EFFECTIVENESS OF GEOGEBRA IN TEACHING MATHEMATICS IN THE VIRTUAL LEARNING ENVIRONMENT

A

THESIS

BY

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LETTER OF CERTIFICATE

This is to certify that Mr. Rupesh Singh Bohara, a student of academic year 2073/075 with campus Roll No. 508 Exam Roll No. 7328436 and T.U. Registration No. 9-2-327-237-2013 has completed his thesis under supervision of Asst. Prof. Krishna Prasad Adhikari, during the period prescribed by the rules and regulations of Tribhuvan University, Nepal. The thesis entitled **"Effectiveness of GeoGebra in teaching mathematics in the virtual learning environment "** has been prepared based on the results of his investigation conducted during the period of February 2021 to June 2021 under the Department of Mathematics Education, University Campus, Tribhuvan University, Kirtipur, Kathmandu. His thesis number is 1636. I recommend and forward his thesis for the evaluation as the partial requirements to award the Degree of Master of Education.

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Prof. Dr. Bed Raj Acharya

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LETTER OF APPROVAL

This thesis entitled **"Effectiveness of GeoGebra in teaching mathematics in the virtual environment"** submitted by **Mr. Rupesh Singh Bohara** in partial fulfillment of the requirement for the Master's Degree in Mathematics Education has approved.

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RECOMMENDATION FOR ACCEPTANCE

This is to certify that Mr. Rupesh Singh Bohara has completed his M.Ed. thesis entitled **"Effectiveness of GeoGebra in teaching mathematics in the virtual learning environment"** under my supervision during the period prescribed the rules and regulation of Tribhuvan University, Kirtipur, Kathmandu, Nepal. The study embodies the result of investigation conducting during the period of 2020-2021 under the Department of Mathematics Education, University Campus, Tribhuvan University, Kirtipur, and Kathmandu. I recommend and forward his thesis to the Department of Mathematics Education for the final viva-voice.

.....

Asst. Prof. Krishna Prasad Adhikari

Supervisor

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DEDICATION

This work is affectionately dedicated to all the national and international respected professors, lectures, teachers, authors and my respected parents Mr. Laxman Singh Bohara and Mrs. Parwati Devi Bohara and all family members whose support, love, care and sacrifices made me a person who I am now.

DECLARATION

This thesis does not contain any others work which is offensive and beyond the copy write norms. To the best of my knowledge and beliefs this research is truly based on my effort and it does not match with any researches that were published earlier in any institutions. I take all the ethical and legal responsibility for submitting this thesis.

……..

(Mr. Rupesh Singh Bohara)

Date:-……

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First of all, I would like to express my heartiest thanks and most sincere gratitude to my respected supervisor/guide Asst. Prof. Krishna Prasad Adhikari, Department of Mathematics Education, T.U. who provided fundamental ideas and techniques to carry out this research, as a researcher supervisor. Without his immense co-operation and regular encouragement, I would not have been able to preset this dissertation in this form.

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I would like to give heartily thanks to my all friends. I am also thankful to my colleagues for their cooperation and help to completion of this work.

Finally, I am indebted to my family members for their inspiration and assistance throughout my study.

.....

Mr. Rupesh Singh Bohara

ABSTRACT

This study entitled "Effectiveness of GeoGebra in Teaching Mathematics in the Virtual Learning Environment." The purpose of this study was to investigate effectiveness of GeoGebra in teaching geometry at grade X and to explore the perception of students in teaching geometry by using GeoGebra software. The effectiveness was measured by comparing achievement of the students taught by using GeoGebra software and without using GeoGebra software in virtual learning environment out of 30/30 students and perception of students was explored through 7 students' interview. The research was based on constructivist view of learning and the design of this study was quasi-experimental design.

Researcher used purposive sampling and selected two schools from the Kathmandu District. For the data collection researcher used achievement test and interview through online platform. The collected data were analyzed by using mean, standard deviation and t-test for quantitative data and for qualitative data descriptive and analytic methods were used.

The findings of this research showed that there is significant difference between the achievement of student taught by using GeoGebra software and conventional method of teaching mathematics in virtual learning environment. GeoGebra tool can increases the participation of students in teaching and learning activities. Students were very excited for learning mathematics by using GeoGebra software. GeoGebra was very useful for visualization of mathematics and supportive to the students in revision. Due to pandemic of COVID-19, teaching learning environment was changed into virtual environment. So that it was very hard to conduct online classes effectively. Again, the mathematics teaching became more complex through online plat-form. But to overcome this problem, GeoGebra software is very useful and helpful in teaching learning. The conclusion of this research is that the GeoGebra software needs to use at secondary level for meaningful and effective mathematics teaching learning in virtual learning environment.

ABBREVIATIONS

T.U. : Tribhuvan University

CDC : Curriculum Development Centre

ICT : Information and Communication Technology

SPSS : Statistical Package of Social Science

C.G. : Control Group

E.G. : Experimental Group

NCF : National Curriculum Framework

NCTM : National Council of Teachers of Mathematics

ZPD : Zone of Proximal Development

STEM : Science, Technology, Engineering and Mathematics

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CHAPTER I

INTRODUCTION

The introduction section of this study entitled "Effectiveness of GeoGebra in teaching mathematics in the virtual learning environment" consists of a background of the study, statement of the problem, the rationale of the study, objectives of the study, research questions and significance of the study, delimitation of the study and operational definitions of the key terms.

Background of the Study

The term 'mathematics' is derived from the Greek word 'mathema', which means learning or study of science. Mathematics is important in our daily life and in different disciplines such as science, commerce, education, and even in research that mathematical knowledge is very essential. Mathematics is taken as a process of learning and interpreting the natural phenomena of each individual. It has been explained in another way as knowledge of numerical and calculation of part of human life. Different people have different meanings of mathematics. For some, it means basic computational skills for daily life whereas to others; mathematics is the study of abstract systems. Thus, mathematics is the body of knowledge related to the concepts of quantity, structure, space, and change. It is the science of patterns found in numbers, space, science, computers, imaginary abstractions, or elsewhere. Through the use of abstraction and logical reasoning, mathematics evolved from counting, calculation, measurement, and the systematic study of the shapes and motions of physical objects (Pandit, et. al., 2017). Mathematics is the foundation for every subject.

In school-level curriculum, mainly the areas of mathematics are arithmetic, algebra, and geometry. According to National Curriculum Framework 2063, published by the Curriculum Development Center (CDC) written that mathematics is the compulsory subject for the Basic Level of school education, class nine, and ten. And optional subjects for class XI and XII of secondary level (CDC, 2063 BC). 'Geometry" is one of the major parts of mathematics at the school level. The word 'geometry' comes from the Greek word "Geometrian' which means 'measurement of the earth'. It is the study of a spatial concept. In ancient times the nature of geometry was informal but nowadays its nature is more formal.

The twenty-first century is the age of scientific and information communication and technological knowledge and invention. Mathematics education is also directly influenced by the development of technology. Use of ICTs in teaching and learning activities are the genuine issue of the world. Classroom teaching is changed into virtual mode due to COVID-19. So, ICT has become more valuable and useful in this pandemic situation of COVID-19. Throughout the advancement of Information, Communication, and Technology [ICT] the world is experiencing a real revolution in the dissemination of knowledge and the enhancement of instruction of knowledge and enhancement of instruction. ICT makes both the contents of learning and the interactions of high-quality instruction affordable and available at any time and anywhere.

