

**EFFECTIVENESS OF GEOGEBRA IN TEACHING GEOMETRY**

**A**

**THESIS**

**BY**

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**FOR THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE  
DEGREE OF MASTER IN MATHEMATICS EDUCATION**

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### Letter of Certificate

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Head

Date: Oct 03, 2020

## Letter of Approval

This thesis entitled ‘Effectiveness of GeoGebra in Teaching Geometry’ submitted by **Mr. Sagar Acharya** in partial fulfillment of the requirement for the Master’s Degree in Education has been approved.

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### **Recommendation for Acceptance**

This is to certify that **Mr. Sagar Acharya** has completed his M.Ed. Thesis entitled '**Effectiveness of GeoGebra in Teaching Geometry**' under my supervision during the period prescribed the rules and regulations of Tribhuvan University, Kirtipur, Kathmandu, Nepal. I recommend and forward his thesis to the Department of Mathematics Education to organize final viva-voce.

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Date: Oct 03, 2020

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**DEDICATION**

Honestly Dedicated

To

My respected parents:

Lokmani Acharya and Dev kumari Acharya

## DECLARATION

This dissertation contains no materials, which has accepted for the award of the other degree in any instructions. It is of best of knowledge and belief. This dissertation contains no materials previously published by any authors except due acknowledgement has been made.

.....

Sagar Acharya

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.....

Sagar Acharya



## ABSTRACT

This study entitled “**Effectiveness of GeoGebra in Teaching Geometry**” is an experimental research. The objectives of this study were to compare the achievement of students taught by GeoGebra assisted teaching method and conventional teaching method on Parallelogram at grade IX, and to identify the students perception towards GeoGebra software in teaching Parallelogram. The research was based on constructivist view of learning. A pre-test and post-test of quasi-experimental research design was used to find the effectiveness of GeoGebra on student’s achievement. Researcher used conventional sampling and selected two schools from the Kathmandu district. For the research purpose, I selected 26 students from Divya Gyan Secondary School (Experimental group) and another 26 students from Jaljala Shishu Sadan Secondary School (Control group). For the data collection, I used mathematical achievement test and a set of questionnaire related to Likert five point scales with observation note. The mathematics achievement test was used to fulfill the first objective; i.e. comparing the achievement of the students taught by using GeoGebra software and traditional method in parallelogram. The set of questionnaire was used for second objective; i.e. analyzing the students view on GeoGebra in learning parallelogram.

The results indicated that there was a significant difference between the average achievement of students taught by using GeoGebra and without using GeoGebra on post-test. The finding illustrated that the students in the experimental group performed better when using GeoGebra than the control group with the traditional teaching method. Additionally, a set of questionnaire related to Likert scale was used to explore the students view about GeoGebra assisted teaching in learning parallelogram. This questionnaire was administered to only experimental group. The result of questionnaire shows that, students have positive perception about GeoGebra software in learning parallelogram of geometry.

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### Abbreviations

ICT	:	Information and Communication Technology
ZPD	:	Zone of Proximal Development
MOE	:	Ministry of Education
CDC	:	Curriculum Development Center
M.ED	:	Master in Education
TU	:	Tribhuvan University
DGS	:	Dynamic Geometry Software
NCTM	:	National Council of Teacher of Mathematics
MAT	:	Mathematical Achievement Test
i.e.	:	That is
P	:	Difficult level
D	:	Discrimination index
t	:	t-distribution
%	:	Percentage

## Chapter I

### INTRODUCTION

The introductory part of this research consists of background of the study, statement of the problem, objective of the study, hypothesis of the study, significance of the study, delimitation of the study, and operational definition of the key terms.

#### **Background of the Study**

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. Secondary level included eight area of content, one of them is Geometry.

For thousands of the years, civilized people have used mathematics to investigate size, shape and the relationships among physical objects. 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 (Garnet, 2008).

In Mathematics teaching and learning, especially in geometry, it is important for students to be able to imagine, construct and understand construction of shapes in order to connect them with related facts (Shadaan & Leong, 2013). While the study of geometry in some shape or form has existed for many millennia, it is within the past twenty years that a shift has occurred in how geometry may be learned through computer-based interactive geometric software. Software such as GeoGebra allows users to construct interactive representations of points, lines and circles. These

geometric objects are interactive and may be resized and shifted around on screen through clicking and dragging actions. In this way, GeoGebra allows students to actively construct their own understanding of geometry.

Today, technology is becoming an important tool in everyday life. Many educational researchers have carried out studies on integrating technology into education in order to increase the quality of teaching and learning (Preiner, 2008).

According to the National Council of Teachers of Mathematics (NCTM) is one of the six principles for school mathematics, as it mentioned that technology is essential in teaching and learning mathematics. It influences the mathematics that is taught and enhances student learning (NCTM, 2000). Furthermore, technology use in mathematics education not only helps students construct their visual representation of mathematical ideas and concepts, summarize and analyze data, and interpret data, but also enables them to investigate every area of mathematics, such as geometry, algebra and statistics (Hohenwarter, Hohenwarter & Lavicza, 2009). With the support of technology, schools can provide extensive opportunities for facilitating, supporting and enriching the learning environment and continuously enhance the quality of the teaching-learning process (Budai, 2011).

According to Light and Blaye (1989), during the last 25 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 aspect that mathematical software can offer to the process of mathematics teaching and learning: multiple display options, experimental work, alimentation of mathematical method and connectivity. Teacher can choose from a variety of software available for mathematics education is GeoGebra, Math lab, Mathematica, SPSS,



Excel etc. Among of them GeoGebra is one of the most popular and easy software for teaching and learning in school level mathematics especially in Geometry.

GeoGebra is dynamic mathematical open source (free) software for teaching and learning mathematics in school level. It was developed by Markus Hohenwarter and an international team of programmers. GeoGebra combines geometry, algebra, statistics, graphing and calculus in one easy to use package (Stols, 2009). GeoGebra is a rapidly expanding community of millions of users located in just about every country. GeoGebra has become the leading provider of mathematics software, supporting science, technology, engineering, and mathematics education (STEM) and innovations in teaching and learning worldwide. It is a form of freely available, open-source educational mathematical software that provide a flexible tool for visualizing mathematical ideas from elementary to University level ranging from simple to complex construction. It is an easy to use as dynamic geometry software (DGS) but also provides basic features of computer algebra system (CAS). GeoGebra is a versatile tool that combines the easy use of DGS with features of CAS. 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 interactive geometry software offering students and teacher's ways to design teaching modules and enable mathematics learning in a meaningful way. GeoGebra is another innovative tool for integrating technology in teaching and learning mathematics (Furner & Marinas, 2012). A powerful teaching tool like GeoGebra supports constructions with points, vectors, segments, polygon, straight lines and all conic sections. Besides that, it can also motivate students to explore mathematics and offer opportunities for critical thinking, which is central to

constructivism. The use of GeoGebra in the case of teaching and conducting geometric lesson in school level is effective in compared to the teaching through traditional or conventional method. The GeoGebra software is very much effective easy to handle and provides the user-friendly environment. So, it is effective to teach the lesson of geometry.

### **Statement of the Problem**

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 are integrate technology in their teaching and learning at secondary level in Nepal. In fact, the school education system is based on a traditional approach (paper pencil test) in Nepal. (Wikipedia, 2015).

Many software has developed related to teaching, learning mathematics, like: GeoGebra, Mathematica, Mat lab, Graphing calculator etc. Among them GeoGebra is most familiar tool, easy to using and making geometry interesting. In secondary level, few mathematics teachers only know about the use of GeoGebra but many of them does not know how to use GeoGebra in mathematics teaching in Nepal.

A review of the literature indicates that GeoGebra as teaching materials that has positive impact on student's achievement in learning mathematics at secondary

level. It also believed that knowledge, skill and understanding of students can be enhanced with the use of dynamic mathematical software GeoGebra. But few number of researchers research on effectiveness of GeoGebra in the topic of Parallelogram. So, this study on the effectiveness of GeoGebra software on mathematics achievement has to be conducted to see how it can be beneficial to improve the educational system in Nepal. And also this study concerns about the effectiveness of GeoGebra software in learning Parallelogram at grade IX. Therefore, this research were initiated and added the following research questions;

- Does the GeoGebra assisted teaching is more effective than the conventional teaching method while teaching Parallelogram at grade IX?
- What are the perceptions of students about the software GeoGebra in teaching Parallelogram?
- How does GeoGebra software motivate students in teaching mathematics?

### **Objective of the Study**

Research objectives should be clear, concise, declarative statement and which provides direction to investigate the variables under the study. The research objectives drive all aspects of the methodology, including instruction design, data collection, analysis, and ultimately the recommendations.

In this research, my main concern is to find the “Effectiveness of GeoGebra in teaching Geometry”. Therefore, the specific objectives of this study were as follows;

- To compare the achievement of students taught by GeoGebra assisted teaching method and conventional teaching method on teaching Parallelogram at grade IX.
- To identify the students perception towards GeoGebra software in teaching Parallelogram at grade IX.

## **Significance of the Study**

Mathematics is a technical subject. It has been taught as a compulsory subject in school education from grade I to X in Nepal. The existing curriculum is silence about use of technology in teaching and learning mathematics at secondary level. As twenty first century is the age of ICT, it should be a tool of educational transformation. Therefore, this study helps to mathematics teachers, schools, researchers, and curriculum designer and policy makers for;

**Mathematics Teachers.** The result of the study would be helpful for mathematics teachers to adopt the effective teaching method using ICT. And also choose the best way of teaching geometrical proof of theorem using GeoGebra. In addition, it would be a best teaching tool to improve their teaching strategies.

**Schools.** School can utilize the GeoGebra software for teaching tool with help of this study.

**Researchers.** This study helps for researchers to find out the effectiveness of using GeoGebra in order field of mathematics.

**Curriculum designers.** This study helps for curriculum designers to find the importance of GeoGebra software in teaching geometry at secondary level and integrate the GeoGebra as a material in curriculum.

**Policy makers.** Finding of this study helps to policy makers for integrating ICT in mathematics teaching and learning from basic level to higher level.

## **Hypothesis of the Study**

Hypothesis means a more assumption or some supposition to be proved or disproved. It related an independent variable to some dependent variable. There are two types of hypothesis formulated in the study, they were as follows:

**Research Hypothesis.** Using GeoGebra provide effective result on the achievement of the students to compare traditional method while teaching theorems related to Parallelogram of geometry.

**Statistical Hypothesis.** The null and alternative hypothesis formulated by the researcher in this study as below;

*H<sub>0</sub>.* There is no significant difference between the achievement of students taught by using GeoGebra software and conventional method on Parallelogram at grade IX.

*H<sub>1</sub>.* There is significant difference between the achievement of students taught by using GeoGebra software and conventional teaching method on Parallelogram at grade IX.

#### **Delimitation of the Study**

In this research, the researcher concerned effectiveness of GeoGebra software and perception of students toward GeoGebra in teaching geometry. The researcher wanted this research make more standard but the researcher had limited time and financial budget. Hence the study was limited on the following aspects;

- The research of this study utilized program GeoGebra 5.0 software for 15 periods of learning activities.
- In this study GeoGebra software was used to teach only Parallelogram at grade IX.
- Two secondary schools from Kathmandu metropolitan city of Kathmandu district were selected for the study.
- Only grade IX students were included in the sample of the study.
- The control group students was taught without using GeoGebra software
- The experimental period of this research was based on completion of targeted chapters.

- Achievement test and questionnaire with observation note were tools for data collection.

### **Operational Definition of the Key Terms**

Every study constitutes some of the key words depend upon the problems, objectives, method, variables etc. In this study, I used the following terms and their operational definitions as follows;

**Curriculum.** In this study, curriculum indicates the compulsory mathematics curriculum of secondary level, which was prepared by CDC of Nepal Government in 2076.

**GeoGebra.** It is a free, multi-platform, open-source dynamic mathematical software which helps to visualize the concepts of mathematics.

**Achievement.** The achievement on this study was defined in terms of the scores obtained by the students.

**Experimental group.** The group of students taught by using GeoGebra software while teaching Parallelogram of geometry was considered as experimental group in the study.

**Control group.** The group of students which were taught by conventional method while teaching Parallelogram of geometry was considered as control group in this study.

**Traditional method.** In this study traditional method represent a teaching strategy in which the teacher constructs and organizes the subject matter and exposes everything by himself. In this method of teaching the teacher was main actor and could be taken as teacher-centered method.

**Secondary level.** Secondary level contains class IX and X but this study was included at grade IX only.

**Effectiveness.** The measure of the effect for this study was included the increase in the average achievement of students in mathematics and students positive view on GeoGebra in learning Parallelogram of geometry.

**Student's perception.** It is a dependent variable of the study. It was measured by questionnaires with observation notes.

## **Chapter II**

### **REVIEW OF RELATED LITERATURE**

A literature review is a written summary of journals, articles, books and others documents, 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 review of the literature, theoretical review of the literature as well as conceptual framework of the study.

#### **Review of Empirical Literature**

Empirical review means reviewing of previous studies on related topic. It helps the researcher to find out the gap and possible research techniques and tools to use in this study. The researcher reviewed some national and international thesis, journals and an articles. The empirical literature related to study area has been reviewed as below:

Chrysanthou (2008), conducted the research on “The use of ICT in Primary mathematics in Cyprus: the case of GeoGebra”. The objectives of this study were to investigate the potential and the implication of GeoGebra for teaching primary mathematics. This research was 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 procedure based upon classroom observation, teacher interview that the use of GeoGebra can provide rich mathematical environment in which students are engaged in classroom activity. This study indicates that the use of GeoGebra in primary mathematics classes was better than the normal classes.



In the same way, Akgul (2014) carried out the research entitled “The effect of using dynamic geometry software on eight grade students’ achievement in transformation geometry, geometric thinking and attitudes towards mathematics and technology”. The objectives of this study were to investigate the effects of Dynamic Geometry Software-Assisted Instruction on 8<sup>th</sup> grade students’ mathematics achievement in transformation geometry. The Static-Group Pre-test, Post-test research design was adopted in this experimental research study. The sample of the study consisted of 34 eight grade students of the 2012-2013 academic year in a private elementary school in Bilkent district in Ankara, Turkey. The experimental group students were taught the subject of transformation geometry by the researcher with Dynamic Geometry software-assisted instruction using GeoGebra while the control group students were taught the same content by the mathematics teacher of the class with the regular instruction. In order to gather data, Mathematics Achievement Test (MAT), Van Hiele Geometric Thinking Level Test (VHL) and Mathematics and Technology Attitude Scale (MTAS) were administered to the students as measuring instruments. The results of the study indicated that the Dynamic Geometry Software-assisted instruction had a significant effect on students’ mathematics achievement in transformation geometry and geometric thinking positively compared to the regular instruction. However, the Dynamic Geometry Software-assisted instruction had no significant effect on students’ attitude towards mathematics and technology.

Similarly, Acharya (2015), had done the research on “Effectiveness of GeoGebra Software on mathematics achievement” for the fulfillment of Master’s Degree Thesis in Mathematics Education. The main objectives of the study were to find the effectiveness of GeoGebra software on mathematics achievement. The researcher adopted pre-test, post-test non-equivalent control group and selected the

Circle chapter to test the effectiveness of GeoGebra. Researcher chooses two secondary schools of grade X students of Kathmandu district also selected 28 students from Panga Secondary School as an experimental group and 25 students from Janasewa Secondary School as control group. After the two weeks of experiment, concluded that experimental group had better achievement than the control group. Five point Likert Scales used to find out the perception of students about the GeoGebra. There was positive perception to use the GeoGebra in Mathematics Teaching.

Likewise, Aydos (2015) studied on the topic “The impact of teaching mathematics with GeoGebra on the conceptual understanding of limit and continuity: the case of Turkish gifted and talented students”. The main purpose of this study was to investigate the impact of teaching mathematics using the GeoGebra software on 12<sup>th</sup> grade gifted and talented students' conceptual understanding of limits and continuity concepts. This study followed a pre-test and post-test-controlled group design. The sample consisted of 34 students studying in a unique high school for gifted and talented students in Turkey. Achievement test and readiness test were the main tools for data collection. This study was guided by the multiple representations' theory. The study found that student attitudes toward learning mathematics through technology improved, as well. The researcher concluded that GeoGebra is an effective tool for teaching calculus to gifted and talented students.

In the same way, Benning, (2015), conducted a journal on “Pre-service teacher use and perception of GeoGebra software as an instructional tool in teaching mathematics”. This paper presents a case study of 85 pre-service mathematics teachers from the University of Cape Coast, Ghana; who enrolled in an instructional technology mathematics course to develop competencies in teaching mathematics

using the GeoGebra software which was being introduced to them for the first time. The study focused on an in-depth investigation of the pre-service teachers' perceptions and use of GeoGebra in teaching mathematics. Questionnaire, interviews and lesson artefacts developed by the teachers were the data sources of the study. Descriptive, t-test and effect size statistics were used to analyse the quantitative data whereas the interview data and lesson artefacts were analysed qualitatively. Statistical analysis confirmed that the use of the GeoGebra helped pre-service teachers expand their own understanding of mathematical concepts as well as their knowledge of instructional strategies. The study also indicated that two perceived barriers; lack of awareness of the GeoGebra software and time constraint in designing GeoGebra lessons hinder pre-service teachers' use of the tool. That notwithstanding, the pre-service teachers' perceived developed attitudes and pedagogical views on the use of GeoGebra point to its potential as an instructional tool in developing their experiences in technology integration within an initial teacher education programme in Ghana.

