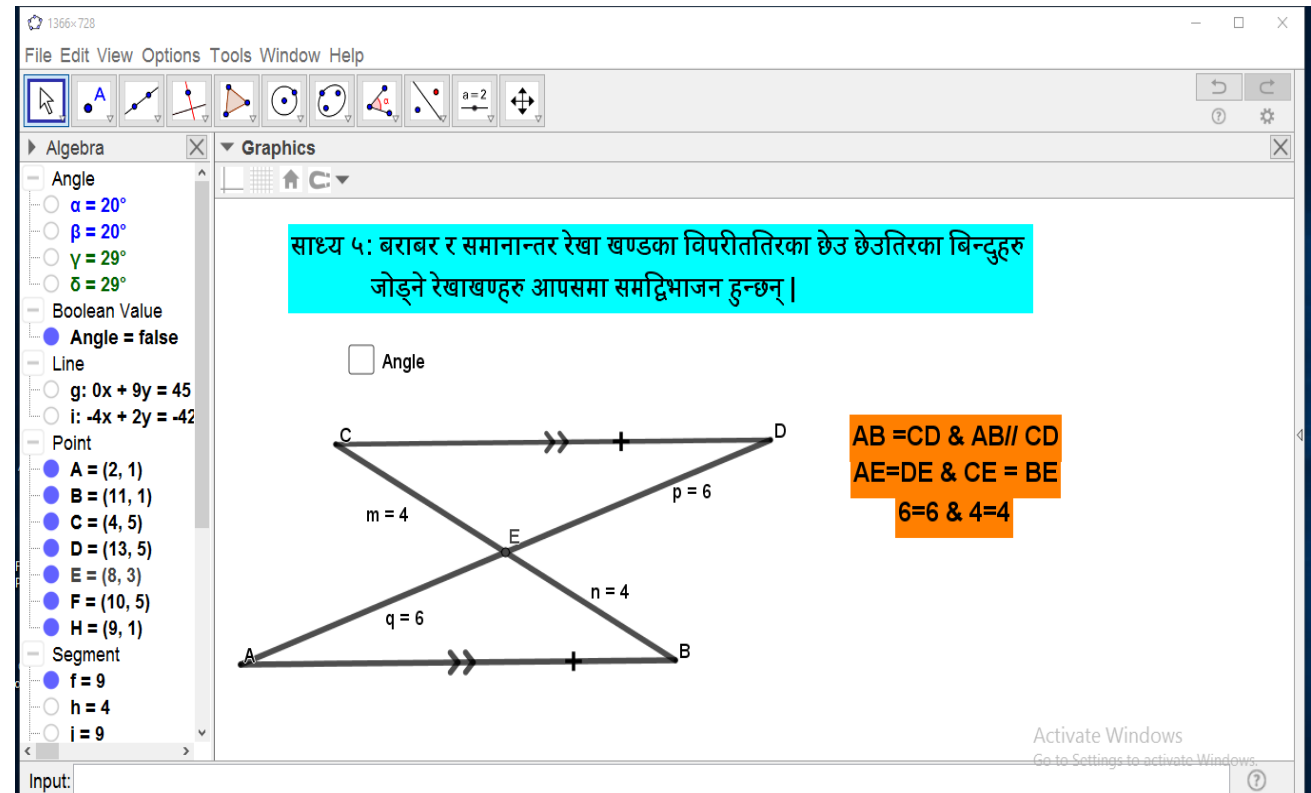
Side AC = Side BD
7 = 7

Side CD = Side AB
6 = 6

Related to teaching Episode-7



Related to teaching Episode-8



Related to teaching Episode-9

teaching episode 11.ggb

File Edit View Options Tools Window Help

Algebra Graphics

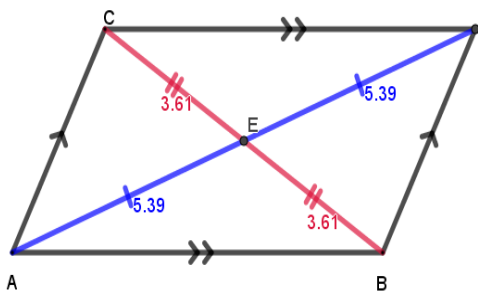
Line
g: $y = 5$
i: $-2x + y = -21$

Point
A = (3, 1)
B = (11, 1)
C = (5, 5)
D = (13, 5)
E = (8, 3)