The increasing use of technology in all aspects of society has encouraged confidence. The creative and productive use of information, communication, and technology is an essential skill for life. ICT capability encompasses is not only the mastery of technical skills and competencies but also supports the broader understanding to apply these skills purposefully, safely, and responsibly in teaching-learning, everyday life, and employment. ICT can be used to find developed, analyzed and present information, as well as to model situations and solve problems. ICT enables rapid access to mathematical ideas and experiences from a wider range of people, communities, and cultures, and allows pupils to experience from a wider range of people to collaborate and exchange information on a wide scale (Acharya, 2072 BS). The appropriate use of ICT tools can enhance mathematics teaching and learning, support conceptual development of mathematics, enables mathematical investigations by learners and teachers to influence how mathematics is taught and learned.

Due to the development of many scientific inventions, mathematics teaching in virtual mode is becoming more effective and easy. Some renowned software that is used for teaching mathematics is GeoGebra, Matlab, Mathematica etc. Among of them, GeoGebra is one of the easy, useful, and most popular software for teaching and learning in school-level mathematics in the virtual learning environment.

GeoGebra is dynamic mathematics software for all levels of education that brings together geometry, algebra, spreadsheets, graphing, statistics, and calculus in one easy-to-use package. Users of GeoGebra software are increased in huge amounts

in this pandemic due to COVID-19. GeoGebra is a rapidly expanding community of millions of users located in just about every country. GeoGebra has become the leading provider of dynamic mathematics software, supporting science, technology, engineering, and mathematics (STEM) education and innovations in teaching and learning worldwide. Quick facts about GeoGebra are: Geometry, Algebra, and Spreadsheet are connected and fully dynamic, Easy-to-use interface, yet many powerful features, authoring tool to create interactive learning resources like web pages, available in many languages for our millions of users around the world, open-source software (www.geogebra.org,2015)

Statement of the Problem

This interchange of conceptions suggests a central place for the computer in our culture, which the often heard, but rather dismissive remark, "it's just a tool", can underestimate. Mathematical concepts and logic lie at the heart of the computer's function; it comes as no surprise that the study of mathematics and the use of ICT may be profitably intermingled. The concepts of algorithm, function, operation, and set all have a concrete manifestation in the world of computers to parallel their abstraction in mathematics (Richard Millwood, 2015).

Mathematics includes verbal and non-verbal aspects. Mathematical discourse revolves around different subjects. Teachers who teach geometry must develop great skills in the formal part of the subjects and integrate them into verbal explanations that have specific wording in geometry, as well as non-verbal aspects. This obligates teachers to have high discourse capabilities, be suitably qualified, in order that they can fulfill the role of mediators between contents and learner. Using innovative pedagogy it will be possible to guarantee to reach required goals, as well as the quality of teaching-learning-evaluation processes (Kivkovicha, 2015).

Generally, geometry is supposed complex subject matter for the students and teachers both in the context of Nepal. Even there was a problem in physical classes to teach meaningfully but now the classroom teaching is changed into virtual mode due to the COVID-19. So, the mathematics teachers and students were facing the problem of meaningful and effective teaching-learning activities. To overcome this research is intended to determine the effect of GeoGebra assist instruction and traditional

method. The experimental research questions, is there effectiveness of GeoGebra in teaching Geometry in the virtual model of teaching-learning? Does achievement differ significantly when GeoGebra is used? These were taken as the statement of problems. Most of the researches are related to the geometry of secondary and lower secondary levels for the use of teachers but I also conducted my research in 'Area of triangles and quadrilaterals of geometry at Secondary Level (Grade-X). Because of the pandemic situation due to COVID-19 schools were closed and students were not getting a chance to learn with teachers and teachers were facing different problems to conduct effective teaching learning activities in virtual palate form. So, I thought that how the teachers can run interactive and meaningful activities easily in virtual teaching? and how the students can learn themselves using GeoGebra? Researcher reviewed the literature as much as possible and I didn't get any research for this purpose in Nepal. Therefore, researcher decided to research "Effectiveness of GeoGebra in teaching mathematics in a virtual learning environment" for teachers and the use of students as a self-study material whereas this research will support students' conceptual and meaningful learning in mathematics in the virtual learning environment.

Objectives of the Study

The main objective of this study was to find the effectiveness of GeoGebra in teaching mathematics in the virtual environment. This has been accomplished by the following objectives:

- To compare the achievement of students taught by using GeoGebra with the achievement of students taught by using conventional/traditional methods.
- To explore the student's perceptions towards the use of GeoGebra in teaching learning mathematics.

Justification of the Study

There are many affecting factors in teaching mathematics in the virtual learning environment. Expansion and use of ICT in teaching is one of them. Many students take mathematics as a difficult and boring subject because they have a lack

conceptual understanding, connection with daily life, and motivation in learning mathematics. In the physical class, you could teach using materials by showing the objects, but online it is difficult. GeoGebra is one of the worldwide useful mathematics software which helps to make effective teaching. So, if we teach geometry by using GeoGebra then students will able to understand conceptually and clearly. We can experiment and visualize the concept of mathematical content by using the applet of GeoGebra. Hence, this study signifies the following aspects:

Mathematics Teachers: The findings of the study help the teachers who are teaching geometry at the secondary level and especially in the virtual environment. It gives an idea to choose the materials and methods for the teaching while in classroom teaching and virtual teaching. It helps to empower the teachers. In the same way, it gives creative ideas to manage ICT-based classrooms and apply the technology in the teaching pedagogy.

Students. It will be very beneficial and helpful to provide an opportunity to explore and build up new conceptual and meaningful learning for the students.

Schools. The findings of the study will be beneficial and helpful to schools to be aware of the contemporary issues of teaching mathematics in the physical classes and the virtual environment in this pandemic of COVID-19.

The Researcher. It will be the source of research and helpful for those who are doing research in the teaching field.

Educational Planner. It will be helpful for the governments who are planning for the development of education policy. It will be helpful for the implementation of the use of ICT in effective virtual classes. It will be helpful for the implementation of the use of ICT in education.

Hypothesis of the study

A hypothesis is a tentative explanation that accounts for a set of facts and can be tested by further investigation (Muijs, 2004). Hypothesis of the study refers to a prediction about what the researcher expects to find. Thus, it is stated in the form of expected relationship between variables. Researcher used Research hypothesis and Statistical hypothesis in this study.

Research hypothesis. The use of GeoGebra Software provides effective results in terms of students' achievement in mathematics teaching compared to the traditional/conventional approach.