Likewise, Sherpa (2016), carried out the research entitled 'Effectiveness of GeoGebra in teaching geometry' for finding the effectiveness in teaching geometry using GeoGebra at grade-VIII. This study follows the pre-test and post-test experimental design to find out the effectiveness in teaching geometry using GeoGebra. The researcher selected simple random sampling to fulfill sample size. In this study test and interview were the main tools for data collection. Research was based on a constructivist view of learning. The study found that the use of GeoGebra while conducting the geometric lesson was effective rather than teaching in conventional method.

Similarly, Bist (2017), had the research on “Use of GeoGebra in Geometric Construction”. The objectives of the study were to compare the achievement of students taught by using GeoGebra and traditional approach, and to explore student’s attitudes towards the use of GeoGebra in geometric construction. To achieve the objectives, pre-test, post-test nonequivalent experimental method was used. Two public secondary schools were selected from Kirtipur Municipality to observe the impact of the use of GeoGebra in geometric construction, regarding student’s achievement and attitudes towards the use of GeoGebra on geometric construction. There was the significant difference in student’s achievement of experimental and control groups on post-test after the one month of regular treatment. 85.81% magnitude of effect on student’s achievement was explained by the use of GeoGebra. A set of questionnaires based on five point Likert’s scale and then an interview were conducted on the experimental group to identify the attitudes towards the use of GeoGebra on geometric construction. GeoGebra helped to reconstruction their state of knowledge and enforced them to engage in enquiry based activities such as searching application of construction. The result was positive attitudes towards use of GeoGebra in geometric construction. The use of GeoGebra enables students to work independently by up-rising their curiosity.

In the similar context, Lamichhane (2017), conducted a research entitled “Effectiveness of GeoGebra on students’ achievement in geometry”. The main objectives of the study were to investigate the effectiveness of GeoGebra Software on student achievement in parallelogram and circle of geometry at grade X. To meet the objectives of the study, the researcher used quasi- experimental design. By using purposive and convenience sampling researcher select two government school of Tanahun district. The researchers chooses 36 students as an experimental group and

39 students as a control group. Mathematics achievement test and questionnaire were data collection tools for the study. This study was adopted APOS theory of constructivism. The result of this study indicated that there was a significant difference between the average achievement score of experimental and control groups on post-test, this finding illustrated that the students in the experimental group performed better when using GeoGebra than the control group with the traditional teaching method.

Likewise, Gajurel (2018), conducted the research on “Effectiveness of the GeoGebra in teaching geometry”. The main objective of the study was to explore the student attitude about GeoGebra and to compare the achievement of students taught by using GeoGebra assist learning method over traditional learning methods in teaching geometry. Researcher used the purposive sampling and selects the two schools from the Dhading. The researcher selected 36 students from two different schools are in the same classes participated in this study with one class assigned as the experimental group and other as the control group. The researcher used achievement test and questionnaires for collect the data. Out of 36, 16 students were selected for experimental group and 20 students were selected for the control group. Research was based on constructive theory. The findings of this study showed that there was significant difference existed in the mean scores between the achievement of the student in experimental group and control group. The result indicated that students in the experimental group performed better than the control group.

In the same manner, Dahal (2018), conducted the research on “Attitude of teachers and students towards the use of social media in teaching and learning”. The main objective of the study was to find out the attitudes of teachers towards the use of social media in teaching and learning, and to find out the attitudes of students towards

the use of social media in learning and compare the attitudes of teachers and students towards the use of media (Facebook, Twitter and YouTube) in teaching and learning. Quantitative research design through the survey and descriptive nature was adopted in this study. The survey design collected required information, opinion and attitude of respondents using questionnaires techniques as well as observation of secondary level student attitude about the social media and then collected data were analyzed using statistical method and descriptive method to reach the conclusion. The data were collected from the large group of student in this survey design. Five community secondary schools of Sindhupalchowk district. Researcher used random sampling method. The findings of this research indicates that secondary level teachers and students has positive attitude towards the use of social media in teaching and learning. In this study, null hypothesis accepted therefore there was no significance different between the teachers and students attitudes towards the social media. The attitudes of teachers were better than the attitudes of students.

Similarly, Shrestha (2019), studies on the topics “Effectiveness of GeoGebra Software in teaching mathematics at secondary level”. The main objectives of the study was to find out the effectiveness of GeoGebra in teaching mathematics, and to explore the perception of students about GeoGebra. This research was based on constructivist view of learning and the design of the study was experimental and researcher used to the quasi-experimental design. Researcher used purposive sampling and selected two schools from the Tanahun district. The researcher selected 25 students from Nirmal Secondary School as a control Group and 25 students selected from Satyawati Secondary School as an experimental Group. For the data collection tools, researcher used achievement test and interview. The collected data were analyzed by statistical method (mean, standard deviation and t-test) for qualitative

data and used to descriptive and analytic method to analysis the data collection from interview. The findings of this research showed that there is significant different between the achievement of students taught by using GeoGebra software and conventional method in teaching mathematics at secondary level. GeoGebra helps to students for conceptual learning.

### **Conclusion**

GeoGebra, as dynamic geometry software, not only provides students with facilities to experiment the mathematical ideas and to associate mathematical concepts with the real-life examples, but also helps students to examine the relation between algebraic and geometrical concepts. Many studies related to GeoGebra indicated that GeoGebra assisted teaching has the positive effects on students' mathematics learning, and it helps to increase the mathematics achievement of students.

Use of ICT in teaching mathematics is major issues in the context of Nepal. Government of Nepal has focused for the use of ICT in teaching at school level curriculum. There were many researches had done on the topics circles, triangles, constructions, coordinate geometry and transformation. So I am intersted to research on the topic of effectiveness of the GeoGebra software on Parallelogram teaching in mathematics at grade IX students for the partial fullfillment of the master degree research course of Tribhuvan University. The major causes of choose this topic is to explore the use of GeoGebra software and promote the ICT based learning in school level.

## **Review of Theoretical Literature**

A theoretical literature of study is the structure that can hold or support a theory of a research study. The theoretical literature of the study introduces and describes the theory that explains why the research problem under study exists.

There are many theories related to human development and their learning such as: Behaviorist theory, Cognitive theory, Constructivist theory, Social-constructivist theory, Psychological theory, Cultural theory, Conflict theory, Humanist and intellectual theories. All theories have their own significant and vital rhythm in learning but this study was based on effectiveness and achievement of students. So, I used social constructivist approach of learning. According to social constructivist theory, learning is an active process in which learners construct and internalize new concepts, idea, and knowledge based on their present and past knowledge and experience.

Social constructivist theory is most often associated with Vygotsky. So it is very supported to teaching and learning mathematics and also increases to the students for their betterment. It is the best constructed when learners collaborate together and the role of the teacher as the facilitator. The theoretical perspective of this study is social constructivist theory of learning. The social constructivist theory was chosen because it builds on prior knowledge: students use what they already know to make connection to new knowledge of GeoGebra-assisted instruction. When students make these connections, they learn new technology and relate it to what they already known. In this study GeoGebra-assisted instruction was based on the constructivist theory of learning, because knowledge is actively constructed by the students while they are making constructions and analyzing figures instead of knowledge being passively received and accepted. Many educators today believe that



the social constructivist theory is a relatively new theory in education. The social constructivist classroom presents the learner with opportunities to build on prior knowledge from experience. Learners are allowed to deal with problems and they find meanings in them because of their real-life context, in solving their problems, learners are encouraged to explore possibilities, invent alternative solutions, collaboration with other learners and finally present the best solutions. It is also claiming that the learners are actively involved in learning process and teaching learning environment is democratic. Students' activities are interactive and teacher as facilitators that are also the main characteristics of social constructivist learning approach.

Vygotsky developed a "Zone of Proximal Development (ZPD)" which was the different between what a child is taught by together. He believed that children learn through social interaction and by learning to solve problems with others, he gave the name this process is called "Scaffolding" (Vygotsky, 1978). Students generally have challenges in understanding the mathematical concepts, therefore in this study the GeoGebra software will introduce as a scaffold to enhance students understanding of geometry teaching. GeoGebra software will act as the primary scaffold in assisting and guiding the students to reach the ZPD.

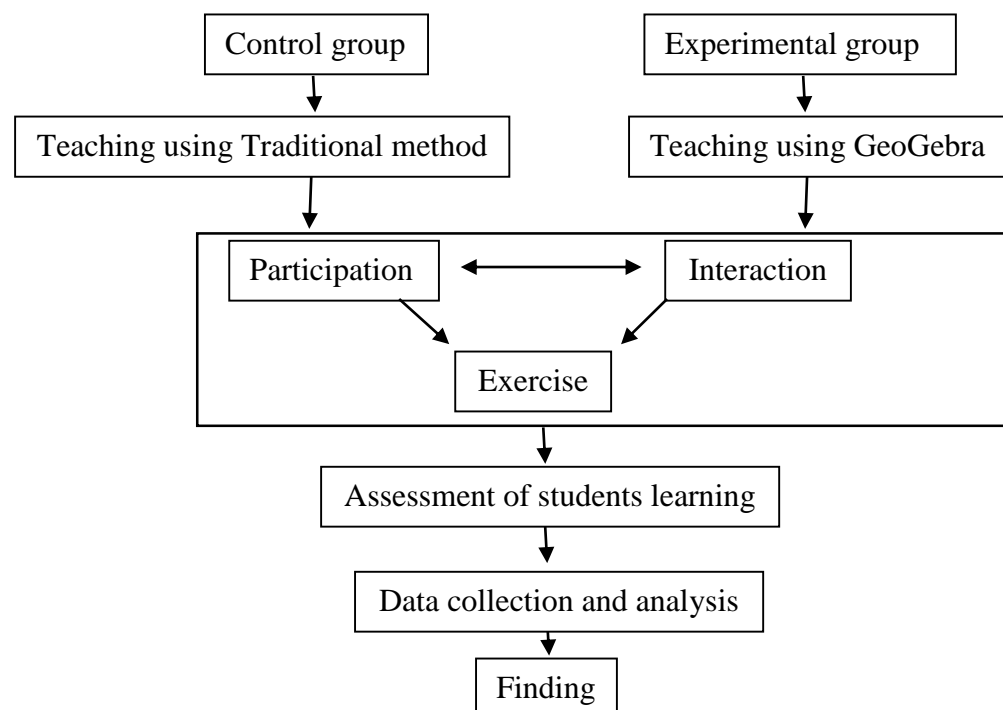
Thus, curriculum should be developed in a spiral manner so that students can build upon what they have already learned. This review of literature includes the social constructivist theory of learning because the students in this study actively built on what they already knew in order to gain an understanding of mathematics. The students have also actively engaging in the process of scaffolding as they taught assistance from more advanced students in their mathematics classes by using GeoGebra software. Students know about the tools of GeoGebra, they can make the figures using the tool and makes the abstract conception after drawing the figure.

## Conceptual Framework of the Study

This sections deals about the conceptual framework for the research.

Conceptual framework is an analytical tools with several variations and contexts. It has established on the basis of research topic, possible areas to fulfill the objectives of the study. It is used to make conceptual distinctions and organize ideas. It is help to make roadmap about our research strong and conceptual frameworks capture something real and do this in a way that is easy to remember and apply. In this study, the use of GeoGebra is the central point of teaching geometry topics. GeoGebra presentation gives a chance to internalize the new knowledge and experience to each individual student. The conceptual framework of this study was given by following figure:

### Conceptual framework



(Source: Lamichhane, 2017)

The researcher used social constructivism theory to construct the conceptual framework. To make the mathematical classroom effective, there must be collaboration between teacher and learner. There were two classes for the research; one was taught by using conventional method and another class was taught by using GeoGebra. In both classes, there were discussion and interaction between the students and teachers. In GeoGebra used class, there was visualization of problem and solution with the help of projector. Solution of problem was generated in the classroom with discussion and iteration. After the completion of chapter, there was taken the examination. The researcher had got the achievement of students both control and experimental group. Researcher compared the achievement of both groups and reached at the conclusion; GeoGebra is effective in teaching mathematical classroom. Before using GeoGebra, there was low participation on mathematical classroom activities and they were passive learners. After using GeoGebra students were very interesting and active participation on classroom learning activities.

## **Chapter III**

### **METHODS AND PROCEDURES**

Research methodology is the most important aspect of research work. It is the bridge to achieve the objectives of the study in systematic way. Simply it means way to gather information. In research, there are three methodologies, such as qualitative research, quantitative research and mixed method research. Researcher used quantitative research methodology to be suitable for this research study. This chapter describes the design, method of the study, population, sample and sampling strategy of the study, data collection tools and techniques, data collection procedures, data analysis and interpretation of the results.

#### **Design of the study**

This study focuses to examine the effectiveness of GeoGebra in teaching “Parallelogram” chapter of geometry at grade IX of secondary level. This study was based on quantitative research. According to this topic, it was experiment in class as well as in class presentation, so quasi-experimental design was used to answer the formulated research questions. Hence, the researcher adopted, pre-test, and post-test non-equivalent group design in this study. Also, the researcher calculated the mean, percentage and chi square value to find out the perception test on experimental group only. According to Best and Kahn (2012), ‘experimental research describes, what happen when certain variable were carefully controlled and manipulated. The research was focused on variable relationships, as define here, deliberate manipulation is always a part of the experimental method. Hence, in this research, the following experimental procedure was used.

*Table 3.1: Design of the study*

<b>Groups</b>	<b>Pre-test</b>	<b>Treatments</b>	<b>Post-test</b>
Experimental	Q1	X	Q2
Control	Q3	Y	Q4

Where, Q1= Pre-test given to experimental group

Q2= Post-test given to experimental group

Q3= Pre-test given to control group

Q4= Post-test given to control group

X= GeoGebra assisted teaching method

Y= Conventional teaching method

### **Field of the study**

Researcher chose Kathmandu Metropolitan city of Kathmandu district as the research site for this study. The reason to choose this site is that the researcher can easily find the participants according to the needs of this research problem.

### **Population, Sample and Sampling Strategy**

**Population.** This study was conducted in Kathmandu district. So, all secondary level students, studied at grade IX on the academic year 2076 in Kathmandu Metropolitan city was considered as population of the study.

**Sample and Sampling Strategy.** Divya Gyan Secondary School Dallu and JalJala Sishu Sadan Secondary School, Dallu were selected as the sample by conventional sampling. Fifty-two students were selected for the data collection. By tossing a coin 26 students from one school were selected for experimental group and another 26 students were selected for control group. The students of grade IX were selected from both schools. Both schools were well equipped, same culture and having sufficient physical infrastructures.

### **Variable of the study**

The variables need to be specified in an experiment so that it is clear to readers what groups are receiving the experimental treatment and what outcomes are being measured (Creswell, 2012). In this research, there are three types of variables, they were given below:

**Independent Variables.** As mentioned by Best & Kahn (2012), the independent variables are the conditions and characteristics that the experimenter manipulates or controls in his or her attempt to ascertain their relationship to observe phenomena. In this study dynamic geometric software GeoGebra assisted teaching method was independent variable.

**Dependent Variables.** The dependent variables are the conditions and characteristics that appear, disappear or change as the experimenter introduces removes or changes independent variables Best & Kahn (2012). Students' achievement in geometry was dependent variable in this study.

**Extraneous Variables.** In this study, the extraneous variables were selection of school, instructor/teacher, subject matter, group, experimental time, test and scoring. Some major affecting variables controlled in the period of experimentation in the following process.

- ***Selection of School.*** Such two schools were selected in sample which was similar in status like socio-economic, facilities, result of the student etc.
- ***Instructor/Teacher.*** Researcher himself taught the both groups. i.e. experimental and control.
- ***Subject Matter.*** In experimental period, the chapter of parallelogram on geometry at grade IX was taught on the both groups.

- **Group.** Experimental and control groups of students were selected by naturally assembled.
- **Experimental Time.** Researcher had provided equal time to both groups.
- **Test.** Same test paper had conducted for the both groups before and after the time of experimentation.
- **Scoring.** Researcher himself had given the score of students in text paper appeared by the students.

### **Experimental Stage**

Experimental stages were categorized into three stages in this study, which as follows;

**Pre-experimental Stage.** In the pre-experimental stage, the researcher developed the test item and questionnaires. The test item was related to the Parallelogram of grade IX. It included in both subjective and objective questions and the questionnaire related to Likert five point scales was based upon the student's view about the GeoGebra software with observation notes. After developing the test items, mathematics achievement test were piloted on the group of students that are not included in sample for pre-test and post-test. Also analyzed the result of pilot test and select the pre-test and post-test item of mathematics achievement test. After selected test item of MAT, pre-test was administered among the students of experimental and control groups for the purpose of group comparable. The pre-test consisted of 8 objective and 6 subjective questions.

**Experimental Stage.** In this stage, researcher himself taught the experimental and control group regularly two weeks. The experimental group of students was taught by using GeoGebra software but the control group of students was taught by using conventional method. In the experimental process, teaching episodes was developed

for experimental group and the observation of students in both groups was done regularly for the time of experimentation.

**Post-experimental Stage.** In this stage, the post-test was administered among both groups. The post-test consisted 8 objective and 6 subjective questions. Also a set of questionnaire with observation note was administered only on experimental group students. It consists of 10 statements related to students view about GeoGebra software. After collecting the students answer and responses, the data were analyzed.