Segment
f = 8
h = 4.47
j = 4.47
k = 8
l = 7.21
m = 10.77
n = 3.61
p = 3.61
q = 5.39
r = 5.39

साध्य ६: समानान्तर चतुर्भुजका विकर्णहरु आपसमा समद्विभाजन हुन्छन् ।

साध्य ७: (साध्य ६ को विलोम) : यदि कुनै चतुर्भुजका विकर्णहरु आपसमा समद्विभाजन हुन्छन् भने उक्त चतुर्भुज समानान्तर चतुर्भुज हुन्छ ।



CE=BE
3.61=3.61

AE=DE
5.39=5.39

Input:

Activate Windows
Go to Settings to activate Windows.

Apendix-2

Mathematics achievement test question for pre-test and post-test.

Class: IX

Full marks: 30

Subject: C. Mathematics

Time: 55 min

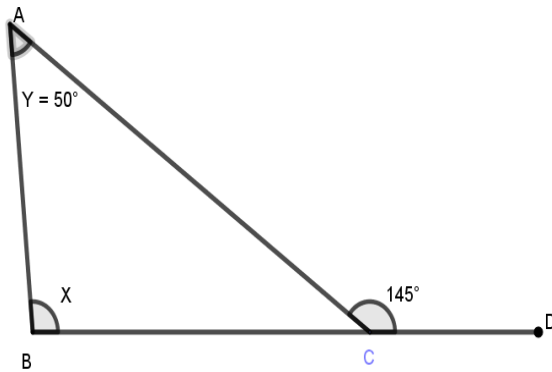
Objective Question

Tick (\checkmark) the best answer.

१. दिइएको चित्रबाट x को मान पत्ता लगाउनुहोस् ।

Find out the value of x from the given figure.

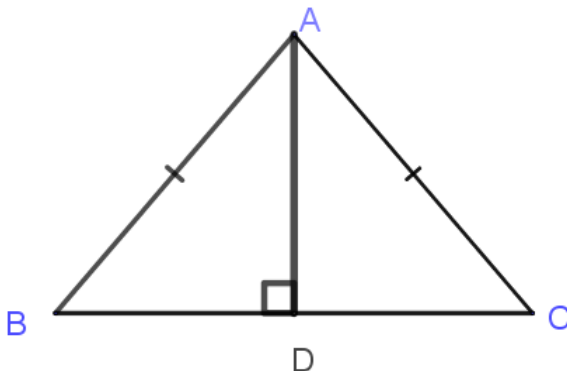
- a. 50° b. 60° c. 95° d. 80°



२. दिइएको चित्रमा $AB = AC = 25$ cm र $BC = 14$ cm छन् । यदि $AD \perp BC$ भए AD को नाप पत्ता लगाउनुहोस् ।

In the given figure $AB = AC = 25$ cm and $BC = 14$ cm. If $AD \perp BC$ then find the value of AD.

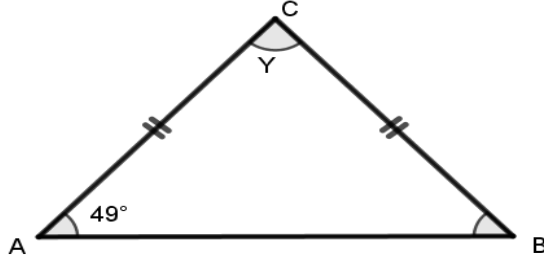
- a. 24 cm b. 42 cm c. 35 cm d. 20 cm



३. दिइएको चित्रबाट y को मान पत्ता लगाउनुहोस् ।

Find the value of y from the given figure.

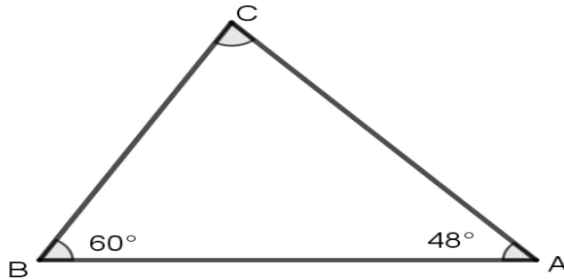
- a. 90° b. 120° c. 82° d. 100°



४. ΔABC मा यदि $\angle BAC = 48^{\circ}$ र $\angle ABC = 60^{\circ}$ भए सबै भन्दा लामो भुजा र सबै भन्दा छोटो भुजा पत्ता लगाउनुहोस् ।

In the given figure ΔABC , if $\angle BAC = 48^{\circ}$ and $\angle ABC = 60^{\circ}$, then find the longest and shortest side.