Statistical Hypothesis. The statistical hypothesis of this study are;

- H0: $\mu 1 = \mu 2$
- H1: $\mu 1 > \mu 2$

(Where $\mu 1$ is the average achievement of student of the experimental group and $\mu 2$ is the average achievement of the control group)

Delimitation of the Study

The research was related to the effectiveness of GeoGebra in teaching mathematics in the virtual environment. The delimitations of this study were as follows:

- This research was focused on the effectiveness of GeoGebra only.
- The study was conducted in two schools in the Kathmandu district.
- The research verged on experimental design with the purposive sampling method.
- It was only confined to secondary level subject matters of class X geometric with the topic "Area of Triangles and Parallelograms".
- Test items, Questionnaires, and interviews were tools to generate primary data.
- The experimental periods were just for fifteen hours only.
- The research was conducted in the virtual platform.

Operational Definition of the Key Terms

Curriculum. In this study, the curriculum is defined as the curriculum of compulsory Mathematics of secondary level, which is prepared by the CDC of the Nepal Government.

Conventional teaching method. In this study, teacher-centered teaching methods where teachers explore the subject matter, solve the mathematical problems of the students are said to be a Convectional Teaching Method. Teachers as givers

and students as the receiver is considered as the Conventional Teaching Method.

Traditional teaching method. The traditional teaching method is that where a teacher directs students to learn through memorization and recitation techniques without developing their critical thinking problem solving and decision-making skills. In my research, the traditional teaching method refers to the lecture method, demonstration method, and problem-solving method without using GeoGebra.

ICT-based learning method. In my research, the teaching method where teachers can use different types of mathematical software and tools for meaningful and conceptual learning of mathematics. The class with the audiovisual presentation with dynamic teaching materials. The class with the interaction and collaboration between teachers and students.

Effectiveness. In this study, effectiveness is defined in terms of increment in a score of students in mathematics, positive change in motivation, the increasing rate in participation of students in the mathematics classroom, increment of the average achievement in mathematics.

Control group. The group that doesn't receive any experimental treatment is called the control group. It is the group that is not exposed by any independent variables. In this study, a group of students who were taught without using GeoGebra software was considered as Control Group.

Experimental group. A group of students who were taught by using dynamic materials/ applets prepared by dynamic software GeoGebra in a mathematics classroom was considered as an experimental group in this study. The group which is given independent variable treatment or is exposed to some independent variable is called the experimental group.

GeoGebra. GeoGebra is the worldwide dynamic and interactive software on geometry, algebra, statistics, calculus application, designed for teaching and learning from school to university level which helps to visualize the concept of mathematics.

Data. In this study, the information which was collected during the process of research was considered as the Data.

CHAPTER- II

REVIEW OF RELATED LITERATURE

This section deals with the review of related literature and focuses on the different effectiveness use of GeoGebra software in teaching mathematics which provides the knowledge of previous attempts and what has happened, established, known, or studied yet. A literature review is a compact written summary of journal, articles, books and the other document that portray the past and current state of information on a research topic which is going to be studied (W. Creswell, 2014).

Likewise, the literature review is a secondary material. It is a continuous process that starts before select the research problem and continues till complete research. It requires doing innovative research, to avoid repetition, and to fulfill the gap in researches. The literature review is an integral part of the research process and makes a valuable contribution to almost every operational step. Different journals, articles, books, published and unpublished thesis and other documents that describe that past and present information (Ranjit, 2017, p. 48).

The main purpose of the literature review is to find the gap between known and unknown things. Also, the benefits of the literature review are to find how the research problem is new and what is the gap or what works have been done as well as what has not been for future research. The researcher reviews the literature by organizing the empirical, theoretical and conceptual framework from books, articles, thesis, journals, online documents, and different web from international and national.

So, I had collected the different unpublished thesis, some books, journals, articles, researches that are related to use of ICT in teaching-learning mathematics. By a deep study of these reports, I had reviewed the following literature as academic writing.

Review of Empirical Literature

Keong, Horani and Danil (2005) carried out the survey to investigate the use of ICT and barriers of integrating ICT into the teaching of mathematics with the main objective to help mathematics teachers in the integration of ICT into their mathematics and science in English under the teaching and learning by the Ministry

of Education since 2003. With the help of 111 responses, the researcher used SPSS statistical tool, and the questionnaire was adopted from the teacher technology survey by the AIR, 1998. The researcher concluded that as these barriers an e-portal for teaching mathematics through the use of ICT in teaching mathematics enhance clear concepts about any subject matters either students or teacher.

In another study, Kemp (2006) found that high-ability Grade IX boys felt the lesson was interesting. Students explored their learning beyond what was assigned by the teacher and were happy and engaged in the lesson using GeoGebra software. The teacher was able to identify students who faced challenges in such a setting and did not engage in the lesson; therefore it was suggested that further strategies need to be incorporated to motivate most students.

The major findings and conclusion of this literature are researchers found that GeoGebra is the best teaching and learning material or application tool in mathematics. These researches show that the effect of technology and the effect of Software is positive in the mental ability of the learner. The level of understanding also increases and the learner is more motivated in the Geometry learning at the Secondary Level. According to the current trends where technologies are increasing very rapidly and in this context education sector also going to improve. During the use of GeoGebra, the teacher must be careful of their time and students' perceptions also their interest and capacity. In Nepal, it is smoothly increasing its use in teaching mathematics. In the above reviews there is briefly did research use of GeoGebra in Geometry shape and its content at the Secondary level.

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

Domenech (2009), conducted the research 'Influence of dynamic geometry software on plane geometry problem-solving strategies', stated that the dynamic geometry software, GeoGebra has influenced learners in the matter of learning geometry throughout the use of GeoGebra. He had concluded that learning geometry with GeoGebra has incredible especially for the learning of plane geometry.

Dogan, (2010) carried out an experimental design study using a pre-posttest to evaluate the success of students learning using the GeoGebra software. It was a twelve-hour course held for a period of two weeks involving two eighth grade classes. It was observed that computer-based activities can efficiently be used in the learning process and the GeoGebra software encouraged higher-order thinking skills. The software was also observed as having a positive effect in motivating students toward learning and retaining their knowledge for a longer period. This was proven based on a recall test conducted a month late.

Zakaria (2012), conducted research entitled "Teacher's Perceptions toward the use of GeoGebra in the Teaching and Learning of Mathematics". Department of Educational Methodology and Practices, Faculty of Education, University Kebangsaan Malaysia, Bangui, Selangor, Malaysia. In this study, approximately 20% of Malaysian students failed to achieve the minimum benchmarks in mathematics. In addition, students do not understand mathematical concepts and lack the necessary skills in problem-solving. The purpose of this study was to examine teacher's perceptions toward the features and tools in GeoGebra. Approach: A GeoGebra workshop was conducted involving 30 secondary school teachers. This study employed a quantitative survey method that uses a questionnaire to collect data. Descriptive statistics were used to gauge teachers' perceptions toward the software during a GeoGebra workshop. The findings showed that teacher's perceptions toward GeoGebra features were at a moderate level (M=3.53). The teacher's perceptions toward the basic construction of geometry and the transformation angle were at a high level, with a mean of 3.85 and 3.78. Teacher's perceptions toward coordinates and equations, functions, and exporting of images were at a moderate level, with a mean of 3.57 and 3.59. The findings indicate that teachers have positive perceptions toward the use of GeoGebra. Conclusion: Based on the findings of this study, GeoGebra can

and should be used as an alternative to promote the use of technology in the teaching and learning of mathematics.