### **Sources of Data**

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

- **Primary Source.** The primary source only based on test items and questionnaire with observation note. The questionnaire was related to Likert five point scales.
- **Secondary Source.** The secondary source based on articles, journals, previous research related for analyzing data.

### **Data Collection Tools and Techniques**

Data collection tools are the major part of the study. It depends on the research design. In this study, GeoGebra is the main tools of data collection and also the following data collection tools were used for the collection of data.

**Mathematics Achievement Test (MAT).** On the basis of objectives of the study, the researcher was prepared the mathematics achievement test as the main instruments of the data collection. The researchers were prepared two types of test items (Subjective and Objective) and which was related to the geometry topic ‘Parallelogram’.

**Construction of Achievement Test.** Test item was prepared on basics of four level of knowledge it include that Knowledge, Comprehension, Skill and Application. Also it



was included five different skills such as (verbal, visual, drawing, logical and application) according to the syllabus prepared by CDC, Government of Nepal.

**Opinionnaire.** The Opinionnaire /questionnaires were related to five point Likert scale used to analysis the students perception on GeoGebra software in learning Parallelogram of geometry. In this study, the set of questionnaire contains 10 statements using Likert five point scales: Strongly agree, Agree, Undecided, Disagree and strongly disagree for positive and negative statement the scoring process was reversed.

### **Reliability and Validity Tools**

Reliability of the test is very important of this study. In this study, the researcher was conducting a pilot test to establish reliability of the test.

A test is said to be valid if it measures what is supposed to measure. To establish the validity of achievement test researcher was used specification grid, help of subject teacher and supervisor.

**Test Items.** The researchers constructed a set of 25 mathematical test items (10 objective and 15 subjective) in the reference of the grid of class 9 published by CDC, Government of Nepal. The set of test items were administered in a 20 students of grade nine of Kanchanjanga Secondary school Dallu, Kathmandu. That school wasn't including in the sample of the study in order to test reliability of each items.

Researcher found out the P-value and D-level of 25 items. Among them 8 objective items and 6 subjective items were accepted and remaining items were rejected. In this study, to determine the internal consistency of achievement test correlation coefficients was tested. To find the reliability of the achievement test, there was applied split half reliability test method was used. By the statistical calculation the value of  $r$  was 0.94, which shows that, there was maximum reliable of questions.

**Perception Test.** The Opinionnaire /questionnaires were related to five point Likert scale used to analysis the students perception on GeoGebra software in learning Parallelogram of geometry. In this study, the set of questionnaire contains 10 statements using Likert five point scales: Strongly agree, Agree, Undecided, Disagree and strongly disagree for positive and negative statement the scoring process was reversed.

**Selection of the Experimental and Control Group.** Researcher did one week regular observation to select the group as the experimental and control group. Both schools were well equipped and full of the infrastructure in Dallu. Researcher informed to the students to be ready for the pre-test just before the pre-test examination was going to be hold.

**Selection of teaching materials.** The main materials of the teaching modules were text book which was developed by CDC, Government of Nepal. Question paper, answer sheets and daily used materials, geometrical shapes constructed by teacher were used for the pre-test and post-test.

### **Data Collection Procedure**

Researcher visited both schools before one week of experiment. He took the permission to conduct research from the principal and subject teacher. In the same date he started the teaching in both groups, in equal teaching hour. Researcher took the class of control group with conventional method and experimental group by using the GeoGebra software. Pre-test was conducted before the experimentation. Experimental group got the regular treatment through the GeoGebra to solve the parallelogram related problems. The researcher prepared teaching episodes for 15 days on the topic of teaching parallelogram on geometry and conduct learning activities on the basis of these episodes also the tutorial for experimental group of the

use of GeoGebra with its tools of window was provided. Then practically, the researcher conducted the lesson on teaching Parallelogram by the use of GeoGebra software for the experimental group. Control group was taught without using GeoGebra software. Researcher kept records on observation notes of student participation on classroom activities, interaction, homework, regularity on the classroom while conducting learning activities on the classroom for both groups. At the end of class, researcher took the test of experimental and control groups. In this way, the necessary data were collected with the help of mathematical achievement-test and a set of questionnaire with observation note.

### **Data Analysis and Interpretation Procedure**

Data analysis and interpretation is the most important part of the study. For this purpose of data collection, two sets of achievement test were used to obtain the achievement of the students in pre-test and post-test. Semi-structure questions were used to observe the perception of students about the GeoGebra software.

For the analysis and interpretation of data, the researcher had calculated the mean, standard deviation, t-value of achievement score of both groups. The researcher had used mean to generalize the data analysis. There were all together 52 students in the analysis of two groups. So, researcher used two-tailed test at 0.05 level of significance to calculate t-value, whether the difference of mean is statistically significant or not by using the method of pooled variance formula.

Also, the data collection from questionnaire was analyzed which was helpful to know the perception of students by using the Likert five point scale was only the experimental group. And student's response was calculating with the help of mean, percentage and chi square values by assigned for strongly disagree, Disagree, Undecided, Agree and strongly agree for all positive statement and for the negative

statements of the scoring process was reversed. This shown that the calculated values are greater than the table values and they were positive response.

### **Ethical Consideration**

Ethical consideration is very important to be considered by researcher while collecting data and information. So, researcher will consider informant's personal matters and organizations own rules. I had followed given ethical consideration in my research:

- At first, being a researcher I took the permission from schools administers, principal and subject teacher.
- The researcher gave short information about research to respondent teacher and students.
- The researcher built trust the respondent and respect the respondent answers.
- Also researcher didn't select the research sample which are culturally, socially and ethically biased.

## **Chapter IV**

### **ANALYSIS AND INTERPRETATION OF DATA**

The most important part of the study is to analyze the collected data. This chapter deals with the analysis and interpretation of data with the help of achievement test and questionnaire. An experimental research was done in concern to the topic “Effectiveness of GeoGebra in Teaching Geometry”. The objective of the study were ‘to compare the achievement of students taught by GeoGebra assisted teaching method and conventional teaching method’ and ‘to explore the students perception towards GeoGebra software in teaching parallelogram at grade IX’.

For the data collection procedure, researcher administered the achievement test in one school (Kanchenjunga Secondary School Dallu Kathmandu). After testing the validity and reliability of the test items, standardized questions were used in pre-test and post-test of the experimental and control group of the study. For the data collection, pre-test, post-test non-equivalent quasi-experimental design was adopted for the purpose of the study. A pre-test was taken to make the group comparable. Primarily, the achievement test of the students in post-test was taken to fulfill the first objective of the study. And for the second objective of the study, A questionnaires related to Likert five point scale were used. Also the students view on GeoGebra was analyzed by using Microsoft Office Excel 2016 for arithmetic mean, percentage and chi square value with based on Likert five point scale. The data were organized, tabulated, analyzed and interpreted as follows;

#### **Comparison of Achievement of Students in Pre-test**

In this section, researcher took the pre-test of experimental and control group. Administered test items were used in this pre-test. The purpose of the pre-test was to compare the achievement between two groups. The pre-test score of student of

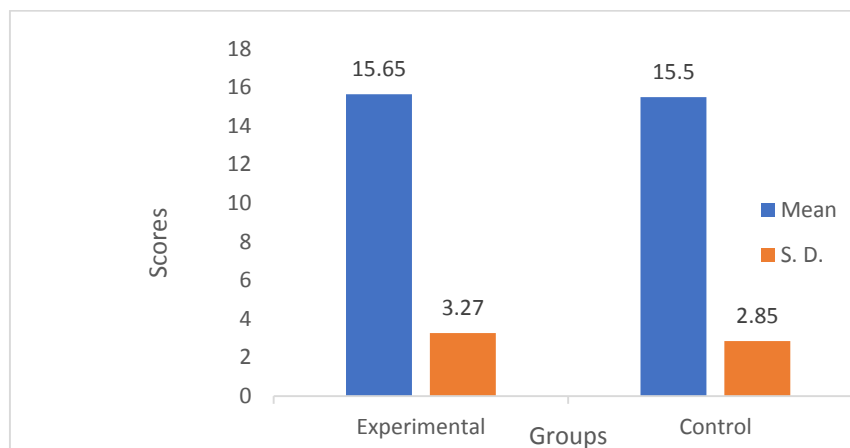
experimental group and control group were of two ways. They were computation of mean and standard deviation of the marks obtained by using formula. The calculated mean, standard deviation and t-value on the pre-test result were shown in the following table;

*Table 4.1: Comparison of student's achievement on pre-test*

Group Type	Sample	Mean	S. D.	Calculated t-value	Decision
Experimental	26	15.65	3.27	0.18	There is no significant difference
Conventional	26	15.50	2.85		

The above table 4.1 shows that, the mean and standard deviation of both experimental group and control groups on pre-test. The mean score of experimental group was 15.65 Out of 25 with the standard deviation of 3.27 and that of control group was 15.5 out of 25 with the standard deviation of 2.85. The calculated t-value was found 0.18. This shows that  $t = 0.18$  is less than the table value 1.96 at 0.05 level of significance. This indicated that the difference of average achievement between these two groups were not significant at 0.05 level of significance. Therefore, the GeoGebra assisted learning group and conventional learning groups were treated as homogeneous and same level of achievement in this study.

*Figure 4.1 Mean and S.D 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 the 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.

#### **Comparison of Achievement of Students in Post-test**

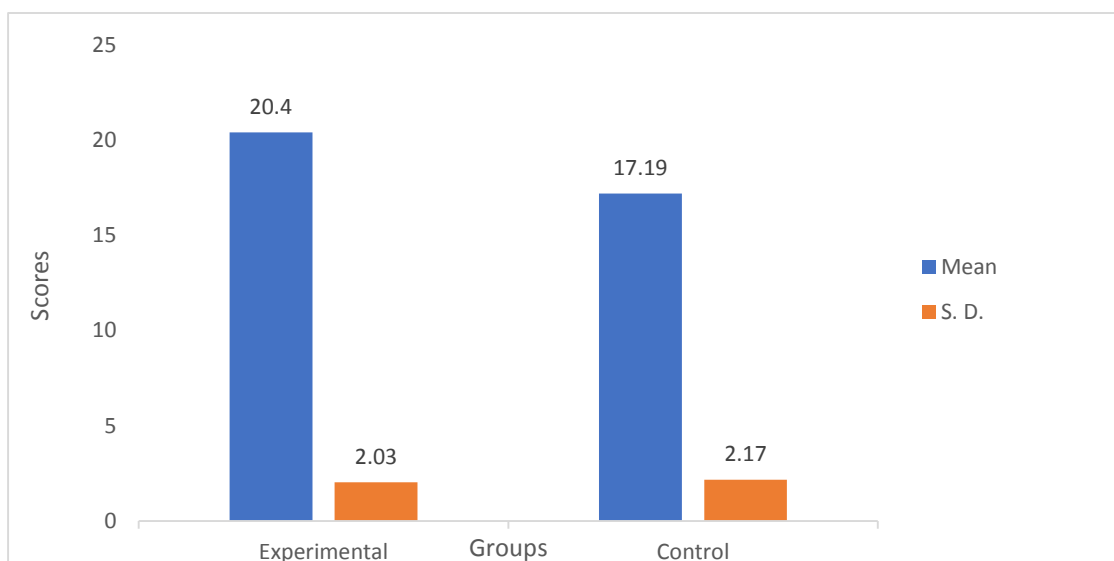
In this section, researcher took the post-test of experimental and control group. After the completion of experimental phase, with gap of eighteen days, the post-test was taken. Administered test items were used in post-test. The purpose of the post-test was to compare the achievement between two groups. The post-test score of student of experimental group and control group were of two ways. They were computation of mean and standard deviation of the marks obtained by using formula. The calculated mean, standard deviation and t-value on the post-test result were shown in the following table;

*Table 4.2: Comparison of student's achievement on post-test*

Group Type	Sample	Mean	S.D.	Calculated t-value	Decision
Experimental	26	20.40	2.03	4.83	There is significant difference.
Control	26	17.19	2.17		

The above table 4.2 shows that, the mean and standard deviation of both Experimental group and Control groups on post-test. The mean score of experimental group was 20.40 Out of 25 with the standard deviation of 2.03 and that of control group was 17.19 out of 25 with the standard deviation of 2.17. The calculated t-value of above data is 4.83. This shows that  $t = 4.83$ , which is greater than the table value 1.96 at 0.05 level of significance. So, the null hypothesis is rejected and concluded that there is significant difference between the average achievements of students taught by GeoGebra assisted teaching and conventional teaching method. Therefore, the GeoGebra assisted learning group had better achievement than the conventional learning groups at the post-test.

*Figure 4.2 Mean and S.D scores distribution of post-test result*

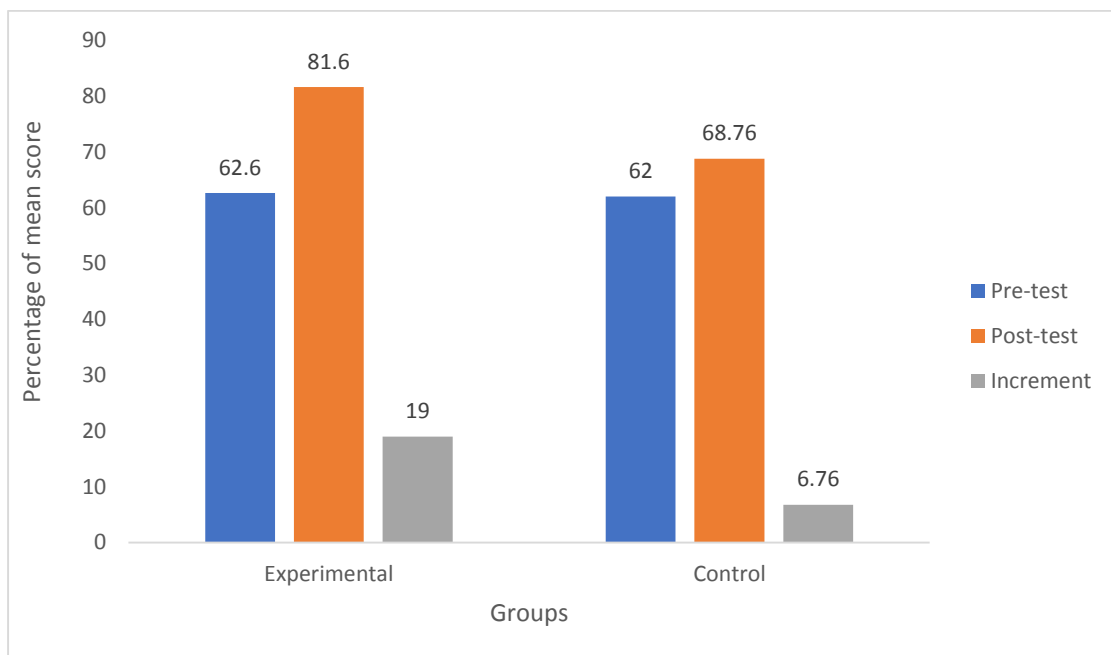


The mean and standard deviation scores obtained by the students of each group in the achievement test (post-test) score have been shown in the above diagram (figure 4.2). The column of experimental group of students is longer than that of control group students. This shows that there is a difference in average achievement scores between experimental and control group on post-test result. Since the difference between the mean and standard deviation on the post-test was 3.21 and



0.14 respectively. Therefore, the diagram (figure 4.2) indicates that, the achievement of students taught by using GeoGebra software is better than traditional method in chapter parallelogram teaching of geometry at grade IX. This shows that the software GeoGebra helps to increase the achievement of students and it has better impact on students learning.

*Figure 4.3: Percentage of Mean score of Experimental and Control groups*



The above diagram (figure 4.3) shows that, the percentage of mean score on pre-test of experimental and control group are 62.6% and 62% respectively. But the percentage of mean score on post-test of experimental group is 81.6% and control group is 68.76%. So, 19% increment in mean score of experimental group but 6.76% increment in mean score of control group. Therefore, percentage of mean score of experimental group is higher than control group of students. Thus, the above diagram shows that the teaching using GeoGebra is more effective than traditional method in parallelogram teaching in geometry at grade IX.