- a. भुजा AB र भुजा AC (side AB and side AC)
b. भुजा AB र भुजा BC (side AB and side BC)
c. भुजा BC र भुजा AC (side BC and side AC)
d. None of the above



५. तलकामध्ये कुन ठीक हुन्छ ?

Which of the following is true?

- a. त्रिभुजकाभित्रीकोणहरूको योगफल 80° हुन्छ।

The sum of interior angle of a triangle is 80° .

- b. तीनै ओटा भुजाकानापहरु फरक फरक भएको त्रिभुज समबाहु हो ।

A triangle is known as equilateral triangle if it has different measurement of all sides.

- c. विषमबाहु त्रिभुजका प्रत्येककोण $60^{\circ}/60^{\circ}$ का हुन्छन् ।

Each angle of a scalene triangle has $60^{\circ}/60^{\circ}$.

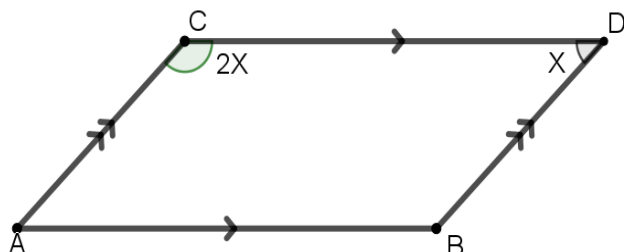
d. समद्विबाहु त्रिभुजका आधारका कोणहरु बराबर हुन्छन् ।

Base angle of an isosceles triangles are equal.

६. दिइएको चित्रबाट x को मान पत्ता लगाउनुहोस ।

Find the value of x from the given figure.

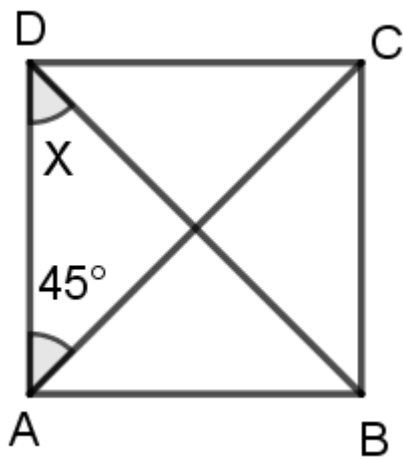
- a. 50° b. 55° c. 60° d. 70°



७. दिइएको चित्रमा ABCD एउटा समबाहु चतुर्भुज हो । यदि $\angle DAC = 45^\circ$ भए $\angle ADB$ को मान पत्ता लगाउनुहोस ।

In the given figure ABCD is a equilateral rhombus. If $\angle DAC = 45^\circ$, find the value of $\angle ADB$.

- a. 60° b. 30° c. 45° d. 90°



८. दुईओटा बराबर र समानान्तर रेखाखण्डका एकैतिरका छेउछेउका बिन्दुहरु जोड्ने रेखाखण्डहरु पनि समानान्तर र हुन्छन् ।

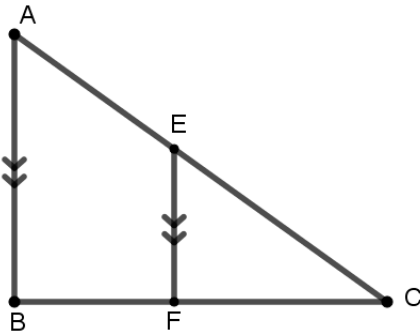
Two line segments which join the ends of two equal and parallel lines towards the same part are themselves parallel and.....

- a. बराबर
b. आधा
c. दोब्बर
d. एक तिहाइ

९. दिइएको चित्रमा $CE=2.4\text{cm}$, $AC=4.8$, $BF= 1.8\text{cm}$, $BC=3.6\text{cm}$, $\angle FEC=54^\circ$ भए $\angle BAC$ को मानकति हुन्छ ?

In the given figure $CE=2.4\text{cm}$, $AC=4.8$, $BF= 1.8\text{cm}$, $BC=3.6\text{cm}$, $\angle FEC=54^\circ$ then find the value of $\angle BAC$.