Acharya (2015) had done the research on "Effectiveness of GeoGebra Software on Mathematics Achievement" for the fulfillment of a Master's Degree in Mathematics Education. The aim of this study was to find the effectiveness of GeoGebra software on the Mathematics Achievement. He adopted a pretest-posttest nonequivalent control group. He selected the two secondary schools of the Kathmandu District. He selected, grade X, 28 students of Panga Secondary School as Experimental Group and 5 students of Jansewa Secondary School as Control Group. After one week of the experiment, concluded that; Experimental Group had better achievement than the control group. A five-point Likert Scale was used to find out the perception of students about the GeoGebra in Mathematics teaching. Also, It indicates that using GeoGebra in teaching and learning geometry is helpful for students and also it increases the students 'achievement. The result of the questionnaire of the above study gave a positive perception about GeoGebra software. Therefore, GeoGebra-based learning is better than the traditional method for better understanding. From the review above, this literature established GeoGebra is one of the open-source mathematical software and it is beneficial for teachers. Also, another study shows that ICT was effective as compared to the traditional method in secondary level for teaching mathematics. Therefore, using ICT in teaching and learning mathematics is as effective as the traditional method.

Bhandari (2015), did research on “Effectiveness of GeoGebra-assisted Instruction in mathematics at secondary level”, with the objective to find the effectiveness of GeoGebra-assisted instruction on the students’ achievement in reflection and rotation at the secondary level. The researcher chooses 25 students of grade IX as an Experimental group and 23 students as a control group, after one week of experiment Researcher gathered data. Also, a five-point Likert-type scale was applied for fostering students’ motivation. This research shows that the students in the experimental group performed significantly better than the students in the control group and the students who were taught by GeoGebra-assisted instruction were more motivated towards the convectional study.

Lamichhane (2017) had done research with the topic "Effectiveness of GeoGebra on students' Achievement in Geometry". The researcher has used 39 students from Shree Chhabdi H.S. School, Shuklagandaki-10 for the control group and 36 students from Shree Gaubfarkodaya H.S. School, Shuklagandaki-8 for the experimental group from grade X in parallelogram and circle by using GeoGebra. After completion of the targeted chapters, the researcher collected the data from the mathematics achievement test and a set questionnaire related to the five-point Likert scale. The conclusion of this study shows the student in the experimental group performed better when using GeoGebra than the control group. The mixed research design was used by the researcher.

Bist (2017) conducted the research on "Use of GeoGebra in Geometric Construction". The objectives of this study were to compare the achievement of students taught by using Geogebra and the traditional approach and to explore student's attitudes towards the use of GeoGebra in geometric construction. To achieve the objectives, a 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 constriction regarding student's achievement and students' attitudes towards the use of GeoGebra on geometric construction. There was a 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 students' achievement was explained by the use of GeoGebra. A set of questionnaires specification grid, national goal of secondary mathematics of CDC 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 reconstruct their state of knowledge and enforces them to engage in inquiry-based activities such as searching application of construction. The result was positive attitudes towards the use of GeoGebra in geometric construction. The use of GeoGebra enables students to work independently by up-rising their curiosity.

Gajurel (2018) had done the research on "Effectiveness of Geogebra in Teaching Geometry". The purpose of this study was to find out the effect of Geogebra in teaching Geometry and to explore the students' attitude about GeoGebra. For this

study, purposive sampling and selected two schools from the Dhading district. In this research, the pretest-posttest experiment was done in teaching geometry. Analysis of questionnaire responses indicated a positive perception about GeoGebra in learning Geometry.

GeoGebra had proven as an effective software to use Geometry teaching in secondary level mathematics. Training should provide to the teacher for using the GeoGebra.

As I mentioned already that the main purpose of the literature review is to find the gap between known and unknown things. Also, the benefits of the literature review are to find how the research problem is new and what is the gap or what works have been done as well as what has not been for future research. So, from the above empirical reviews, I conclude that maximum researches conducted in the use of GeoGebra in teaching-learning mathematics focus only on the use of the teachers in physical classes but my research focuses on the use of GeoGebra for both the teachers and students in the virtual environment.

Theoretical framework

The education system, teaching and learning process, teachers, teaching material, learning environment as well as students should be according to the demand of time and situation. That should be similar to the worldwide environment. They should mostly care about the student's learning capacity, prior knowledge, and their interest and proper environment, etc. There are many theories related to human development and their learning such as Behaviorist theory, Constructive theory, Social Constructivist theory, Cultural theory, Humanist theory, and intellectual development theory, etc.

My study was based on Vygotsky's social constructivist perspectives, because knowledge is actively constructed by students while they are making construction and analyzing figures instead of knowledge being passively received and accepted. The Zone of Proximal Development (ZPD), in the learning of Area of triangles and quadrilaterals in Geometry, the more skilled students used to assist their peers with information and manner of constructing diagrams and the more capable students were

able to fill in gaps in their peers‟ knowledge or explanations what they have missed. The peers have gained a different insight and developed a different manner of understanding the concept of the Area of triangles and quadrilaterals.

Additionally, when working in groups due to the differing ZPD of each student, they may have differing views; therefore through interaction with peers, they can achieve shared understanding. However, in such a situation, there must be a balance in terms of the insights and ideas contributed by each group member; it is important to have shared views and justifications of opinions to reach mutual understanding. This enables all students to participate in critical thinking skills because one's cognitive development becomes apparent when new views and ideas are taken into the current cognitive states (Leong, 2013).

At the conclusion, a constructivist classroom may contain the following four characteristics: cognitive exploration to encourage inquiry and direct hands- on, minds- on activities; student autonomy where students are in charge of their own learning; social interaction where students work together in groups with opportunities for cognitive conflict; and student- centered where students‟ ideas and opinions are important. In this respect, it can also be concluded that the role of students here is more active than a teacher. The teacher stays as only a facilitator.

Vygotsky developed a "zone of proximal development" which was the difference between what a child is taught by others. He believed that children learn through social interaction and by learning to solve problems with others, he named this process is "scaffolding" (Vygotsky, 1978). The study will draw upon the constructivist theory of social interaction for cognitive development. The main principles will anchor on the zone of proximal development (ZPD) and scaffolding. Students generally have challenges in understanding mathematical concepts; therefore in this study, the GeoGebra software was introduced as a scaffold to enhance student understanding of the Area of triangles and quadrilaterals. The ZPD is described as the variance between one's mental age and the level one might attain in problem-solving with guidance. Scaffolding refers to the guidance provided for one to reach the ZPD. In this study, the GeoGebra software basically acts as the primary scaffoldin assisting and guiding the students to reach their ZPD. The students were required to work in pairs to construct diagrams and make observations based on their constructions.

Students formed their own interpretations through shared understanding with the guidance of the GeoGebra where they were able to explore and visualize on their own. On top of that, the teacher and peers also played a part in the scaffolding process. The teacher advocated instructional intervention at the beginning of the lesson to introduce the software tools to enable the students to work in pairs on their own using the step-by- step guide without the teacher's assistance. The teacher's role hereafter is more of a facilitator, to encourage students to actively participate in the lesson and make significant connections. This relates to Paget's work, where he stressed the need to provide formal instructions to assist students to reach a developmental stage where they are able to accommodate and assimilate the student opportunities to guide one another and reach a level of shared understanding.