### **Perception of Students about GeoGebra Assisted Teaching**

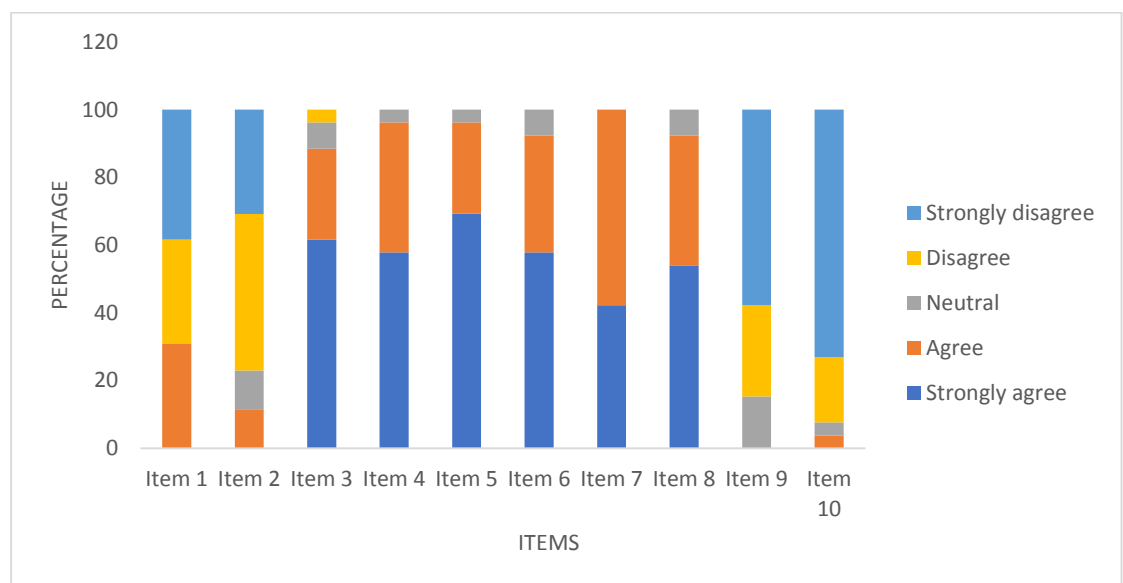
GeoGebra is dynamic software for teaching and learning mathematics classroom. The researcher used GeoGebra software for 15 episode of teaching Geometry 'Parallelogram and its Properties'. Students were very excited for learning and participated in classroom activities. So, to find out the perception of students about GeoGebra, the researcher took a questionnaire related to students view about GeoGebra software among 26 students on experimental group only whose response were tabulated. The quantitative data are provided in table 4.3 (in Likert scale). 5,4,3,2 and 1 indicated strongly agree, agree, neutral, disagree and strongly disagree for positive statement and 1,2,3,4 and 5 indicated strongly agree, agree, neutral, disagree and strongly disagree for negative statements.

Table 4.3: Result of students Perception on GeoGebra

S N	Items		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total	Mean	Chi Square value
			Fre.							
1	At the beginning, I didn't like GeoGebra software	Fre.	0	8	0	8	10	26	3.77	17.8
		%	0	30.8	0	30.8	38.4	100		
2	I didn't like studying geometry lesson by using GeoGebra software	Fre.	0	3	3	12	8	26	3.96	17.5
		%	0	11.5	11.5	46.2	30.8	100		
3	GeoGebra software help me, a lot to learn the geometric concepts	Fre.	16	7	2	1	0	26	4.46	33.5
		%	61.6	26.9	7.7	3.8	0	100		
4	GeoGebra software helps to easy to under-standing geometrical theorems and problems	Fre.	15	10	1	0	0	26	4.54	36.5
		%	57.8	38.4	3.8	0	0	100		
5	GeoGebra is essential and improvement for the teaching geometry	Fre.	18	7	1	0	0	26	4.65	46
		%	69.3	26.9	3.8	0	0	100		
6	GeoGebra software helps to visualizing the problems of geometric concepts	Fre.	15	9	2	0	0	26	4.50	33.5
		%	57.8	34.5	7.7	0	0	100		
7	GeoGebra software enhance my learning in geometric lessons	Fre.	11	15	0	0	0	26	4.42	40.5
		%	42.2	57.8	0	0	0	100		
8	GeoGebra software helps to make the learning more enjoyable	Fre.	14	10	2	0	0	26	4.46	31.5
		%	53.9	38.4	7.7	0	0	100		
9	GeoGebra software makes geometric classes were boring	Fre.	0	0	4	7	15	26	4.42	30
		%	0	0	15.3	26.9	57.8	100		
10	Using GeoGebra makes geometry more difficult for me	Fre.	0	1	1	5	19	26	4.62	48.5
		%	0	3.8	3.8	19.3	73.1	100		
Overall mean = 4.38										

The above table 4.3 shows that, the highest mean 4.65 was on the item ‘GeoGebra is essential and important for geometry teaching’ and the lowest mean was 3.77, which is obtained on the item ‘At the beginning, I didn’t like GeoGebra software’. Other item’s mean was near about the average mean 4.38. According to Denbel (2015) and Shadaan & KwanEu (2013), a mean score of 3.0 or higher indicates a positive feedback or view about GeoGebra and the mean score lower than 3.0 indicates negative feedback or view about GeoGebra in learning geometry. The result from overall mean 4.38 and all statements of calculated chi square values were greater than the table values at 0.05 level of significance with 4 degree of freedom. Which shows that students have positive responses or view about the GeoGebra software and the result was significant on each statements.

*Figure 4.4 Percentage of students view on GeoGebra*



From the above table 4.3 and figure 4.4, the first statement ‘At the beginning, I did not like GeoGebra software’ have chi square value 17.8 which is greater than the tabulated value of 9.488. So the statement is significant at 0.05 level of significance with 4 degree of freedom. The mean response of students was found 3.77 which is less than the average value. More than 60% of students disagreed with this statement.

This shows that most of the students liked GeoGebra software and they were interested to learn geometry with GeoGebra software. They are very active and curious while using GeoGebra in mathematics class.

Similarly, the item-2 'I didn't like studying geometry lesson by using GeoGebra software' have chi square value 17.5 which is greater than the tabulated value of 9.488. So the statement is significant at 0.05 level of significance with 4 degree of freedom. The mean response of students was found 3.96 which is less than the average value. More than 75% of students disagreed with this statement. This shows that most of the students liked GeoGebra software and they were interested to learn geometry with GeoGebra software. They want to solve mathematical problems by using GeoGebra software.

Likewise, the item-3 'GeoGebra software help me, a lot to learn the geometric concepts' have chi square value 33.5 which is greater than the tabulated value of 9.488. So the statement is significant at 0.05 level of significance with 4 degree of freedom. The mean response of students was found 4.46 which is greater than the average value. More than 85% of students agreed with this statement. This shows that most of the students liked GeoGebra software and they were interested to learn geometry with GeoGebra software. It means GeoGebra software was helpful to learned geometric concepts and it increased the active participation of mathematical classroom and also promote the geometric knowledge.

In the same way, item-4 'GeoGebra software makes easy to under-standing geometrical theorems and problems' have chi square value 36.5 which is greater than the tabulated value of 9.488. So the statement is significant at 0.05 level of significance with 4 degree of freedom. The mean response of students was found 4.54 which is greater than the average value. More than 95% of students agreed with this

statement. This shows that most of the students liked GeoGebra software and they were interested to learn geometry with GeoGebra software. It means they are understanding the geometrical theorems and problems from GeoGebra software.

Item-5 'GeoGebra is essential and improvement for the teaching geometry' have chi square value 46 which is greater than the tabulated value of 9.488. So the statement is significant at 0.05 level of significance with 4 degree of freedom. The mean response of students was found 4.65 which is greater than the average value. More than 95% of students' agreed with this statement. This shows that most of the students liked GeoGebra software and they were interested to learn geometry with GeoGebra software. It means that the students are positive and they felt easy in learning from GeoGebra software.

Similarly, the item-6 'GeoGebra software helps to visualizing the problems of geometric concepts' have chi square value 33.5 which is greater than the tabulated value of 9.488. So the statement is significant at 0.05 level of significance with 4 degree of freedom. The mean response of students was found 4.50 which is greater than the average value. More than 90% of students agreed with this statement. This shows that most of the students liked GeoGebra software and they were interested to learn geometry with GeoGebra software. They are very active, curious and fell easy to learn visual concepts while using GeoGebra in mathematics class.

The item-7 'GeoGebra software enhance my learning in geometric lessons' have chi square value 40.5 which is greater than the tabulated value of 9.488. So the statement is significant at 0.05 level of significance with 4 degree of freedom. The mean response of students was found 4.42 which is greater than the average value. 100% students agreed with this statement. This shows that all of the students liked GeoGebra software and they were interested to learn geometry with GeoGebra

software. They are improve the geometrical concepts and satisfies from GeoGebra software.

The item-8 'GeoGebra software helps to make the learning more enjoyable' have chi square value 31.5 which is greater than the tabulated value of 9.488. So the statement is significant at 0.05 level of significance with 4 degree of freedom. The mean response of students was found 4.46 which is greater than the average value. More than 90% of students agreed with this statement. This shows that most of the students liked GeoGebra software and they were interested to learn geometry with GeoGebra software. They feel enjoy and satisfies on geometric lesson from GeoGebra software.

Likewise, the item-9 'GeoGebra software makes geometric classes were boring' have chi square value 30 which is greater than the tabulated value of 9.488. So the statement is significant at 0.05 level of significance with 4 degree of freedom. The mean response of students was found 4.42 which is greater than the average value. More than 80% of students disagreed with this statement. This shows that most of the students liked GeoGebra software and they were interested to learn geometry with GeoGebra software. They are feel very important and interesting software for learning geometric lesson on that experimental group.

And the item-10 'Using GeoGebra makes geometry more difficult for me' have chi square value 48.5 which is greater than the tabulated value of 9.488. So the statement is significant at 0.05 level of significance with 4 degree of freedom. The mean response of students was found 4.62 which is greater than the average value. More than 90% of students disagreed with this statement. This shows that most of the students liked GeoGebra software and they were interested to learn geometry with

GeoGebra software. They are felt GeoGebra software makes easy for learning and understanding the geometrical concepts and problems as well as theorems.

Therefore, most of the students gave the positive responses about the above items and felt easy to understanding the geometrical concepts as well as problems and theorems. They were happy and interesting to learn the geometrical concepts. Also promote the students number in mathematical classroom activities. So, Geogebra is very essential and important software for teaching and learning geometrical concepts, problems and theorems. Among 26 students in an experimental group, researcher took semi-structure interview with 5 students based on. The perception of students presented by the sample students were discussion on the following heading;

### **GeoGebra for Conceptual Learning**

Researcher used GeoGebra software for all episodes. While asking to students, “*What difference did you got learning in GeoGebra assisted teaching and conventional teaching method?*” Respondent’s views were;

**Student 1.** *“I found many difference in teaching method. In conventional teaching, I learnt mathematics by practice but now I learnt mathematics by understanding. I can memories these parallelogram’s related theorem for long time without looking the book and copies.”*

**Student 2.** *“I am very excited to learn mathematics in the GeoGebra assisted class, because I can easily understand the mathematics and I can easily memorize, write what I learnt in the classroom.”*

These above response of the students reveals that, GeoGebra assisted teaching was becoming very helpful to the learner for conceptual development of knowledge. Students were very happy and excited in mathematical classroom and they can feel easy



to learn conceptual knowledge from GeoGebra software. It is grate innovation in the field of mathematics teaching. It is very supportive for the students as well as teachers.

### **GeoGebra for Visualization of Mathematical Problems**

There were 15 episodes of experimental classes for the teaching ‘parallelogram’. Each episode was visualized. Students not only practices but also visualize the mathematical concepts and problems as well as theorems. Respondents were feeling excited and said *“Parallelogram are moving, how? Can we extend the all geometrical figure as our wish? We haven’t seen moving of geometrical figure.”*

It is visualizing software. It has the properties that every geometrical concepts can be taught by visualizing. The researcher found that, visualization of mathematics helps the students for better understanding. Not only the geometrical concepts, has it also helped in other field of mathematics like algebra, sets, probability etc. So it is very useful mathematical software.

### **GeoGebra as a Motivator for Geometry Learning**

In the GeoGebra assist teaching class, students were involved in integrating and solving the mathematical problems with friends as well as teacher. They were interested in practicing mathematics. Respondents’ say *“We like to practice mathematics watching through the projector. Also asked that, is it possible all topics of mathematics watch through projector? , Can we make this videos to broadcast through our television at home?”*

This shows that, GeoGebra motivates students in learning mathematics. It increased the faculty level of students about the mathematics. All topics of geometry may not draw by the pen and paper. It such case, GeoGebra can provide the clear concepts of such topics. It helps learners to develop the geometrical reasoning skills. The students were motivated by the teachers as they felt that the mathematics class

becoming interesting and it promote the classroom participation as well as mathematical results.

### **Positive perceptions towards GeoGebra assisted Teaching**

Researcher through the 15 episodes while in the experiment. There was many changes in students behavior, such as; interest in doing homework, classroom participation, involving the submission of classwork, interesting with friends as well as teacher. While the question asking in the interview, *“Give your views and suggestions for use of GeoGebra in teaching mathematics.”* Student’s answer was, *“We liked GeoGebra software for teaching mathematics. It made us very clear concept about parallelogram’s related theorems and problems. We hope we’ll do better in coming examination. We feel it would be better, if we could learn always by using GeoGebra in teaching mathematics”*.

So, researcher found that, students were happy in learning with GeoGebra. Students can understand the mathematics by using the visual materials. Use of materials has positive effects for learning mathematics. In any view, GeoGebra can address the interest of students as teacher.

Review by Thambi and KwanEu (2013) also shows that students in experimental group perform better when using GeoGebra software than the control group with the traditional learning method. The result of this study indicates that there was significant difference between the average achievement score of experimental and control group in post-test. Based on their finding, this suggested that GeoGebra was very helpful for teaching and learning Geometry. And the development of technology tools GeoGebra increase the student’s achievement in their learning geometry. Overly the above result shows that, in teaching geometry, using GeoGebra software was more effective than traditional method on Parallelogram teaching of geometry at grade IX. Also students gave positive feedback about the GeoGebra software.

## **Chapter V**

### **SUMMARY, FINDINGS, CONCLUSION AND RECOMMENDATIONS**

This chapter deals with summary, findings, conclusion and recommendations. This section is very essential for research study. This chapter helps to find out the conclusion and main theme of the study.

#### **Summary of the Study**

This is an experimental research related to “Effectiveness of GeoGebra in Teaching Geometry” at secondary level. The objectives of this research were to compare the achievement of students taught by GeoGebra assisted teaching method and conventional teaching method on Parallelogram at grade IX, and to identify the students perception towards GeoGebra software in teaching Parallelogram at grade IX. The research was based on quasi-experimental design selecting two private schools at Kathmandu Metropolitan city in Kathmandu district. Mathematics achievement test and questionnaire with observation note were used as data collection tools. The reliability of these tools was determined by using statistical formulae and validity of the tools was insured by expert judgment and secondary school mathematics curriculum.

For the data collection of the study, pilot test was conducted on 20 students of Kanchenjunga Secondary School, Dally Kathmandu. The researcher developed and tested the reliability of achievement test and also find the difficult level (P %) and discrimination index (D) of the items before their administration. The pilot test consisted of 10 multiple choice items and 15 subjective items on the area on parallelogram of geometry at grade IX.

A pre-test, post-test equivalent group design of quasi-experimental design was adopted for the purpose of this study. Students of class IX of Kathmandu district have been considered as population. The sample schools were selected through the conventional method of sampling which were named as “Divya Gyan Secondary School and JalJala Sishu Sadan Secondary School” which was located on Dallu Kathmandu.

After the 15 days teaching in Divya Gyan Secondary School by using GeoGebra software, researcher collects data from mathematics achievement test and students view on GeoGebra by questionnaire related to Likert five point scales of this experimental group. Also teaching 15 days in JalJala Sishu Sadan Secondary School by using traditional method, researcher collects the data from only mathematics achievement test of this control group.

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

In this study, teaching using GeoGebra software was more effective than the traditional method on parallelogram of geometry at grade IX. The result highlighted that students in the experimental group performed better using GeoGebra than the control group that use of traditional method. In addition, students view on GeoGebra was analyzed through a set of questionnaire based on Likert five point scale consists of ten items. This questionnaire was distributed to only experimental group and result

shows that students gave positive feedback about GeoGebra software in learning parallelogram of geometry at grade IX.

### **Findings of the Study**

Accepting and rejecting the significance of null hypotheses constructed for the study determined the effectiveness of GeoGebra software as compared to traditional method and questionnaire related to Likert five point scale constructed for the analyzing students view on GeoGebra software in teaching parallelogram of geometry at grade IX. The findings of the study, were observed from the calculated and tabulated t-value, chi square value recorded in table for hypotheses to achieve the objective of the study. Also from percentage and mean (in table 4.3) for analyze students view on GeoGebra. The major findings of the study were;

- There is no significant difference between the average achievement score of students on parallelogram of experimental and control group on pre-test.
- There is significant difference between the average achievement score of these groups on post-test. i.e. the average achievement score of experimental group is higher than the control group.
- Teaching using GeoGebra software was more effective than traditional method in parallelogram teaching of geometry.
- This result also shows that students gave positive feedback or view about the GeoGebra software in teaching and learning parallelogram.
- GeoGebra supports students for conceptual learning.
- The results shows that GeoGebra makes geometry class very interesting and enjoyable.
- GeoGebra is very useful for visualization of mathematical concepts.

- GeoGebra increases the participation of students in teaching, learning process.
- 75% of students of experimental group gave positive view on GeoGebra was enhancing students learning and understanding in geometry lesson. And GeoGebra software is very essential for the betterment of student's achievement and helps to improvement of achievement on teaching geometry.

### **Conclusion of the Study**

This research is one of the valuable researches in mathematics teaching. GeoGebra plays significant role for the improvement in teaching and learning mathematics. Achievement of experimental group is better than the control group. Students have positive perception towards GeoGebra assisted teaching. Students are motivated in learning mathematics. GeoGebra help to students for conceptual learning. The use of GeoGebra in parallelogram increased overall student's motivation, engagement and achievement. There is in-depth participation of students in class room interaction and problem solving. GeoGebra play the role of ZPD of the students and level of understanding is increasing. GeoGebra helpe to students for express hidden talent. It is better if CDC include GeoGebra in secondary level. The use of GeoGebra in teaching and learning parallelogram has proven that best strategy in geometry teaching for the better construction and better understanding the conventional approach in the context of Nepal.