- a. 106° b. 60° c. 75° d. 54°



१०. त्रिभुजका दुई भुजाका मध्यविन्दु जोड्ने रेखा तेश्रो भुजासंग हुन्छ।

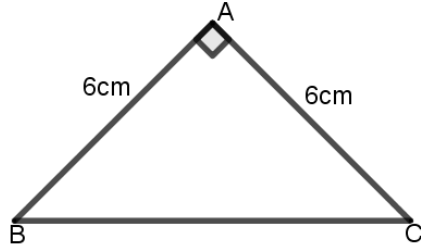
A line joining the middle points of the two sides of a triangle isto the third side.

- a. आधा
b. दाब्बर
c. समानान्तर
d. बराब

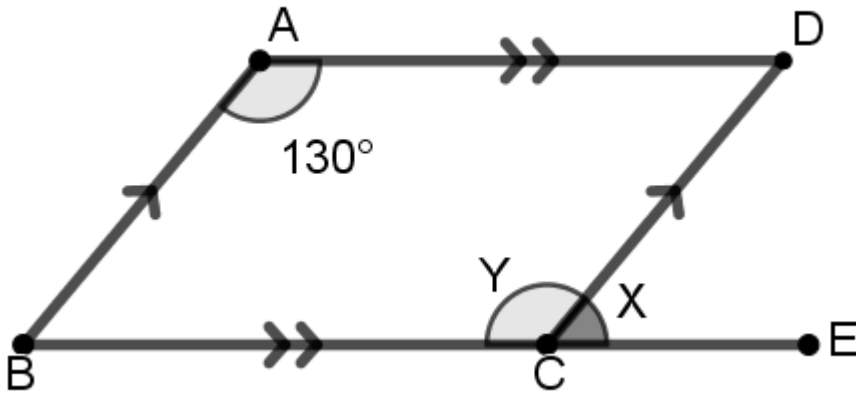
The-end

Subjective Question
Group 'A' [2*2=4]

१. दिइएको चित्रबाट BC को नाप पत्ता लगाउनुहोस् ।
Find the value of BC from the given figure.



२. दिइएको चित्रबाट x र y को मान पत्ता लगाउनुहोस् ।
Find the value of x and y from the given figure.



Group 'B' [4*4=16]

३. समद्विबाहु त्रिभुजको शीर्षकोणको अर्धक आधारमा लम्ब हुन्छ र यसले आधारलाई समद्विभाजन गर्दछ भनि प्रमाणित गर्नुहोस् ।

Prove that the bisector of vertical angle of an isosceles triangle is perpendicular to the base and bisects the base.

४. त्रिभुजको एउटा भुजालाई लम्ब्याउदा बन्ने बाहिरी कोण दुई अनासन्न कोणहरूको योगफलसंग बराबर हुन्छ भनि प्रमाणित गर्नुहोस् ।

Prove that exterior angle of a triangle formed by producing any one sides of a triangle is equal to the sum of non-adjacent interior angles.

५. समान्तर चतुर्भुजका सम्मुख भुजाहरू र सम्मुख कोणहरू बराबर हुन्छन् भनि प्रमाणित गर्नुहोस् ।

Prove that opposite sides and angles of a parallelogram are equal.

६. बराबर र समान्तर रेखा खण्डका विपरीत तिरका छेउ छेउका बिन्दुहरू जोड्ने रेखाखण्डहरू आपसमा समद्विभाजन हुन्छ भनि प्रमाणित गर्नुहोस्

Prove that line segment joining the end points of equal and parallel line on the opposite side bisects each others.

THE-END

Apendix-3

Student Perception on GeoGebra Software

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

S.N.	Items	Strongly agree	Agree	Undecided	Disagree	Strongly disagree	Total
1	GeoGebra software helps to learn Mathematics concepts.						
2	At the beginning, I did not like GeoGebra software.						
3	I feel confident when the activities do by using GeoGebra software.						
4	Using GeoGebra makes geometry more difficult for me.						
5	I prefer to learn Mathematics with GeoGebra software.						
6	GeoGebra software helps visualizing the problems of geometry concept.						
7	Geogebra software help to increase my achievement in the geometry..						
8	GeoGebra software can help to make the learning more enjoyable.						
9	I am happy if the teacher usesthe GeoGebra software in teaching Mathematics.						
10	GeoGebra makes geometry class boring.						