Vygotsky's theory is very closely related to the learning classroom where he forces social interaction and cultural environment to play a vital role in the development of the cognitive level of a human being. The mind's primary function is to create and see things in a way that is organized into a schema that helps the mind to see them as being real (Piaget, 1980).

This takes the place of individual capacity to learn and develop new knowledge. In my study, students will place in groups where the scaffolding process takes place for them to learn the "Area of Triangles and Quadrilaterals" on the pre-knowledge and help of GeoGebra and with the peer discussion student can generalized and develop the understanding of mathematical concepts. In this process, students will take part as active participants and the role of the teacher will be just facilitator. Which can help to the students to critical thinking skill as a student contributes ideas and view to understand the common knowledge.

In my research, I was an instructor and the learners were active to construct the knowledge in the teaching and learning process. I used to encourage students to constantly assess how the activity is helping them to gain understanding. I gave them ever-broadening tools to keep learning. I used the GeoGebra classroom with dynamic materials for the students to practice and learn themselves. Students used to play with the GeoGebra applet in the GeoGebra classroom with a well-planned virtual classroom environment, I tried to make the interaction between teacher and students

and students and students. I encouraged the learning and reflection process. Overall, I tried to create an environment of learning by doing according to their level.

Conceptual framework

The conceptual framework has been established on the basis of the research topic, possible areas to fulfill the objectives of the study. It is a compulsory part of the research because it gives the direction to the researcher to complete their work. Systematically, comparatively and analytically. The researcher follows the reviewer's conceptual framework as a necessary component. So, the study entitled "Effectiveness of GeoGebra in teaching Mathematics at Secondary Level" will follow the following sketch conceptual framework to fulfill the objectives which are constructed by using the empirical literature review and theoretical literature review.

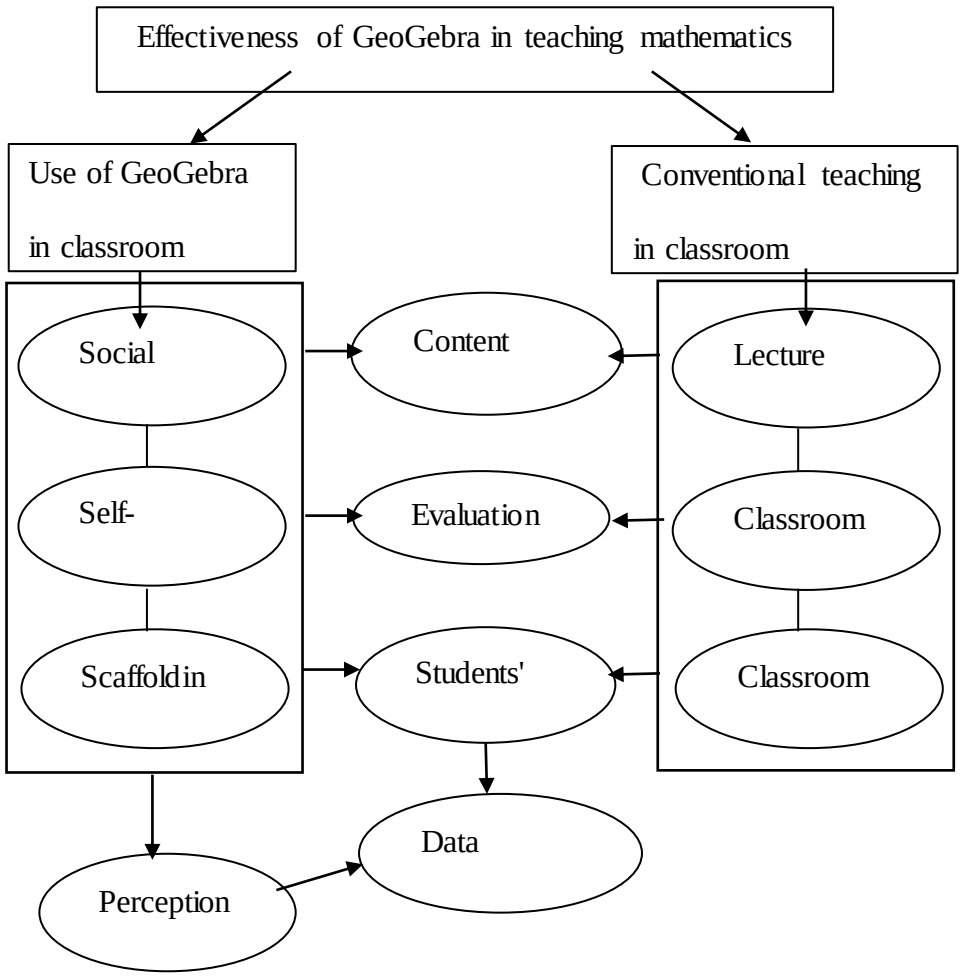

Figure 2.1 Conceptual framework

Conceptual framework consisted of the relationship between a dependent variable and independent variables and the process of the whole study. I used social constructivism theory to construct the conceptual framework. To make the mathematical classroom effective, there must be a collaboration between teacher and learner. There were two classes for the study; one was taught by using the conventional method and another class was taught by using GeoGebra.

According to the above Conceptual Framework, for the experimental group, knowledge was constructed from social interaction, self-exploration, and scaffolding linking new knowledge to the learner's existing knowledge. The teacher started the class by motivating the students. Then, with the help of GeoGebra software, the teacher entered the contents creating a proper environment for social interaction and self-exploration. The researcher gave the idea to construct knowledge on the basis of interaction and self-exploration.

At last, the researcher helped as a facilitator to fill ZPD, repeating the same cycle every day which followed the process of action, interaction, and reflection. On the other hand, for the control group, the teacher taught the student by conventional or traditional method every day following the lecture, discussion, and exercise. The teacher observed and noted the student perception by the behaviors shown by them towards the use of GeoGebra software for the experimental group. After the completion of the lesson, researcher took the examination to evaluate. The researcher got the achievement of the students of both the control group and experimental g The researcher compared the achievement of both groups and reached the conclusion.

CHAPTER III

METHODS AND PROCEDURES

Research methodology is the most important part of research work. It is a bridge to achieve the objectives of the study in systematic way. Simply, it is a way of gathered information. Authenticity and reliability of any research depends upon the tools and methods used for data collection. This chapter gives the clear and concrete direction to answer the research questions to achieve the objectives and to summarize the findings of the study on the basis of conceptual framework. In this chapter, design of the study, sample, variable, tools and experimental phase were mentioned as below.

Design of the Study

Research design is the design of the path of the research. It is the detailed path of the investigation. Thus, research design compares the overall strategy followed in collecting and analyzing data (Gay, Mills and Airasion, 2012). The research design is the detailed plan of the whole study. In fact, it is the blueprint of the detailed procedure of performing the experiment, testing the hypothesis and analyzing. With the obtained data and summarizing the finding, the study clearly follows the quantitative approach. Due to the world pandemic COVID-19, schools were running in the virtual environment. As my research topic, I collected data through online platform for this research.