### **Recommendations for the Educational Implications**

The use of GeoGebra in teaching mathematics helps to inspire the students for the learning and improve the scores in mathematics. So it has much educational implication in the education field as well as ICT based learning. The major educational implications of the research are follows;

- It could be used as the supportive materials for teacher.
- This research would help to those persons who want to research in GeoGebra.
- GeoGebra software can be used as the pedagogy of teaching.
- Teachers, students, researchers, educationist study this research and they can design the teaching method by using GeoGebra.
- It can be used for the educational policy maker.
- This research can be usable for CDC of school level.
- This researcher can be used for software developer.
- This research can be useful to facilitate ICT in school level in Nepal.

Since, GeoGebra is very essential and important software for learner, teacher and educationist. After the completion of the research, the researcher conclude that there is positive role of use of GeoGebra for the achievement of the students rather than the conventional method.

### **Recommendation for Further Study**

This study was limited to the effectiveness of GeoGebra on teaching mathematics in Geometry teaching only. It focused on student's achievement in topic of 'Parallelogram' of geometry at grade IX. It was done in small sample size. There are many areas remaining for research related to GeoGebra. Based on this research, researcher has following recommendation for the further study;

- To test the effectiveness of GeoGebra in Basic level of School in Nepal.
- To find the effectiveness of GeoGebra software in teaching mathematics in University level.
- To explore the use of technology in public and private schools of Nepal.
- To explore the effectiveness of GeoGebra for teaching arithmetic/algebra/transformation topics at school level.

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## APPENDICES

### Appendix A

#### Subjective and Objective Questions for Pilot Test

Class: IX

Full Marks: 42

Subject: C. Mathematics

Time: 1:15 min

All questions are compulsory

**Objective Questions** (Tick the correct ( $\surd$ ) answer):

#### Group A (Knowledge)

[10× 1=10 marks]

1 Which one of the following characteristics of Parallelogram based on sides?

- a. All sides are equal.
- b. Opposite sides are parallel.
- c. Opposite sides are equal.
- d. Opposite sides are parallel and equal.

2. Which are the characteristics of Parallelogram based on angles?

- a. All angles are equal.
- b. Opposite angles are equal.
- c. All angles are  $90^\circ$ .
- d. All angles are different.

3. Which of the following is the formula for finding area of parallelogram?

- a.  $A = b \times h$
- b.  $A = d_1 \times d_2$
- c.  $A = \frac{1}{2} (b \times h)$
- d.  $A = \frac{1}{2} (d_1 \times d_2)$

4. In a parallelogram, the base and height are 4 cm and 5 cm respectively. What is its area?

- a.  $9 \text{ cm}^2$
- b.  $20 \text{ cm}^2$
- c.  $10 \text{ cm}^2$
- d.  $22 \text{ cm}^2$

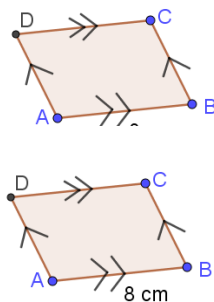
5. In a parallelogram ABCD, what is the relation between AD and BC?

- a. Parallel
- b. Equal
- c. perpendicular
- d. Parallel and equal

6. In a parallelogram ABCD,  $AB = 8 \text{ cm}$ , what is the length of CD.

- a. 4 cm
- b. 16 cm
- c. 8 cm
- d. 6 cm

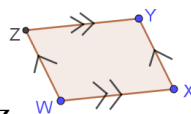
7. What is the relation between area of parallelogram and triangle standing on same base?



- a. Equal in area
- b. Different in area
- c. Area of triangle =  $2 \times$  area of parallelogram
- d. Area of triangle =  $\frac{1}{2}$  area of parallelogram

8. In a quadrilateral WXYZ, which angles should be equal to be a parallelogram?

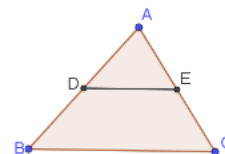
- a.  $\angle W = \angle X$  &  $\angle W = \angle Y$
- b.  $\angle X = \angle Y$
- c.  $\angle W = \angle Y$  &  $\angle X = \angle Z$
- d.  $\angle Y = \angle Z$



9. In triangle ABC, D and E are the mid point of AB and AC respectively.

What is the relation between BC and DE .

- a. Parallel
- b. equal
- c. Parallel and equal
- d. perpendicular



10. which of the following statements is not correct?

- a. Parallelogram is subset of quadrilatera
- b. Every quadrilaterals are parallelograms.
- c. Parallelograms has opposite angles are equal.
- d. Every parallelograms are quadrilateral.

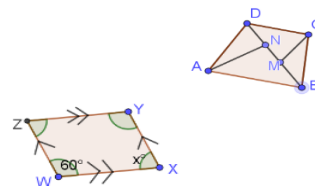
**Subjective Questions (Solve the following questions):**

**Group B (Comprehension)**

[10 × 1 = 10 marks]

11. What is the area of quadrilateral ABCD, in which BD=8 cm,

AN=6 cm and CM=3 cm.



12. What is the value of x in the given parallelogram WXYZ?

13. In a parallelogram MNOP,  $\angle N = (2x + 10)^\circ$  and  $\angle P = 120^\circ$ . What is the value of x?

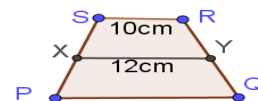
14. In the given parallelogram ABCD,  $AB + CD = 14$  cm. what is the length of CD?

15. In the given parallelogram ABCD, if  $\angle B = (2x + 25)^\circ$  and  $\angle D = (4x - 15)^\circ$ .

What is the angle of  $\angle BAD$ ?

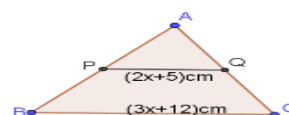
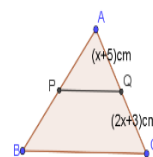
16. In the figure, PQRS is a trapezium. If RS=10 cm and median

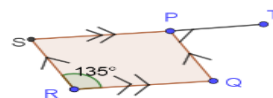
XY=12 cm then find the length of PQ.



17. In the given figure,  $AQ = (x + 5)$  cm and  $QC = (2x + 3)$  cm. what is the length of AC?

18. In the figure,  $PQ = (2x + 5)$  cm and  $BC = (3x + 12)$  cm. what is the length of BC?



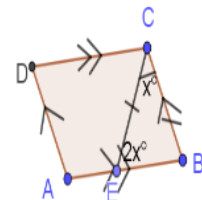


19. In the figure, PQRS is a parallelogram. If  $\angle QRS = 135^\circ$  then what

Is the value of  $\angle QPT$  ?

20. In the given parallelogram ABCD, E is any point on AB.

If  $BC = CE$ ,  $\angle BEC = 2x$  and  $\angle BCE = x$ , what is the value of  $\angle ADC$ ?



**Group C (Skills)**

[3 × 4 = 12 marks]

21. Prove that the diagonals of a parallelogram bisect to each other.

22. Prove that the diagonals of a rhombus bisect each other at right angles.

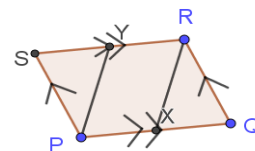
23. The opposite sides and angles of a parallelogram are equal.

**Group D (Application)**

[2 × 5 = 10 marks]

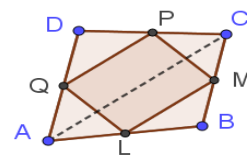
24. PQRS is a parallelogram. If X and Y are the mid-points of PQ and RS,

Prove that PXYR is a Parallelogram.



25. Let L, M, P and Q be the mid points of four sides AB, BC, CD and DA of a

Quadrilateral ABCD respectively. Prove that LMPQ is a parallelogram.



**Answer keys for Objectives Questions:**

**Group A**

1	2	3	4	5	6	7	8	9	10
d	b	a	b	a	c	d	c	a	b

**Answer keys for Subjective Questions**

**Group B**

11	12	13	14	15	16	17	18	19	20
72	120	55	7	230	14	14	18	45	72

**Group C**

Q.N	Answer	Marks
21.	i) Given: in parallelogram ABCD, the diagonals AC and BD intersected at O. To prove: OA=OC and OB=OD.	4 1
	ii) In $\triangle AOB$ and $\triangle COD$ : $\angle BAO = \angle OCD$ , $AB = CD$ and $\angle ABO = \angle OCD$	1
	iii) $\triangle AOB \approx \triangle COD$ by SAS facts.	1
	iv) OA=OC and OB=OD (by corresponding sides of congruent triangles.)	1
22.	i) Given: ABCD is a rhombus in which the diagonals AC and BD intersect at O. To prove: AO=CO, DO=BO, and $\angle AOB$ or, $\angle BOC$ or, $\angle COD$ or, $\angle AOD = 90^\circ$	1
	ii) ABCD is a parallelogram (because ABCD is rhombus). AO=CO and DO=BO (diagonals of parallelogram bisect each other)	1
	iii) $\triangle ABC$ is isosceles triangles and OB is median of $\triangle ABC$ (from ii.)	1
	iv) $\angle AOB = \angle BOC = 90^\circ$ (median of isosceles triangle is perp. To the base)	1
23.	i) Given: in a parallelogram ABCD, $AB \parallel CD$ and $AD \parallel BC$ To prove: $AB = CD$ & $AD = BC$ and $\angle ABC = \angle ADC$ & $\angle DAB = \angle BCD$	1
	ii) In $\triangle ABD$ and $\triangle BCD$ : $\angle ABD = \angle BDC$ , $BD = BD$ , $\angle ADB = \angle DBC$ So, $\triangle ABD \approx \triangle BCD$ by ASA facts.	1
	iii) $AB = CD$ & $AD = BC$ and $\angle DAB = \angle BCD$ by corresponding sides & angles of a congruent triangles.	1
	iv) $\angle ABD + \angle DBC = \angle BDC + \angle ADB$ (from ii.) & $\angle ABC = \angle ADC$ (from iii.)	1
Thus, $AB = CD$ , $AD = BC$ and $\angle ABC = \angle ADC$ , $\angle DAB = \angle BCD$ .		
<b>Group D</b>		
24.	i) Given: PQRS is a parallelogram, SY=YR, PX=QX & To prove: PXRY is a parallelogram.	1
	ii) $SR = PQ$ (opposite sides of parallelogram) $YR = \frac{1}{2} SR$ & $PX = \frac{1}{2} PQ$ (X & Y be mid points of PQ & SR)	1
	iii) $PX = YR$ (from ii.) & $PX \parallel YR$ (opposite sides of parallelogram)	1
	iv) $PY = XR$ , $PY \parallel XR$ (By theorem 4)	1
	v) PXRY is a parallelogram By opposite sides are parallel and equal.	1
25.	i) Given: L, M, P and Q be mid points of AB, BC, CD and DA of Quad. ABCD. To prove: LMPQ is a parallelogram & Construction: AC is joined.	1
	ii) $LM \parallel AC$ & $LM = \frac{1}{2} AC$ and $PQ \parallel AC$ & $PQ = \frac{1}{2} AC$	1
	iii) $PQ = LM$ & $PQ \parallel LM$ (from ii.)	1
	iv) $QL = PM$ & $QL \parallel PM$ (from iii.)	1
	v) LMPQ is a parallelogram (from iii & iv)	1

## Appendix B

### Mathematical Achievement Test Prepared for Pre-test and Post-test

Class: IX

Full Marks: 25

Subject: C. Mathematics

Time: 45 min

All questions are compulsory

**Group A** (Tick the correct (✓) answer): [8× 1=8 marks]

1. Which one of the following characteristics of Parallelogram based on sides?

- |                                 |   |
|---------------------------------|---|
| c. All sides are equal.         | c. Opposite sides are equal.              |
| d. Opposite sides are parallel. | d. Opposite sides are equal and parallel. |

2. In a parallelogram, the base and height are 6 cm and 5 cm respectively.

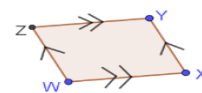
What is its area?    a. 9 cm<sup>2</sup>                      b. 30 cm<sup>2</sup>                      c. 10 cm<sup>2</sup>                      d. 22 cm<sup>2</sup>

3. What is the relation between area of parallelogram and triangle standing on same base?

- |                      |  |
|----------------------|--|
| a. Equal in area     | c. Area of triangle = 2× area of parallelogram |
| b. Different in area | d. Area of triangle = ½ area of parallelogram  |

4. In a quadrilateral WXYZ, which angles should be equal to be a parallelogram?

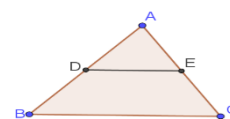
- |  |                          |  |                          |
|--|--------------------------|--|--------------------------|
| a. $\angle W = \angle X$ & $\angle W = \angle Y$ | b. $\angle X = \angle Y$ | c. $\angle W = \angle Y$ & $\angle X = \angle Z$ | d. $\angle Y = \angle Z$ |
|--|--------------------------|--|--------------------------|



5. In triangle ABC, D and E are the mid point of AB and AC respectively.

What is the relation between BC and DE .

- |                         |          |                       |                  |
|-------------------------|----------|-----------------------|------------------|
| b. $DE = \frac{1}{2}BC$ | b. equal | c. Parallel and equal | d. perpendicular |
|-------------------------|----------|-----------------------|------------------|

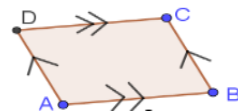


6. which of the following statements is not correct?

- |  |  |
|--|--|
| a. Parallelogram is subset of quadrilateral. | b. Parallelograms has opposite angles are equal. |
| c. Every quadrilaterals are parallelograms.  | d. Every parallelograms are quadrilateral.       |

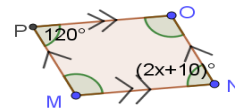
7. In the given parallelogram ABCD,  $AB+CD=18$  cm. what is the length of CD?

- a. 14 cm      b. 9 cm      c. 10 cm      d. 15 cm



8. In a parallelogram MNOP,  $\angle N=(2x+10)^\circ$  and  $\angle P=120^\circ$ . What is the value of x?

- a.  $60^\circ$       b.  $110^\circ$       c.  $120^\circ$       d.  $55^\circ$

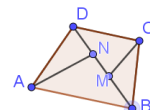


**Group B:**

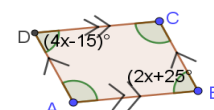
[ $4 \times 2 = 8$  marks]

9. What is the area of quadrilateral ABCD, in which  $BD=12$  cm,

$AN=6$  cm and  $CM=5$  cm.



10. In the given parallelogram ABCD, if  $\angle B = (2x+25)^\circ$  and  $\angle D = (4x-15)^\circ$ .

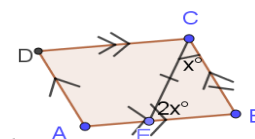
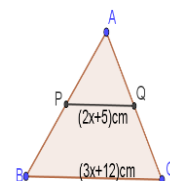


What is the angle of  $\angle BAD$ ?

11. In the figure,  $PQ = (2x+5)$  cm and  $BC = (3x+12)$  cm. what is the length of BC?

12. In the given parallelogram ABCD, E is any point on AB.

If  $BC=CE$ ,  $\angle BEC=2x$  and  $\angle BCE=x$ , what is the value of x.



**Group C**

[ $1 \times 4 = 4$  marks]

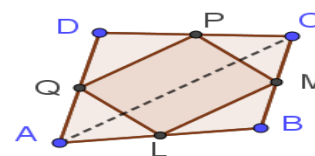
13. Prove that the diagonals of a parallelogram bisect to each other.

**Group D**

[ $1 \times 5 = 5$  mark]

14. Let L, M, P and Q be the mid points of four sides AB, BC, CD and DA of a

Quadrilateral ABCD respectively. Prove that LMPQ is a parallelogram.





## Appendix C

### Teaching Episode 1

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Properties</b> )	Time: 45 Minutes
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

**1. Specific Objectives:** At the end of the class students will be able to;

- Define parallelogram and identify the properties of parallelogram,
- Construct a parallelogram by using GeoGebra software.

**2. Required Materials:**

- Computer/Laptop, well managed projector lab, white board, marker etc.
- GeoGebra version 5.0 software should be installed in the computer/laptop.

**3. Classroom Activities:**

- It is the first day of teaching mathematics from the projector lab. So, at first teacher will introduce the mathematical software GeoGebra and explain how to use in this software in mathematical classroom and motivates to students by saying important and use of multimedia in mathematics classroom.
- Teacher will ask and interact with students by asking some questions related to Parallelogram such as; How many sides of a parallelogram?, How many angles of a parallelogram?, What is the sum of the angles of a parallelogram? what are the properties of parallelogram? etc.
- Teacher will open the GeoGebra software and introduce about the its perspectives and visualize their tools such as; angles, line segments, point, parallel and perpendicular lines, mid points, polygon, circle, etc. in the Graphical view of GeoGebra software.
- Teacher will construct the parallelogram by using line segments, parallel lines, points etc.
- At last, the teacher and students will discuss about the steps of parallelogram construction by GeoGebra.

**4. Evaluation:** What are the properties of Parallelogram?

## 5. Homework:

- Construct a parallelogram PQRS.
- Write the steps of constructing a parallelogram on GeoGebra.

## 6. Appendix: Construction Protocol for GeoGebra;

- Open GeoGebra software 5.0 and select on Graphic view
- Click on line segment and draw parallelogram by using parallel line.
- Click on angle tools and plot the length, angles and area.
- Go to the text option and write definition, properties etc. then we get parallelogram ABCD.