Appendix-4

Reliability of the test

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

$$\begin{aligned}\text{Correlation Coefficient (r}_{oe}\text{)} &= \frac{\Sigma XY}{\sqrt{N \Sigma X^2 \cdot N \Sigma Y^2}} \\ &= \frac{532}{\sqrt{482 \times 613}} \\ &= \frac{532}{543.56} \\ &= \mathbf{0.97}\end{aligned}$$

$$\begin{aligned}\text{Reliability Coefficient (r)} &= \frac{2 r_{oe}}{1 + r_{oe}} \\ &= \frac{2 \times 0.97}{1 + 0.97} \\ &= \frac{1.94}{1.97} \\ &= \mathbf{0.98}\end{aligned}$$

Appendix - 5

Score of pre-test

S.N.	Score of Students in Experimental Group	Score of Students in Control Group
1	12	7
2	13	8
3	8	10
4	13	8
5	10	8
6	18	7
7	7	11
8	10	6
9	10	6
10	10	5
11	13	5
12	9	5
13	11	10
14	4	13
15	2	9
16	9	4
17	10	7
18	12	6
19	11	4
20	3	6
21	6	8
22	5	10
23	7	10
24	3	11
25	4	7
26	8	1
27	4	3
28	1	4
29	4	2
30	4	1
	Total: 241	2
		2
		Total: 206
	$N_1 = 30, \bar{x}_1 = 8.03, s_1^2 = 15.95,$ $s_1 = 3.99$	$N_2 = 32, \bar{x}_2 = 6.44, s_2^2 = 9.59,$ $s_2 = 3.1$

Note: N_1 and N_2 denotes the number of students
 \bar{x}_1 and \bar{x}_2 denotes the mean
 s_1^2 and s_2^2 denotes the variance
 s_1 and s_2 denotes the standard deviation

Appendix - 6

Score of post-test

S.N.	Score of Students in Experimental Group	Score of Students in Control Group
1	28	17
2	28	19
3	25	23
4	18	23
5	27	16
6	30	25
7	23	12
8	21	11
9	22	18
10	23	8
11	24	13
12	21	16
13	22	20
14	21	24
15	20	13
16	27	17
17	15	19
18	19	8
19	16	9
20	20	14
21	11	9
22	13	18
23	21	13
24	13	11
25	14	10
26	9	7
27	16	12
28	18	11
29	16	4
30	14	9
	Total: 595	8
		4
		Total: 441
	$N_1 = 30, \bar{x}_1 = 19.83, s_1^2 = 28.47,$ $s_1 = 5.33$	$N_2 = 32, \bar{x}_2 = 13.78, s_2^2 = 31.64,$ $s_2 = 5.62$
<p>Note: N_1 and N_2 denotes the number of students \bar{x}_1 and \bar{x}_2 denotes mean s_1^2 and s_2^2 denotes variance s_1 and s_2 denotes standard deviation</p>		

Appendix - 7

Statistical formula used in data collection and analysis procedure

S.N.	Subject	Notation	Formula
1	Pooled Variance	S_p^2	$\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$
2	t - distribution	t	$\frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$
3	F-distribution	F	$\frac{S_1^2}{S_2^2}$
4	Degree of freedom	$d.f.$	$n_1 + n_2 - 2$
5	Pearsons's Correlation Coefficient	r_{oe}	$\frac{N \sum XY}{\sqrt{N \sum X^2 \cdot N \sum Y^2}}$
6	Reliability Coefficient	r	$\frac{2 r_{oe}}{1 + r_{oe}}$

Appendix-8

Ten statements about Geo-gebra are of different levels on the basis of Affective domain of Bloom's Taxonomy. They can be categorized as follows:

S.N.	Statements	Level
1	GeoGebra software helps to learn Mathematical concepts.	Responding
2	At the beginning, I did not like GeoGebra software.	Responding
3	I feel confident when the activities are done by using GeoGebra software.	Receiving
4	Using GeoGebra makes geometry more difficult for me.	Responding
5	I prefer to learn Mathematics with GeoGebra software.	Valuing
6	GeoGebra software helps visualizing the problems of geometrical concept.	Organisation
7	Geogebra software helps to increase my achievement in the geometry.	Valuing
8	GeoGebra software can help to make the learning more enjoyable	Characterization
9	I am happy if the teacher uses the GeoGebra software in teaching Mathematics.	Responding
10	GeoGebra makes geometry class boring.	Organization

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