To fulfill the objectives of the study, the researcher followed a quasi-experimental design to compare the achievement of students taught by GeoGebra assisted classroom and conventional classroom, and explore the student's perception towards the use of GeoGebra. Among various types of quasi-experimental design, the researcher selected "pretest-posttest non-equivalent group design" because this design is often used in classroom experiments when experimental and control groups were such naturally assembled group's intact classes (Best & Khan, 2009). According to Gay et al (2012), in experimental research, the researcher manipulates at one independent variable, other relevant variables and observes the effect on one or more independent variables. According to the hypothesis, the pretest was taken through Google-form to find students' label of understanding before treatment, and post-test

was administrated to find the difference of achievement between the experimental and control groups after the treatment. After testing the validity and reliability of test items, correct questions were used in the Pre-test and Post-test of the experimental group and control group. To explore the perception of students about GeoGebra, the researcher took the interviews with seven students of the experimental group. Separate achievement test items were used through Google-form to measure the label of understanding by including test items from ninth course content and to measure the achievement of students after the treatment by including test items from tenth course content. The paradigm of the study was as follow:

Table 1: Design of the study

Groups	**Pre-test**	**Treatment**	**Post-test**
Experimental	P_1	T_1	P_2
Control	P_3	T_2	P_4

To fulfill the study, the researcher made two groups of students from homogenous as possible by selecting schools of similar status and focusing same cognitive structure of students to control extraneous variables.

According to this design, P1 and P2 represent the pre-test and post-test respectively for the experimental group and P3 and P4 represent the pre-test and post-test respectively for the control group. The researcher took the same achievement (pre-test) of both groups before treatment. A pre-test for both groups was used to assess similarities between the two groups. After the pre-test, the researcher taught the experimental group regularly by using GeoGebra software known as treatment T1. But researcher taught to control group regularly by using the conventional method known as treatment T2. At the end of experimentation time, an achievement test was conducted for both group and researcher compared and analyzed their score by using the statistical tool.

Selection of Teaching Episodes

For this study, the researcher developed fifteen episodes for the teaching of fifteen days. All fifteen episodes were constructed from the geometry of class X. Ten

teaching episodes were taken from the area of triangle and quadrilateral from geometry and five episodes were taken from the chapter circle, after complication of the chapter to fulfill fifteen episodes. These lesson plans were constructed on the basis of the constructivist approach to learning. The major steps of the episodes were discussion and demonstration respectively. The expert judgment and the mathematics curriculum of grade X had measured the validity of these instruments. By addressing the suggestions provided by the experts, the constructed episodes were finalized for teaching and learning.

Internal Validity. An experiment has internal validity to the extent that the independent variables that have been manipulated actually have a genuine effect on the dependent variables. Many factors play a key role to decrease the effect of manipulated variables upon independent variables. Effects of controlling such types of variables ways are following discuss:

History. Events outside of the study/experiment or between repeated measures of the dependent variable may affect participants' responses to experimental procedures. Often, these are large-scale events (natural disaster, political change, etc.) that affect participants' attitudes and behaviors such that it becomes impossible to determine whether any change on the dependent measures is due to the independent variable, or the historical event. To control this variable, the researcher did it in a short time period.

Subject characteristics. First of all, subject characteristics are one of the possible threats to internal validity in the present study. The characteristics of subjects matter which may affect the internal validity. Students who participated in the study were from the same grade level, so their ages were closed to each other. So, these characteristics have not influenced the results accidentally.

Selection bias. Selection bias is likely to affect the internal validity results when the researcher makes a comparison between the non-equivalent experimental and control group. It is another treat to the experiment. But in this study, the equivalency of two groups at the beginning of this study was censure by the analysis of pretest results.

Experimental mortality. Experimental mortality means the loss of subjects during the period of experimentation. To control this threat, the researcher discussed with the administration of the schools the selection of the group and make sure that all students will not leave the class in the research period.

External validity. External validity is the extent to which the variable relationship can be generalized to other treatment variables, other measurement variables, and other populations (Best and khan, p. 171, 2009). The possible factors that affect the external validity and their controls are discussed as below:

Pre-test Treatment Interaction

The pre-test made the participants more aware and sensitive to the treatment. Therefore, it influenced the response to the treatment. To control this effect, the researcher took pre-test and post-test in the period of fifteen days.

Multiple Treatment Interaction

If participants of the research group receive more than one treatment, the effect of the prior treatment can affect or interact with later treatment. To overcome this, a single treatment was used in the experimental group.

Phases of Experiment

These experiments were completed in three phases. They were pre-experimental phase, experimental phase and post experimental phase.

Pre-experimental phase. This phase is the planning phase of the study. The period before the experiment is known as the pre-experiment phase. In this phase, the researcher prepared the achievement test, teaching episode, the daily lesson module, slides of teaching, teaching materials, learning about school, and validation of the modules with the help of experts and the curriculum of grade X. Also, the researcher prepared pre-test, administration of pre-test in population, analysis of pre-test result then make ready for the experiment.

Experimental phase. This phase is the main phase of the study. In this phase, the researcher taught in both groups. The researcher taught by conventional teaching method for the control group and taught by using GeoGebra software for the

experimental group with the help of teaching episodes. There were fifteen lesson modules. The researcher conducted a post-test after the completion of the lesson.

Post-experimental phase. This phase is the final phase of the study which begins after the completion of the Experimental phase. At this stage, the researcher compared and analyzed the pre-test and post-test by using statistical tools. Also, the feeling of the students was noted by the researcher through observation.

Population and Sample

This study was based on grade X, students of Kathmandu district defining as the experimental group and control groups. At that time there was no lockdown after the first phase of the corona virus. So, the researcher conducted a pre-test physically. Due to the lack of economic sources, socio-cultural environment, a pandemic of the corona virus and time, the researcher conducted the pre-test in five different Secondary Schools of Kathmandu by convenience sampling method to find the homogenous group. Out of them, the researcher selected two secondary schools having homogenous groups for research after the analysis of pre-test. According to the quantitative research, two schools were selected to find the effectiveness of GeoGebra in mathematics teaching and learning at the secondary level in the virtual environment. After the selection of two schools, the researcher selected the Experimental Group from students of Creative Academy and Control Group from students of Ujjwal Shishu Niketan Academy according to the convenience of the researcher as a secondary level mathematics teacher of both schools.

Variables

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

An independent variable is an attribute or characteristic that influences or affects an outcome or dependent variable. A dependent variable is an attribute or characteristic that is dependent on or influenced by the independent variable (Creswell, 2012). Its meaning is if one variable depends upon another variable that is

term as a dependent variable and the variable that is antecedent to the dependent variable is known as the independent variable. Variables that are not related to the purpose of the study but may affect the dependent variable are known as extraneous variables. The variables of my study will classify as follow:

Independent variables. In this study, dynamic software GeoGebra while teaching geometry in the area of triangles and quadrilaterals in class X was an independent variable.

Dependent variables. In this research, the achievement of students and perceptions of the students towards the use of GeoGebra in teaching-learning on the area of triangles and quadrilateral in class X was the dependent variable.