Teaching Episode 1.ggb

File Edit View Options Tools Window Help Sign in

Algebra Graphics

$a = 5.98$   
 $c = 3.56$   
 $q1 = 19.44$   
 text2 = "Propert  
 text3 = "1. Opp  
 text4 = "2. Opp  
 text5 = "3. Sum  
 text6 = "4. Diag  
 text7 = "Definiti  
 $\delta = 65.78^\circ$   
 $\gamma = 114.22^\circ$   
 $\beta = 65.78^\circ$   
 $\alpha = 114.22^\circ$   
 Textq1 = "Area  
 $E = (5.08, 2.04)$   
 $F = (8.58, 2.06)$   
 $j = 3.5$   
 $G = (9.5, 4.2)$   
 $k = 2.33$

Definition:  
 A quadrilateral having opposite angles are equal and opposite sides are equal and parallel is known as parallelogram.

Area of DABC = 19.44

Properties of Parallelogram:

1. Opposite sides are equal.  
 i)  $AB=CD$  & ii)  $AD=BC$
2. Opposite angles are equal.  
 i)  $\angle A = \angle C$  & ii)  $\angle B = \angle D$
3. Sum of adjacent angle is  $180^\circ$   
 i)  $\angle A + \angle B = 180^\circ$  ii)  $\angle B + \angle C = 180^\circ$   
 iii)  $\angle C + \angle D = 180^\circ$  iv)  $\angle D + \angle A = 180^\circ$
4. Diagonals bisect each other  
 i)  $OH=OF$  ii)  $OE=OG$
5. The sum of interior angles of a parallelogram is  $360^\circ$ .  
 i)  $\angle A + \angle B + \angle C + \angle D = 360^\circ$ .

Input:

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1/11/2020

## Appendix D

### Teaching Episode 2

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Theorem1</b> )	Time: 45 Minutes
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

**1. Specific Objectives:** At the end of the class students will be able to;

- Prove that the opposite sides of parallelogram are equal,
- Calculate the unknown sides and area of parallelogram.

**2. Required Materials:**

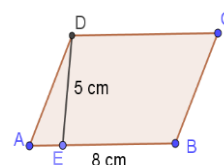
- Computer/Laptop, well managed projector lab, white board, marker etc.
- GeoGebra version 5.0 software should be installed in the computer/laptop.

**3. Classroom Activities:**

- Revision of previous lesson
- Teacher will check the pre-knowledge about the opposite sides of a parallelogram and clarify them by figure.
- Teacher will write the statement of the theorem “The opposite sides of parallelogram are equal” and discuss with students.
- Teacher will be used to GeoGebra software for figure and Prove of this theorem. He will demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that, teacher and students both interaction on each other about figure and statement of theorem.
- Then after teacher will ask some question to students about the statement and discuss with students answers.
- At last, the teacher and students will discuss about the how to find out the unknown sides of various type of parallelograms.

**4. Homework:**

- What is the length of CD and area of a given parallelogram ABCD?
- Write the steps of constructing the theorems “The opposite sides of a parallelogram are equal” on GeoGebra.



### 5. Appendix: Construction protocol for GeoGebra;

- Open GeoGebra software 5.0 and select on Graphic view
- Click on line segment and draw parallelogram with diagonal by using parallel line.
- Go to the text option and prove the theorem with statement and reason.

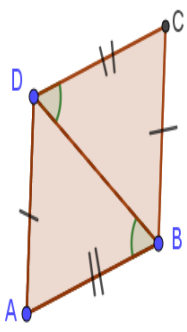
Teaching Episode 2.ggb

File Edit View Options Tools Window Help Sign in

Algebra Graphics

$B_1 = (-1.82, 5.4)$   
 $s = 0.39$   
 $C_1 = (-1.7, 5.4)$   
 $D_1 = (-1.64, 5.4)$   
 $g_1 = 0.4$   
 $E_1 = (-2.2, 2.5)$   
 $F_1 = (-2.08, 2.5)$   
 $h_1 = 0.57$   
 $G_1 = (-2.06, 2.5)$   
 $H_1 = (-1.9, 2.0)$   
 $i_1 = 0.62$   
 $I_1 = (-0.84, 4.2)$   
 $J_1 = (-0.26, 4.2)$   
 $j_1 = 0.59$   
 $K_1 = (-3.74, 3)$   
 $L_1 = (-3.36, 3)$   
 $k_1 = 0.4$

Statement: The opposite sides of a parallelogram are equal.



Statement	Reason
1. In $\triangle ABD$ and $\triangle BCD$	1.
i) $\angle ABD = \angle BDC$ (A)	i) Alternate angle in $AB \parallel CD$
ii) $BD = BD$ (S)	ii) Common side
iii) $\angle ADB = \angle CBD$ (A)	iii) Alternate angle in $AD \parallel BC$
2. $\triangle ABD \cong \triangle BCD$	2. BY ASA facts
3. $AB = CD$ and $AD = BC$	3. Being corresponding sides of the congruent triangles.

Given: In parallelogram ABCD,  
 $AB \parallel CD$  and  $AD \parallel BC$   
 To Prove:  $AB = CD$  and  $AD = BC$   
 Construction: Join BD

Hence proved.

Input: Wolfram Mathematica 9

12:44 PM 1/11/2020

## Appendix E

### Teaching Episode 3

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Theorem 2:</b> Converse of Theorem 1) Time: 45 Minutes	
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

1. **Specific Objectives:** At the end of the class students will be able to;
  - Prove that the quadrilateral whose opposite sides are equal is a parallelogram.
2. **Required Materials:**
  - Computer/Laptop, well managed projector lab, white board, marker etc.
  - GeoGebra version 5.0 software should be installed in the computer/laptop.
3. **Classroom Activities:**
  - Revision of previous lesson
  - Teacher will check the pre-knowledge about the quadrilateral and whose opposite sides also clarify them by figure.
  - Teacher will write the statement of the theorem “The quadrilateral whose opposite sides are equal is a parallelogram” and discuss with students.
  - Teacher will be used to GeoGebra software for figure and Prove of this theorem. He will demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that, teacher and students both interaction on each other about figure and statement of theorem.
  - Then after teacher will ask some question to students about the statement and discuss with students answers.
4. At last, the teacher will summarize that lesson.
5. **Homework:** WXYZ is a quadrilateral in which  $WX=ZY$  and  $WZ=XY$ . Then prove that it is a parallelogram.
6. **Appendix:** Construction protocol for GeoGebra;
  - Open GeoGebra software 5.0 and select on Graphic view
  - Click on line segment and draw parallelogram with diagonal by using parallel line.
  - Go to the text option and prove the theorem with statement and reason.

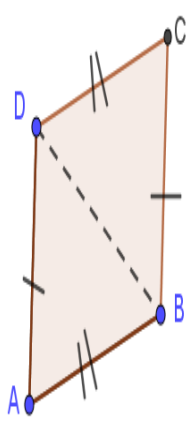
Teaching Episode 3.ggb

File Edit View Options Tools Window Help Sign in

Algebra

- $B_1 = (-2, 4.88)$
- $g_1 = 0.57$
- $C_1 = (-1.96, 5)$
- $D_1 = (-1.72, 4)$
- $h_1 = 0.59$
- $E_1 = (-2.36, 2)$
- $F_1 = (-2.22, 1)$
- $i_1 = 0.58$
- $G_1 = (-2.22, 2)$
- $H_1 = (-1.96, 1)$
- $j_1 = 0.65$
- $l_1 = (-0.72, 3.9)$
- $J_1 = (-0.08, 3)$
- $k_1 = 0.64$
- $K_1 = (-3.58, 3)$
- $L_1 = (-3.14, 2)$
- $l_1 = 0.46$

Graphics



A quadrilateral whose opposite sides are equal is a parallelogram

Given: In quadrilateral ABCD,  
AB=CD & AD=BC

To Prove: ABCD is a parallelogram

Construction: Join BD

Statement	Reason
1. In $\triangle ABC$ and $\triangle BCD$ i) $AB=CD$ (S) ii) $AD=BC$ (S) iii) $BD=BD$ (S)	1. i) Given ii) Given iii) Common side
2. $\triangle ABD \cong \triangle BCD$	2. BY SSS facts
3. $\angle ABD = \angle BDC$ and $\angle ADB = \angle DBC$	3. Being corresponding angles of the corresponding triangles.
4. $AB \parallel CD$ and $AD \parallel BC$	4. Being alternate angles are equal (from 3)
5. ABCD is a parallelogram	5. Being opposite sides of a quadrilateral are parallel (from 4)

Hence proved.

Input: ?



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## Appendix F

### Teaching Episode 4

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Theorem 3</b> )	Time: 45 Minutes
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

**1. Specific Objectives:** At the end of the class students will be able to;

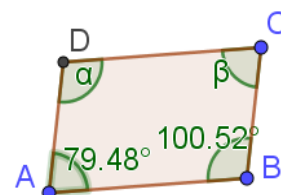
- Prove that the opposite angles of parallelogram are equal,
- Calculate the unknown angles of parallelogram.

**2. Required Materials:**

- Computer/Laptop, well managed projector lab, white board, marker etc.
- GeoGebra version 5.0 software should be installed in the computer/laptop.

**3. Classroom Activities:**

- Revision of previous lesson
- Teacher will check the pre-knowledge about the opposite angles of a parallelogram and clarify them by figure.
- Teacher will write the statement of the theorem “The opposite angles of parallelogram are equal” and discuss with students.
- Teacher will be used to GeoGebra software for figure and prove of this theorem. He will demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that, teacher and students both interaction on each other about figure and statement of theorem.
- Then after teacher will ask some question to students about the statement and discuss with students answers.
- At last, the teacher and students will discuss about the how to find out the unknown angles of various types of parallelograms.



#### 4. Homework:

- Find the unknown angles of a given parallelogram?
- Write the steps of constructing the theorems “The opposite angles of a parallelogram are equal” on GeoGebra.

#### 5. Appendix: Construction protocol for GeoGebra;

- Open GeoGebra software 5.0 and select on Graphic view
- Click on line segment and draw parallelogram with diagonal by using parallel line.
- Go to the text option and prove the theorem with statement and reason.

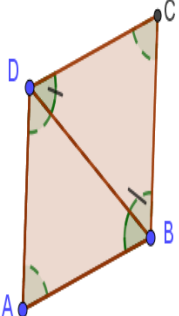
Teaching Episode 4.ggb

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Algebra Graphics

h<sub>1</sub> = 13.23  
 text20 = "Thus,  $\angle ABC =$   
 F<sub>1</sub> = (3.07, -2.89)  
 G<sub>1</sub> = (16.29, -2.62)  
 i<sub>1</sub> = 13.22  
 text21 = "Hence Prove  
 l = 68.82°  
 $\theta = 57.36^\circ$   
 $\eta = 53.82^\circ$   
 $\mu = 53.82^\circ$   
 $\lambda = 68.82^\circ$   
 $\kappa = 57.36^\circ$   
 H<sub>1</sub> = (-3, 4.7)  
 l<sub>1</sub> = (-2.7, 4.62)  
 j<sub>1</sub> = 0.31  
 J<sub>1</sub> = (-1.16, 3.36)  
 K<sub>1</sub> = (-0.78, 3.18)  
 k<sub>1</sub> = 0.42

Statement: The opposite angles of a parallelogram are equal.



Given: In parallelogram ABCD,  
 AB//CD and AD//BC  
 To Prove: i)  $\angle ABC = \angle ADC$   
 ii)  $\angle DAB = \angle BCD$   
 Construction: Join BD

Statement	Reason
1. In $\triangle ABD$ and $\triangle BCD$ i) $\angle ABD = \angle BDC$ (A) ii) $BD = BD$ (S) iii) $\angle ADB = \angle DBC$ (A)	1. i) Alternate angle in AB//CD ii) Common side iii) Alternate angle in AD//BC
2. $\triangle ABD \cong \triangle BCD$	2. BY ASA facts
3. $\angle DAB = \angle BCD$	3. Being corresponding angles of the congruent triangles.
4. $\angle ABD + \angle DBC = \angle BDC + \angle ADB$	4. From 1 (i) and (iii)
5. $\angle ABC = \angle ADC$	5. From (4)
Thus, $\angle ABC = \angle ADC$ and $\angle DAB = \angle BCD$	
Hence Proved.	

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## Appendix G

### Teaching Episode 5

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Theorem 4:</b> Converse of Theorem 3) Time: 45 Minutes	
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

- 1. Specific Objectives:** At the end of the class students will be able to;
  - Prove that the quadrilateral whose opposite angles are equal is a parallelogram,
  - Calculate the unknown angles of parallelogram.
- 2. Required Materials:**
  - Computer/Laptop, well managed projector lab, white board, marker etc.
  - GeoGebra version 5.0 software should be installed in the computer/laptop.
- 3. Classroom Activities:**
  - Revision of previous lesson
  - Teacher will check the pre-knowledge about the quadrilateral and whose opposite angles also clarify them by figure.
  - Teacher will write the statement of the theorem “The the quadrilateral whose opposite angles are equal is a parallelogram” and discuss with students.
  - Teacher will be used to GeoGebra software for figure and prove of this theorem. He will demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that, teacher and students both interaction on each other about figure and statement of theorem.
  - Then after teacher will ask some question to students about the statement and discuss with students answers.
- 4.** At last, the teacher will summarize that lesson.
- 5. Homework:**
  - In quadrilateral ABCD,  $\angle A = \angle C$  and  $\angle B = \angle D$ . Then prove that it is a parallelogram.

## 6. Appendix: Construction protocol for GeoGebra;

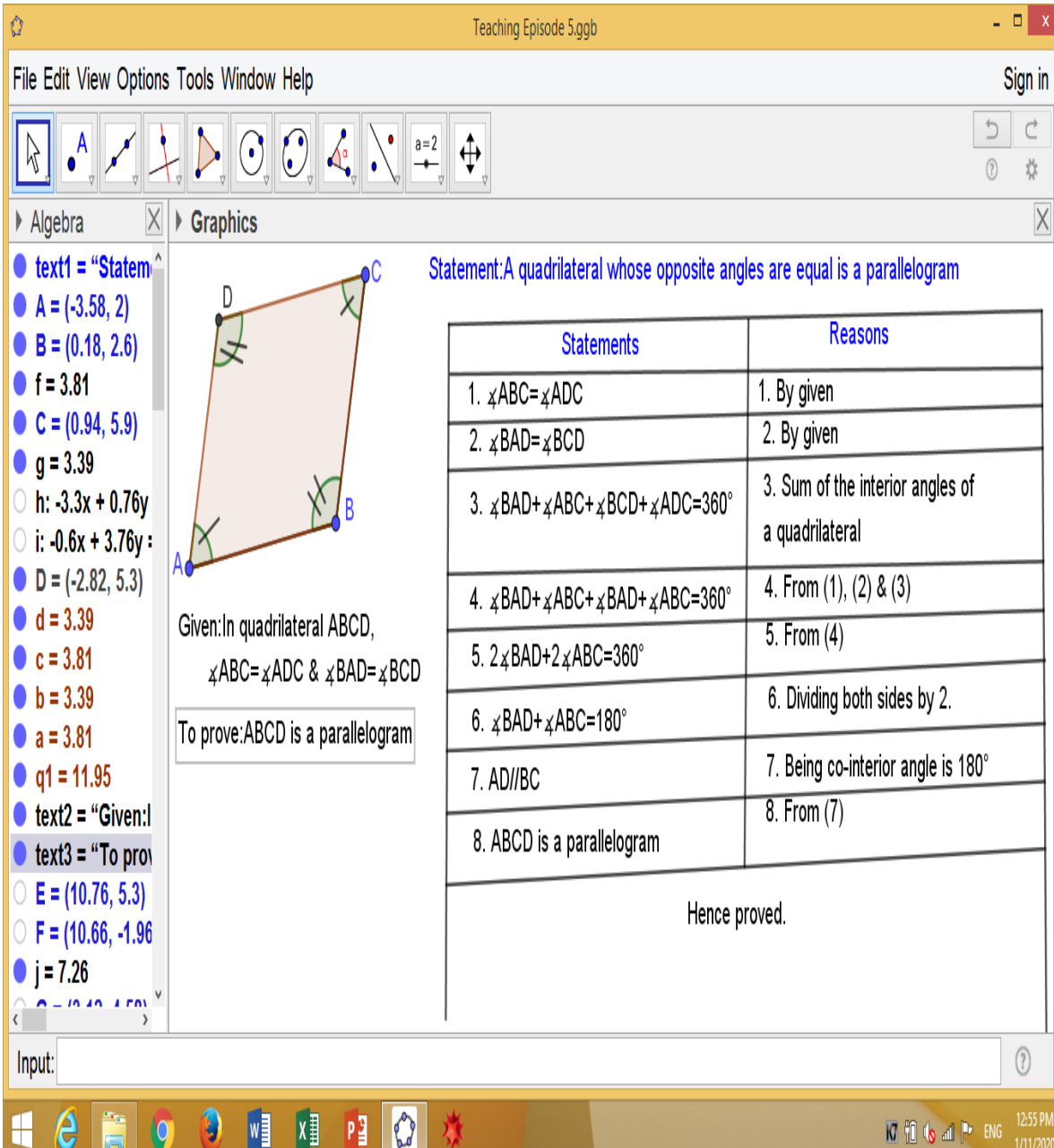
- Open GeoGebra software 5.0 and select on Graphic view
- Click on line segment and draw parallelogram with diagonal by using parallel line.
- Go to the text option and prove the theorem with statement and reason.

Teaching Episode 5.ggb

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Algebra Graphics

Statement: A quadrilateral whose opposite angles are equal is a parallelogram



Given: In quadrilateral ABCD,  
 $\angle ABC = \angle ADC$  &  $\angle BAD = \angle BCD$

To prove: ABCD is a parallelogram

Statements	Reasons
1. $\angle ABC = \angle ADC$	1. By given
2. $\angle BAD = \angle BCD$	2. By given
3. $\angle BAD + \angle ABC + \angle BCD + \angle ADC = 360^\circ$	3. Sum of the interior angles of a quadrilateral
4. $\angle BAD + \angle ABC + \angle BAD + \angle ABC = 360^\circ$	4. From (1), (2) & (3)
5. $2\angle BAD + 2\angle ABC = 360^\circ$	5. From (4)
6. $\angle BAD + \angle ABC = 180^\circ$	6. Dividing both sides by 2.
7. $AD \parallel BC$	7. Being co-interior angle is $180^\circ$
8. ABCD is a parallelogram	8. From (7)

Hence proved.

Input:

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1/11/2020

## Appendix H

### Teaching Episode 6

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Theorem 5</b> )	Time: 45 Minutes
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

**1. Specific Objectives:** At the end of the class students will be able to;

- Prove that the diagonals of a parallelogram bisect to each other,
- Calculate the area of parallelogram when diagonals are given.

**2. Required Materials:**

- Computer/Laptop, well managed projector lab, white board, marker etc.
- GeoGebra version 5.0 software should be installed in the computer/laptop.

**3. Classroom Activities:**

- Revision of previous lesson
- Teacher will check the pre-knowledge about the diagonals of a parallelogram and clarify them by figure.
- Teacher will write the statement of the theorem “The diagonals of a parallelogram bisect to each other” and discuss with students.
- Teacher will be used to GeoGebra software for figure and prove of this theorem. He will demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that, teacher and students both interaction on each other about figure and statement of theorem.
- Then after teacher will ask some question to students about the statement and discuss with students answers.
- At last, the teacher and students will discuss about the how to find out the area of various parallelograms when diagonals are given.

**4. Homework:**

- Find the area of a given parallelogram when diagonals are given?
- Write the steps of constructing the theorems “The diagonals of a parallelogram bisect to each other” on GeoGebra.

## 5. Appendix: Construction protocol for GeoGebra;

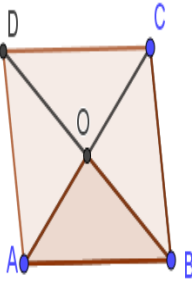
Teaching Episode 6.ggb

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Algebra Graphics

$A = (-4.04, 3)$   
 $B = (-0.66, 3.04)$   
 $f = 3.38$   
 $C = (-1.14, 5.42)$   
 $g = 2.43$   
 $h: -2.38x - 0.48y$   
 $i: -0.04x + 3.38y$   
 $D = (-4.52, 5.38)$   
 $c = 3.38$   
 $b = 2.43$   
 $a = 3.38$   
 $d = 2.43$   
 $q1 = 8.06$   
 $j = 4.51$   
 $k = 3.78$   
 $O = (-2.59, 4.21)$   
 $text1 = \text{"Statem"}$   
 $text2 = \text{"The dia"}$   
 $text3 = \text{"Given:l"}$

Statement: The diagonals of a parallelogram bisect each other.



Given: In parallelogram ABCD, diagonals AC and BD intersect at O.

To prove:  $OA=OC$  and  $OB=OD$

Proof:

Statements	Reasons
1. In $\triangle AOB$ and $\triangle COD$	1.
i) $\angle BAO = \angle OCD$ (A)	i) Being alternate angle in $AB \parallel CD$
ii) $AB = CD$ (S)	ii) Opposite sides of a parallelogram ABCD
iii) $\angle ABO = \angle ODC$ (A)	iii) Being alternate angle in $AB \parallel CD$
2. $\triangle AOB \cong \triangle COD$	2. BY ASA facts
3. $OA = OC$ and $OB = OD$	3. Corresponding sides of the congruent triangles.

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## Appendix I

### Teaching Episode 7

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Theorem 6:</b> Converse of Theorem 5) Time: 45 Minutes	
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

**1. Specific Objectives:** At the end of the class students will be able to;

- Prove that: If the diagonals of a quadrilateral bisect each other then it is a parallelogram,

**2. Required Materials:**

- Computer/Laptop, well managed projector lab, white board, marker etc.
- GeoGebra version 5.0 software should be installed in the computer/laptop.

**3. Classroom Activities:**

- Revision of previous lesson
- Teacher will check the pre-knowledge about the diagonals of a quadrilateral and clarify them by figure.
- Teacher will write the statement of the theorem “If the diagonals of a quadrilateral bisect each other then it is a parallelogram” and discuss with students.
- Teacher will be used to GeoGebra software for figure and prove of this theorem. He will demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that, teacher and students both interaction on each other about figure and statement of theorem.
- Then after teacher will ask some question to students about the statement and discuss with students answers.
- At last, the teacher will summarize the lesson.

**4. Homework:**

- If the diagonals PR and QS bisect the quadrilateral PQRS. Then prove that it is a parallelogram.
- Write the steps of constructing the theorems “If the diagonals of a quadrilateral bisect each other then it is a parallelogram” on GeoGebra.

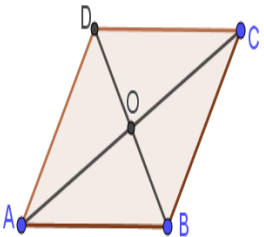
## 5. Appendix: Construction protocol for GeoGebra;

Teaching Episode 7.ggb

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Algebra Graphics

Statement: If the diagonals of a quadrilateral bisect each other than it is a parallelogram.



Given: In quadrilateral ABCD, diagonals AC and BD bisect each other at O. ( $OA=OC$  &  $OB=OD$ )

To prove: ABCD is a parallelogram.

Proof:

Statements	Reasons
1. In $\triangle AOB$ and $\triangle COD$	1.
i) $OA=OC$ (S)	i) Given
ii) $\angle AOB = \angle DOC$ (A)	ii) Vertically opposite angles
iii) $OB=OD$ (S)	iii) Given
2. $\triangle AOB \cong \triangle COD$	2. By SAS facts
3. $AB=CD$ and $\angle OAB = \angle OCD$	3. Corresponding parts of congruent triangles
4. $AB \parallel CD$ and $BC \parallel AD$	4. From (3)
5. ABCD is a parallelogram	5. Being opposite sides of a quadrilateral are parallel.

Hence proved.

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## Appendix J

### Teaching Episode 8

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Theorem 7</b> )	Time: 45 Minutes
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

1. **Specific Objectives:** At the end of the class students will be able to;
  - Prove that the line segment which join the ends on the same sides of equal and parallel lines segments are equal and parallel (In quadrilateral MNOP,  $MN=OP$  and  $MN \parallel OP$  than prove that:  $NO=MP$ ).
2. **Required Materials:**
  - Computer/Laptop, well managed projector lab, white board, marker etc.
  - GeoGebra version 5.0 software should be installed in the computer/laptop.
3. **Classroom Activities:**
  - Revision of previous lesson
  - Teacher will check the pre-knowledge about the equal and parallel line segment of a quadrilateral and clarify them by figure.
  - Teacher will write the statement of the theorem “In quadrilateral MNOP,  $MN=OP$  and  $MN \parallel OP$  than prove that:  $NO=MP$ ” and discuss with students.
  - Teacher will be used to GeoGebra software for figure and prove of this theorem. He will demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that, teacher and students both interaction on each other about figure and statement of theorem.
  - Then after teacher will ask some question to students about the statement and discuss with students answers.
  - At last, the teacher will summarize the lesson.
4. **Homework:**
  - In quadrilateral ABCD,  $AB=DA$  and  $AB \parallel DA$  than prove that:  $AD=BC$ .

## 5. Appendix: Construction protocol for GeoGebra;

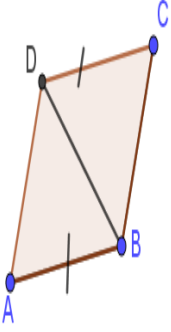
Teaching Episode 8.ggb

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Algebra Graphics

text1 = "Statement"  
 text2 = "The line"  
 A = (-4.06, 1.76)  
 B = (-1.48, 2.16)  
 f = 2.61  
 C = (-0.74, 4.36)  
 g = 2.32  
 h:  $-2.2x + 0.74y$   
 i:  $-0.4x + 2.58y =$   
 D = (-3.32, 3.96)  
 c = 2.61  
 b = 2.32  
 a = 2.61  
 d = 2.32  
 q1 = 5.38  
 E = (-2.36, 4.32)  
 F = (-2.48, 3.92)  
 j = 0.42  
 G = (-2.7, 2.28)

Statement: The line segments which join the ends on the same side of equal and parallel line segments are equal and parallel. (In quadrilateral ABCD, if  $AB=CD$  and  $AB\parallel CD$ , prove that  $AD=BC$  and  $AD\parallel BC$ .)



Statements	Reasons
1. In $\triangle BCD$ and $\triangle BAD$	1.
i) $AB=CD$ (S)	i) Given
ii) $\angle BDC = \angle ABD$ (A)	ii) Alternate angles in $AB\parallel CD$
iii) $BD=BD$ (S)	iii) Common sides
2. $\triangle BCD \cong \triangle BAD$	2. By SAS facts
3. $AD=BC$	3. Corresponding sides of congruent triangles.
4. $\angle ADB = \angle DBC$	4. Corresponding angles of congruent triangles.
5. $AD\parallel BC$	5. Alternate angles are equal (from 4).

Given: i)  $AB=CD$ ,  $AB\parallel CD$   
 ii)  $AD$  &  $BC$  are joined.  
 To prove:  $AD=BC$  and  $AD\parallel BC$ .  
 Construction: join  $BD$   
 Proof:

Hence proved.

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## Appendix K

### Teaching Episode 9

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Theorem 8</b> )	Time: 45 Minutes
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

1. **Specific Objectives:** At the end of the class students will be able to;
  - Prove that the two line segments joining the opposite end points of two equal and parallel line segments are bisect each other.
2. **Required Materials:**
  - Computer/Laptop, well managed projector lab, white board, marker etc.
  - GeoGebra version 5.0 software should be installed in the computer/laptop.
3. **Classroom Activities:**
  - Revision of previous lesson
  - Teacher will check the pre-knowledge about the equal opposite angles and parallel line segment and clarify them by figure.
  - Teacher will write the statement of the theorem “the two line segments joining the opposite end points of two equal and parallel line segments are bisect each other” and discuss with students.
  - Teacher will be used to GeoGebra software for figure and prove of this theorem. He will demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that, teacher and students both interaction on each other about figure and statement of theorem.
  - Then after teacher will ask some question to students about the statement and discuss with students answers.
  - At last, the teacher will summarize the lesson.
4. **Homework:**
  - Write the steps of constructing the theorems “the two line segments joining the opposite end points of two equal and parallel line segments are bisect each other” on GeoGebra.

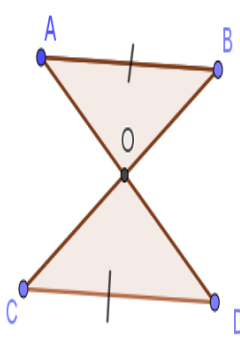
5. Appendix: Construction protocol for GeoGebra;

Teaching Episode 9.ggb

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Algebra Graphics

Statement: Two line segments joining the opposite end points of two equal and parallel line segments are bisect each other



Given:  $AB=CD$ ,  $AB \parallel CD$  where  $AD$  &  $BC$  are intersect at  $O$ .

To prove:  $AO=OD$  &  $CO=OB$  ( $AD$  &  $BC$  bisect each other).

Proof:

Statements	Reasons
1. In $\triangle AOB$ and $\triangle COD$	1.
i) $\angle OAB = \angle ODC$ (A)	i) Alternate angles in $AB \parallel CD$
ii) $AB=CD$ (S)	ii) Given
iii) $\angle ABO = \angle OCD$ (A)	iii) Alternate angles in $AB \parallel CD$
2. $\triangle AOB \cong \triangle COD$	2. By ASA facts.
3. $AO=OD$ and $CO=OB$	3. Corresponding sides of congruent triangles.
4. $AD$ and $BC$ bisect each other.	4. From (3)

Hence proved.

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## Appendix L

### Teaching Episode 10

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Theorem 9</b> )	Time: 45 Minutes
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

1. **Specific Objectives:** At the end of the class students will be able to;
  - Identify the property of rectangle,
  - Prove that the all angles of a rectangle are right angle.
2. **Required Materials:**
  - Computer/Laptop, well managed projector lab, white board, marker etc.
  - GeoGebra version 5.0 software should be installed in the computer/laptop.
3. **Classroom Activities:**
  - Revision of previous lesson
  - Teacher will check the pre-knowledge about the property of a rectangle and clarify them by figure.
  - Teacher will write the statement of the theorem “all angles of a rectangle are right angle” and discuss with students.
  - Teacher will be used to GeoGebra software for figure and prove of this theorem. He will demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that, teacher and students both interaction on each other about figure and statement of theorem.
  - Then after teacher will ask some question to students about the statement and discuss with students answers.
4. At last, the teacher and students will summarize that lesson.
5. **Homework:**
  - What are the properties of rectangle?
  - Write the steps of constructing the theorems “all angles of a rectangle are right angle” on GeoGebra.

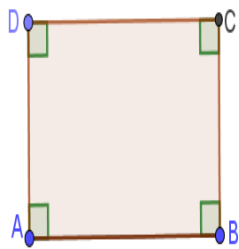
## 6. Appendix: Construction protocol for GeoGebra;

Teaching Episode 10.ggb

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Algebra Graphics

Statement: All angles of a rectangle are right angle.



Given: ABCD is a rectangle, in which  
 $AB \parallel DC$ ,  $AD \parallel BC$  &  $\angle A = 90^\circ$ .

To prove:  $\angle A = \angle B = \angle C = \angle D = 90^\circ$

Proof:

Statements	Reasons
1. $\angle A = 90^\circ$	1. Given
2. ABCD is a parallelogram	2. Being $AB \parallel DC$ & $AD \parallel BC$
3. $\angle A = \angle C$	3. Being opposite angles of parallelogram
4. $\angle C = 90^\circ$	4. From (1) & (2)
5. $\angle A + \angle B = 180^\circ$ or, $90^\circ + \angle B = 180^\circ$ or, $\angle B = 90^\circ$	5. The sum of co-interior angle is $180^\circ$ , $AD \parallel BC$
6. $\angle B = \angle D = 90^\circ$	6. Being opposite angles of parallelogram.
7. $\angle A = \angle B = \angle C = \angle D = 90^\circ$	7. From statement (1),(4),(5) & (6).

Hence proved.

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## Appendix M

### Teaching Episode 11

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Theorem 10</b> )	Time: 45 Minutes
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

**1. Specific Objectives:** At the end of the class students will be able to;

- Prove that the diagonals of a rectangle are equal,
- calculate the area of rectangle.

**2. Required Materials:**

- Computer/Laptop, well managed projector lab, white board, marker etc.
- GeoGebra version 5.0 software should be installed in the computer/laptop.

**3. Classroom Activities:**

- Revision of previous lesson
- Teacher will check the pre-knowledge about the diagonals of a rectangle and clarify them by figure.
- Teacher will write the statement of the theorem “diagonals of a rectangle are equal” and discuss with students.
- Teacher will be used to GeoGebra software for figure and prove of this theorem. He will demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that, teacher and students both interaction on each other about figure and statement of theorem.
- Then after teacher will ask some question to students about the statement and discuss with students answers.
- At last, the teacher will summarize that lesson.

**4. Homework:**

- Findout the area of rectangle in which  $l=6$  cm and  $b=4$  cm.
- PQRS is a rectangle in which  $PQ \parallel SR$ ,  $PS \parallel QR$  and  $\angle S=90^\circ$ . Then prove that:  $PR=QS$ .

5. Appendix: Construction protocol for GeoGebra;

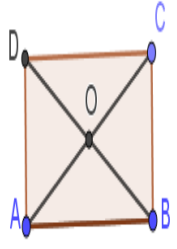
Teaching Episode 11.ggb

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Algebra Graphics

$A = (-3.3, 3.48)$   
 $B = (-0.18, 3.54)$   
 $f = 3.12$   
 $g: -3.12x - 0.06y$   
 $h: -3.12x - 0.06y$   
 $C = (-0.21, 5.2)$   
 $i: -0.06x + 3.12y$   
 $D = (-3.33, 5.14)$   
 $d = 1.66$   
 $c = 3.12$   
 $b = 1.66$   
 $a = 3.12$   
 $q1 = 5.17$   
 $j = 3.53$   
 $k = 3.53$   
 $text1 = \text{"Statement"}$   
 $text2 = \text{"Given:"}$   
 $text3 = \text{"To prove:"}$   
 $text4 = \text{"Proof:"}$

Statement: Diagonals of a rectangle are equal.



Given: ABCD is a rectangle, in which  
 $AB \parallel DC, AD \parallel BC$  &  $\angle A = 90^\circ$ .