Extraneous variables. In this research, selection of school, instructor, subject matter, selection of teaching materials, school environment, the discipline of the students, experimental time, students' labor, home environment, availability of the device, internet access, electricity, maturation of student and test was considered as extraneous variables.

Control mechanism for extraneous variable. Many research conclusions of the experimental research were open to question due to the influence directly or indirectly of extraneous variables (Best & Khan, 2006). The researcher should control the extraneous variable to ensure the validity of the result of the research. In my research, two schools were selected in the sample which had a similar mean. The same test papers were conducted for both groups before the experimentation. The researcher had been teaching in both the schools as a secondary level mathematics teacher. So, the researcher had been requesting guardians or parents to manage the devices, internet and betty back up for one year ago during the pandemic of coronavirus disease session one. Required devices and materials were managed and students were habitual in online classes from the first lockdown due to pandemic situation created by corona virus disease. minimize the extraneous variable. Students and researcher used to turn on their webcam, compulsorily. There were system of assignment submission through Google classroom, viber and messenger. The researcher had taught the chapter geometry in the area of triangles and quadrilaterals in class X for both groups in the experimental period. Similarly, the researcher had

provided equal time to both groups and the same test papers were conducted for both groups after the experimentation. In this way, the extraneous variable was controlled.

Treatment Mechanism

Two schools were selected after taking a pre-test of five schools. Two schools that had near mean were select for two types of groups. Then, the researcher had taught 15 lessons according to the teaching hours of geometry in the area of triangles and quadrilaterals in grade X recommended by CDC. Also, the researcher had taught the following lesson plan, teaching episode and GeoGebra programs to the experimental group but for the control group researcher had taught by conventional teaching and learning method. The researcher had used GeoGebra software in teaching-learning and also, students were enrolled in GeoGebra classroom and given GeoGebra applets to do self-study for the experimental group. To find the students perception towards the use of GeoGebra software for teaching, the researcher had taken interview.

Data Collection Tools and Instruments

There are many tools or instruments to collect the data. It depends on the research design. In this study, the following data collection tools were used for the collection of the data, Such as; questionnaire, attitude scale, interview schedule, checklist, rating scale, interview, achievement test, etc. Among them, the researcher had conducted achievement tests and interview to fulfill the first and second objectives respectively. The researcher had conducted achievement tests for both the group as pre-test and post-test and interviews were taken for the experimental group after treatment to find the perception of the students in term percentage. Brief information about achievement tests and interviews are presented below:

Achievement test. The researcher had conducted an achievement test through an online platform by using Google forms to fulfill the first objective of the study which is "To compare the achievement of the students taught by using GeoGebra and traditional method in geometry in the area of triangles and quadrilaterals in class X". Achievement were categorized as pre-test and post-test. They were in parallel form. The researcher had pointed out the theorems, problems relating to the area of triangles and quadrilaterals in class X. The pre-test was constructed from class 9. For that

contain was related to basic knowledge of the area of triangles and quadrilaterals. The achievement test was constructed from the same content. On the basic, that topic four-level (knowledge, understanding, application skill, and higher ability) including five different skills (verbal, visual, drawing, logical and application). In this study, the researcher had conducted a pilot test among the students of grade X at similar schools in the near area. That school will not contain in sampled school. The pilot test was conducted before the study. This was helpful to minimize the error of the tool and which was helpful to conduct the test in the correct way.

Interview guideline. After the administration of the questionnaires, a semi-structured interview was taken by the researcher to identify the student's perception towards the effectiveness of GeoGebra in teaching geometry at the secondary level on the basis of creativity, curiosity, independence, and visual thinking dimensions. Questions had collected the student's concept, understanding, belief, and detailed description of the students to the use of GeoGebra in mathematics teaching.

Item analysis of the Test

In the item analysis, the difficulty level (P-value) and discrimination index (D-value) of the test were computed to check which items accept for the achievement test and to check the quality of the test item. The researcher had conducted the pilot test in similar schools in the same area which schools were not included in the sample. The researcher had conducted a pilot test in Mangal Secondary School, Kirtipur for pre-test and in South Valley English School, Kirtipur for post-test. By using the statistical tool, the researcher had computed the P-value and D-value. Then, the researcher had modified and canceled the items according to the result of P-value and D- value. From the test items of achievement test for pre-test, there was decided that the two items question number 19 and question number 32 were eliminated. Because Q.No.32 had a p-value of 0%, so it can't able to measure the achievement level of students as well as Q.No.9 has a 100% p-value, so it may also can't able to measure the level of knowledge of students. Similarly, from the test items of achievement test for post-test, there was decided that the four items, question numbers 35, 36, 41, and 44 were eliminated. Because their p-value was 0%, so they can't able to measure the achievement level of students and it may also can't able to measure the level of

knowledge of students. After canceling and modifying the items, the redefined instruments of achievement tests were prepared for pre-test and post- test.

Reliability and validity of achievement test

In this study, the researcher had conducted the pilot test on grade X students of a Secondary School in Kathmandu who were not select for the sample. There are two types of reliability - internal and external reliability. Internal reliability assesses the consistency of results across items within a test. External reliability refers to the extent to which a measure varies from one use to another. To determine the reliability of the test, the researcher had founded internal consistency of the achievement test by using a correlation coefficient. To test the correlation coefficient, the Split half method was applied and the reliability of the achievement test was founded. Every researcher attempts to achieve maximum validity in his/her research work. To make a significant contribution to the development of knowledge, an experiment must be valid (Best and khan). The validity of the achievement test was determined by using the specification grid and expert judgment.

Selection of teaching materials

The authoritarian textbook was chosen for teaching and learning. The researcher had prepared a chart of figures, slides from PowerPoint. The other required material was question papers in Google form which were created by the researcher himself. The researcher had managed the main device laptop and GeoGebra software 5.0 himself. Fortunately, with the help of one institute, the researcher got an opportunity to use Smart Board to apply the GeoGebra software properly.

Data Collection Procedure

The researcher collected the data for this research from the primary source. For this purpose, the researcher visited each sampled school along with achievement tests, requested letters from T.U. to get full support from the administration. After that, the researcher requested the headmaster and subject teacher for the experiment. The researcher took the pilot test at Mangal Secondary School Kirtipur, Kathmandu which was a non-sampled school student to ensure the reliability of the test.

The researcher selected five higher secondary schools for the pre-test. According to the analysis of pre-test and being a Secondary level mathematics teacher

of both schools named Creative Academy, Kirtipur, Kathmandu and Ujjwaj Shishu Niketan Academy, Sahidpath, Kirtipur, Kathmandu then researcher selected two homogenous schools among five schools. The researcher separated these schools respectively experimental and control groups by tossing the coin. The experimental group was treated with GeoGebra assist teaching methods and the control group was treated with the conventional method. After the treatment on both groups, the researcher took the post-test from both groups and analyzed the post-test and pre-test result in mean, standard deviation, and t-test.

After treatment of the experimental group, the researcher took the interview of seven students to know the perception of students towards GeoGebra after completion of the experiment of classes. For the interview, questionnaires were based on creativity, curiosity, independence, and visual thinking. The researcher also used their own experience and observation to construct questionnaires.