To prove: Diagonals  $AC = BD$

Proof:

Statements	Reasons
1. In $\triangle BAD$ and $\triangle BCD$ . i) $AD = BC$ (S) ii) $\angle BAD = \angle CBD = 90^\circ$ (A) iii) $AB = AB$ (S)	1. i) Opposite sides of parallelogram. ii) Each angles of a rectangle is right angle. iii) Common sides
2. $\triangle BAD \cong \triangle BCD$	2. By SAS facts
3. $AC = BD$	3. Corresponding sides of congruent triangles are equal

Hence proved.

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## Appendix N

### Teaching Episode 12

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Theorem 11</b> )	Time: 45 Minutes
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

1. **Specific Objectives:** At the end of the class students will be able to;
  - Prove that: If the diagonals of a parallelogram are equal, then it is a rectangle.
2. **Required Materials:**
  - Computer/Laptop, well managed projector lab, white board, marker etc.
  - GeoGebra version 5.0 software should be installed in the computer/laptop.
3. **Classroom Activities:**
  - Revision of previous lesson
  - Teacher will check the pre-knowledge about the relation between parallelogram and rectangle also clarify them by figure.
  - Teacher will write the statement of the theorem “If the diagonals of a parallelogram are equal, then it is a rectangle” and discuss with students.
  - Teacher will be used to GeoGebra software for figure and prove of this theorem. He will demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that, teacher and students both interaction on each other about figure and statement of theorem.
  - Then after teacher will ask some question to students about the statement and discuss with students answers.
  - At last, the teacher will summarize that lesson.
4. **Homework:**
  - MNOP is a parallelogram in which  $MN \parallel PO$ ,  $MP \parallel NO$  and  $MO = NP$ . Prove that: ABCD is a rectangle.

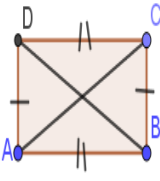
## 5. Appendix: Construction protocol for GeoGebra;

Teaching Episode 12.ggb

File Edit View Options Tools Window Help Sign in

Algebra Graphics

Statement: If the diagonals of a parallelogram are equal, then it is a rectangle.



Given: ABCD is a parallelogram in which  $AB \parallel CD$ ,  $AD \parallel BC$  and  $AC = BD$

To prove: ABCD is a rectangle.

Proof:

Statements	Reasons
1. In $\triangle BCD$ and $\triangle ABC$	1.
i) $AB = CD$ (S)	i) Opposite sides of parallelogram
ii) $BC = BC$ (S)	ii) Common sides
iii) $AC = BD$ (S)	iii) Given
2. $\triangle BCD \cong \triangle ABC$	2. By SSS facts
3. $\angle BCD = \angle ABC$	3. Corresponding angles of congruent triangles are equal.
4. $\angle BCD + \angle ABC = 180^\circ$ $\Rightarrow \angle BCD + \angle BCD = 180^\circ$ $\Rightarrow 2 \angle BCD = 180^\circ \Rightarrow \angle BCD = 90^\circ$	4. The sum of the co-interior is $180^\circ$ .
5. $\angle BCD = \angle ABC = 90^\circ$	5. From (3) & (4)
6. $\angle A = \angle B = \angle C = \angle D = 90^\circ$	6. Opposite angles of a parallelogram.

Thus, ABCD is a rectangle. proved.

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## Appendix O

### Teaching Episode 13

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Theorem 12</b> )	Time: 45 Minutes
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

**1. Specific Objectives:** At the end of the class students will be able to;

- Prove that: If the diagonals of a rhombus are equal, then it is a square.

**2. Required Materials:**

- Computer/Laptop, well managed projector lab, white board, marker etc.
- GeoGebra version 5.0 software should be installed in the computer/laptop.

**3. Classroom Activities:**

- Revision of previous lesson
- Teacher will check the pre-knowledge about the relation between rhombus and square also clarify them by figure.
- Teacher will write the statement of the theorem “If the diagonals of a rhombus are equal, then it is a square” and discuss with students.
- Teacher will be used to GeoGebra software for figure and prove of this theorem. He will demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that, teacher and students both interaction on each other about figure and statement of theorem.
- Then after teacher will ask some question to students about the statement and discuss with students answers.
- At last, the teacher will summarize that lesson.

**4. Homework:**

- PQRS is a rhombus, in which  $PQ=QR=RS=SP$  and  $PR=QS$ . Then prove that PQRS is a square.

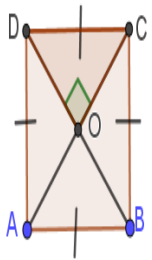
## 5. Appendix: Construction protocol for GeoGebra;

Teaching Episode 13.ggb

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Algebra Graphics

Statement: If the diagonals of a rhombus are equal, then it is a square.



Given: ABCD is a rhombus, in which  
 $AB=BC=CD=DA$  &  $AC=BD$

To prove: ABCD is a square

Proof

Statements	Reasons
1. In $\triangle BCD$ and $\triangle ABC$	1.
i) $AB=CD$ (S)	i) Given
ii) $BC=BC$ (S)	ii) Common side
iii) $AC=BD$ (S)	iii) Given
2. $\triangle BCD \cong \triangle ABC$	2. By SSS facts
3. $\angle BCD = \angle ABC$	3. Corresponding angles of congruent triangles.
4. $\angle BCD + \angle ABC = 180^\circ$ $\Rightarrow \angle BCD + \angle BCD = 180^\circ$ $\Rightarrow 2\angle BCD = 180^\circ \Rightarrow \angle BCD = 90^\circ$	4. The sum of co-interior angles is $180^\circ$ .
5. $\angle A = \angle B = \angle C = \angle D = 90^\circ$	5. Opposite angles of parallelogram are equal
6. $AB=BC=CD=DA$	6. By given
7. ABCD is a square.	7. From statement (5) & (6).

Hence proved.

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## Appendix P

### Teaching Episode 14

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Theorem 13</b> )	Time: 45 Minutes
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

1. **Specific Objectives:** At the end of the class students will be able to;
  - Prove that: the diagonals of a rhombus bisect each other at right angles.
2. **Required Materials:**
  - Computer/Laptop, well managed projector lab, white board, marker etc.
  - GeoGebra version 5.0 software should be installed in the computer/laptop.
3. **Classroom Activities:**
  - Revision of previous lesson
  - Teacher will check the pre-knowledge about the rhombus and its bisectors also clarify them by figure.
  - Teacher will write the statement of the theorem “the diagonals of a rhombus bisect each other at right angles” and discuss with students.
  - Teacher will be used to GeoGebra software for figure and prove of this theorem. He will demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that, teacher and students both interaction on each other about figure and statement of theorem.
  - Then after teacher will ask some question to students about the statement and discuss with students answers.
  - At last, the teacher will summarize that lesson.
4. **Homework:**
  - Write the steps of constructing the theorems “the diagonals of a rhombus bisect each other at right angles” on GeoGebra.

5. Appendix: Construction protocol for GeoGebra;

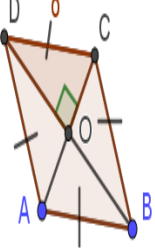
Teaching Episode 14.ggb

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Algebra Graphics

$A = (-5.56, 3.88)$   
  $B = (-3.48, 3.68)$   
  $f = 2.09$   
  $c: (x + 5.56)^2 + ($   
  $d: (x + 3.48)^2 + ($   
  $D_1 = (-4.69, 1.98$   
  $C = (-4.35, 5.58)$   
  $g = 2.09$   
  $e: (x + 4.35)^2 + ($   
  $D = (-6.43, 5.78)$   
  $E = (-3.48, 3.68)$   
  $h = 2.09$   
  $i = 2.09$   
  $j = 2.09$   
  $d_1 = 2.09$   
  $c_1 = 2.09$   
  $b = 2.09$   
  $a = 2.09$   
  $q1 = 3.78$

Statement: The diagonals of a rhombus bisect each other at right angles.



Given: ABCD is a rhombus in which the diagonals AC & BD are intersected at O.

To prove:

i)  $AO=CO$  &  $BO=DO$   
 ii)  $\angle AOB$  or  $\angle BOC$  or  $\angle COD$  or  $\angle AOD=90^\circ$

Proof:

Statements	Reasons
1. ABCD is a parallelogram	1. Being ABCD is a rhombus.
2. $AO=CO, BO=DO$	2. Diagonals of parm. bisect each other.
3. $\triangle BCD$ is an isosceles & OC is median of $\triangle BCD$ .	3. From given $BC=CD$ & being $Ao=Co$ in (2)
4. $\angle COD=\angle BOC=90^\circ$	4. Median of isosceles triangle is perpendicular to the base.

Hence proved.

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Excel 2013

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## Appendix Q

### Teaching Episode 15

Class: IX	Date: .....
Subject: C. Mathematics	No. of Students: 26
Topic: Parallelogram ( <b>Theorem 14</b> )	Time: 45 Minutes
School: Divya Gyan Secondary School Dallu Ktm.	Teacher: Sagar Acharya

1. **Specific Objectives:** At the end of the class students will be able to;
  - Prove that the diagonal divides a parallelogram into two congruent triangles.
2. **Required Materials:**
  - Computer/Laptop, well managed projector lab, white board, marker etc.
  - GeoGebra version 5.0 software should be installed in the computer/laptop.
3. **Classroom Activities:**
  - Revision of previous lesson
  - Teacher will check the pre-knowledge about the relation between parallelogram and congruent triangles also clarify them by figure.
  - Teacher will write the statement of the theorem “the diagonal divides a parallelogram into two congruent triangles” and discuss with students.
  - Teacher will be used to GeoGebra software for figure and prove of this theorem. He will demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that, teacher and students both interaction on each other about figure and statement of theorem.
  - Then after teacher will ask some question to students about the statement and discuss with students answers.
  - At last, the teacher will summarize that lesson.
4. **Homework:**
  - ABCD is a parallelogram in which AC is a diagonals. Then prove that:  
 $\triangle ACD \approx \triangle ABC$ .

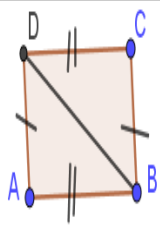
## 5. Appendix: Construction protocol for GeoGebra;

Teaching Episode 15.ggb

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Algebra Graphics

$A = (-3.23, 4.1)$   
 $B = (-0.52, 4.16)$   
 $f = 2.71$   
 $C = (-0.67, 5.87)$   
 $g = 1.72$   
 $h: -0.06x + 2.71$   
 $i: -1.72x - 0.15y$   
 $D = (-3.38, 5.81)$   
 $d = 1.72$   
 $c = 2.71$   
 $b = 1.72$   
 $a = 2.71$   
 $q1 = 4.66$   
 $E = (-2.22, 6.06)$   
 $F = (-2.26, 5.62)$   
 $j = 0.44$   
 $G = (-2.07, 6.1)$   
 $H = (-2.07, 5.68)$   
 $k = 0.42$



Statements: Diagonal divides a parallelogram into two congruent triangles.

Given: ABCD is a parallelogram  
in which AC is a diagonal.

To prove:  $\triangle ABD \cong \triangle BCD$

Proof:

Statements	Reasons
1. In $\triangle ABD$ and $\triangle BCD$	1.
i) $AB=CD$ (S)	i) Opposite sides of parallelogram ABCD.
ii) $AD=BC$ (S)	ii) Opposite sides of parallelogram ABCD.
iii) $BD=BD$ (S)	iii) Common sides.
2. $\triangle ABD \cong \triangle BCD$	2. BY SSS facts.

Hence proved.

Input: \_\_\_\_\_

PowerPoint 2013

1:14 PM  
1/11/2020

## Appendix R

### Score of Pre-test and Post-test

Pre-Test			Post-Test		
S.N.	Experimental Group	Control Group	S.N.	Experimental Group	Control Group
1	19	16	1	22	18
2	18	13	2	22	15
3	18	19	3	23	20
4	16	12	4	19	14
5	17	18	5	20	18
6	13	14	6	18	16
7	18	10	7	21	13
8	20	17	8	24	17
9	15	19	9	19	20
10	15	14	10	19	17
11	18	14	11	21	16
12	16	18	12	18	18
13	18	16	13	21	16
14	14	16	14	18	18
15	18	15	15	21	17
16	9	17	16	16	18
17	10	20	17	19	20
18	9	18	18	16	20
19	11	10	19	22	14
20	18	18	20	22	18
21	11	13	21	18	18
22	15	13	22	19	15
23	18	12	23	20	15
24	19	15	24	22	16
25	16	18	25	20	18
26	18	18	26	21	22
Sum	407	403	Sum	521	447
Mean	15.65	15.5	Mean	20.04	17.19
S.D.	3.27	2.82	S.D.	2.03	2.17
t-value	0.18		t-value	4.83	

## Appendix S

### Scales of student's perception on GeoGebra software

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

S. N.	Items	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1	I have a computer/laptop with GeoGebra software					
2	At the beginning, I didn't like GeoGebra software					
3	I liked studying geometry lesson by using GeoGebra software					
4	GeoGebra software help me, a lot to learn the geometric concepts					
5	GeoGebra is essential and important for geometry teaching					
6	GeoGebra software helps to easy to under-standing geometrical theorems and problems					
7	GeoGebra software helps to visualizing the problems of geometric concepts					
8	GeoGebra software helps to make the learning more enjoyable					
9	GeoGebra software makes geometric classes were boring					
10	Using GeoGebra makes geometry more difficult for me					



## Appendix T

### Guideline for the interview with students

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

1. Give your opinion about GeoGebra software?
2. Why do you like mathematics?
3. Do you understand mathematics teaching in school?  
What are the factors you fell difficult to understand the mathematics?
4. Why ICT/multimedia is necessary to learn mathematics?
5. Do you have computer/laptop at your home?
6. What do know about GeoGebra?
7. Have you heard GeoGebra software before?
8. Do you have internet at your home? How do you use internet for learning mathematics?
9. What are the benefits of GeoGebra for mathematics learning?
10. Give your suggestions to make GeoGebra more effective in learning mathematics?

## Appendix U

## Item Analysis of Objective Test Items

Q. N.	Number of Students																				Right Answers	P % Value	D Value	Remarks
	Upper (27%)					Average (46%)										Lower (27%)								
	1	2	3	4	5	6	7	8	9	10	1	1	1	1	1	1	1	1	1	2				
1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	0	1	0	0	1	1	14	70	0.4	Accept
2	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	19	95	0	Reject
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20	100	0	Reject
4	1	1	1	1	1	1	1	1	0	0	1	1	0	0	1	1	1	1	0	0	14	70	0.4	Accept
5	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	19	95	0	Reject
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	19	95	0.2	Reject
7	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	9	45	0.6	Accept
8	1	1	1	1	1	0	1	1	1	1	1	0	1	0	0	0	0	0	1	0	12	60	0.8	Accept
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	17	85	0.4	Accept
10	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	16	80	0.6	Accept
11	1	1	1	0	0	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	9	45	0.6	Accept
12	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	7	35	0.2	Reject
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	15	75	1	Accept
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	16	80	0.8	Accept
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	16	80	0.8	Accept
16	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	5	25	-0.2	Reject
17	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	7	35	0.2	Reject
18	1	1	1	1	1	0	0	1	0	1	1	1	1	1	0	0	0	0	0	0	11	55	1	Accept
19	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	7	35	0.2	Reject
20	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	1	1	14	70	0.8	Accept
Total Score	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0				

Interpretation Criteria for P Value	
Indicator (%)	Meaning
0-39	Very Difficult
40-60	General
61-75	Substantial
76-90	Easy
91-100	Very Easy

Interpretation Criteria for D Value	
Degree	Meaning
-1-0.19	Negligible
0.20-0.29	General
0.30-0.39	Good
0.40-1	Very Good

Source: (Khanal, 2071)

Appendix V

Item Analysis of Subjective Test Items

Q. N.	Number of Students																				Right Answer	P % Value	D Value	Remarks
	Upper (27%)					Average (46%)										Lower (27%)								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	19	95	0.2	Accept
	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	1	1	0	14	70	0.6	
	1	1	1	1	0	1	1	0	0	1	0	0	0	1	1	0	0	0	0	0	9	45	0.8	
	1	1	1	1	1	0	1	1	1	1	0	0	0	1	0	0	1	0	0	0	10	50	0.8	
																					13	65	0.6	
22	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1	10	50	0.4	Reject
	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	5	25	0	
	1	1	1	0	0	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	8	40	0.6	
	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0	6	30	0	
																					7.25	36.25	0.25	
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20	100	0	Reject
	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	0	19	98	0.4	
	1	1	1	1	1	1	0	1	0	1	1	1	0	1	0	0	1	0	0	1	18	90	0.6	
	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	19	95	0.2	
																					19	95	0.3	
Total	12	10	9	9	9	9	9	9	7	6	6	6	6	6	6	6	6	6	5	5				
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20	100	0	Reject
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	18	90	0.4		
	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	0	17	85	0.4	
	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	17	85	0.4	
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20	100	0	
																					18.4	92	0.24	
25	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	0	1	17	85	0.4	Accept	
	1	1	1	1	1	1	1	0	1	0	1	0	1	0	1	0	0	1	1	14	70	0.4		
	1	1	1	0	1	1	1	1	1	1	1	0	0	1	0	0	0	1	0	0	12	60		0.6
	1	1	1	1	0	0	1	0	1	0	0	0	1	0	1	1	1	0	0	0	10	50		0.4
	1	1	1	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	1	12	60		0.8
																					13	65	0.52	
Total	10	10	9	9	9	9	9	9	9	8	8	7	7	7	7	7	6	6	5	5				