Data Analysis and Interpretation Procedure

The researcher analyzed and interpreted the obtained data by using different statistical techniques. After the completion of the data collection procedure, the researcher started data analysis. For the achievement test, the statistical device of Mean, Standard Deviation, and t-test was applied to find the difference in the two groups. In fact, Mean, Standard Deviation, and t-test were used to compare the effectiveness of GeoGebra in the area of triangle and quadrilateral at grade X. The researcher had used means to generalize the data analysis. There were altogether 60 students in the analysis of two groups. So, the researcher used a two-tailed t-test at 0.05 level of significance is the 60? Degree of freedom to calculate t-value, whether the difference of mean is statistically significant or no by using the method pooled variance formula.

Semi-structured interviews were tools to know the perception of students about GeoGebra. Student's views were collected from the interview. The researcher interpreted the views of students. To analyze the qualitative data, thematic analysis was adopted. The researcher had done a transcription of the data, coding the data, and organized the data in a similar code selection.

Ethical considerations

Ethical Consideration is very important to be considered by researchers while collecting information. So, the researcher considered informants' personal matters, organization's own rules. The informants weren't be imposed to give answers. They were requested at their own pace. This study was conducted for the academic purpose while collecting data, ethical considerations were ensured for the primary data privacy. The researcher took permission from the school administration of schools. With regarding this study, the researcher was clearly informed of his objectives to respondents. The researcher built trust with the respondents. The researcher didn't bias socially, culturally, ethically while selecting the schools as the research sample. The researcher did respect the respondent's answers. He did not use the data for another purpose except his research.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

The most important part of the study is to analyze the collected data from the raw score of the students of pretest and posttest of the two groups, control and experiment. This chapter conveys the analysis and interpretation of the data collected through achievement tests and interviews. Each hypothesis discussion entails a discussion of the test conducted and findings from data. For the purpose of analyzing all types of statistical data, statistical formulas were used to set at the 0.05 confidence level.

This is experimental research related to the effectiveness of GeoGebra in geometry teaching at the secondary level. The objectives of this research were to compare students' achievement of experimental and control groups and to explore students' perceptions towards the use of GeoGebra in teaching mathematics in the virtual environment.

For the data collection procedure, the researcher administered the achievement tests. The researcher had collected the above information and analyzed it under the following headings:

- Comparison of the achievement of students in the GeoGebra assist learning and conventional learning group in the pretest.
- Comparison of the achievement of students in the GeoGebra assist learning and conventional learning group in the posttest.
- Explore the perception of the students about the GeoGebra in teaching geometry.(Teaching episodes are included in Appendix H)

Comparison of Achievement of Students in the Pretest

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

They were computations of the mean and standard deviation of the marks obtained by using formula. The calculated mean, standard deviation, and t-value on the pretest result are shown in the following table,

Table 2: Comparison of Achievement of Students in the Pretest

Group	Sample	Mean	Standard Deviation .	Calculated t-value	Decision
Experimental	30	19.666	5.504	0.032	There is no significance difference.
Control	30	19.566	5.250		

In the above tables present the mean and standard deviation of both GeoGebra assist learning and conventional learning groups on the pretest. The mean score of GeoGebra assist learning was 19.666 out of 30 with a standard deviation of 5.504 and that of the conventional learning group was 19.566 out of 30 with a standard deviation of 5.250 The calculated t-value of the above data was 0.032. This shows that t=0.032, which was less than the table value 1.96 at 0.05 level of significance. This indicated that the differences between these two groups were not significant at 0.05 level of significance. Therefore, the GeoGebra assist learning group and conventional learning group were at the same level of achievement at the beginning of the study.

Comparison of the Achievement of Student in Post-test

In this section, the researcher took the post-test of the experimental group and control group both. After the completion of the experimental phase, with a gap of fifteen days, a post-test was taken. Administered test items were used in post-test after the pilot test. The purpose of the post-test was to compare the achievement between experimental and control groups. The post-test score of students of GeoGebra assists the learning group and conventional learning group with work

involved in the 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 are shown in the following table:

Table 3: Comparison of the Achievement of Student in Post-test

Group	Sample	Mean	Standard Deviation	Calculated t-value	Sig. (2-tailed)	Decision
Experimental	30	35.66	3.83	3.607	0.001	There is significant difference.
Control	30	30.8	7.62			

The above tables present the mean and standard deviation of both GeoGebra assist learning and conventional learning groups on post-test. The mean score of GeoGebra assist learning was 35.66 out of 30 with a standard deviation of 3.83 and that of the conventional learning group was 30.8 out of 30 with a standard deviation of 7.62. The measure of mean shows that the achievement of the experimental group or GeoGebra assist group is better than that of the conventional group after the experiment. The standard deviation of the experimental group shows more uniform than that of the conventional group because the small standard deviation means a high degree of uniformity of the observation as well as homogeneity of the series. The calculated t-value was found 3.607. This shows that $|t|=3.607$, which is greater than the table value 1.96 at 0.05 level of significance. Also, it shows t-value 3.607 and p-value $0.001<0.05$ implies that there is significance difference between the mean achievement of the experimental group or GeoGebra assisted group and the conventional group. So, the null hypothesis is rejected and concludes that there is a significant difference between the achievement of students taught by GeoGebra assist teaching and conventional or traditional method teaching. Hence, the GeoGebra assist learning group had better achievement than the conventional learning group at the post-test.

Perception of Students about the GeoGebra Assisted Teaching

GeoGebra is dynamic software for learning mathematics. The researcher used GeoGebra software for 15 episodes of teaching Geometry ‘Area of Triangles and

Quadrilaterals'. Students were very excited to learn and participated actively in teaching-learning activities. To find out the perception of the students towards the use of GeoGebra, the researcher took semi-structured interviews with the students. Among the 30 students in the Experimental Group, the researcher took the interview with seven students. The perception of students presented by the sample students was discussed in the following headings:

GeoGebra for conceptual learning. The researcher used GeoGebra software for all teaching episodes. While asking students, "What difference did you get learning in conventional teaching and GeoGebra assist teaching?" Respondent's views were;

Respondent A: *"In conventional teaching, I learned mathematics by practice without any good logic but now I learned mathematics by understanding the actual concept. I can memories these theorems of Geometry 'Area of Triangles and Quadrilaterals' for a long time. I feel very interesting in the GeoGebra classroom for self-study. I found many more differences in teaching."*

Mathematics classes become very fruitful by using GeoGebra with the help of a smart board. Geometry is one of the important sectors of mathematics. Students can learn mathematics by visualization. It helps for concept formation and long-term memorization.

In the same way, the response of the next interviewer was;

Respondent B: *"I feel very good to learn mathematical content in the GeoGebra assist class because I can easily understand the mathematical concept and I feel easy to memorize instead of the conventional classroom."*

The above responses showed that GeoGebra assist teaching is becoming very helpful to the learners for conceptual learning. Students were very excited and happy in learning. They were able to say and write what they learned means improvement of learning. GeoGebra is dynamic software for teaching-learning activities. We can visualize the mathematical concept. It is a very great innovation in the field of mathematics teaching. It is very supportive for learning mathematics for students and teachers as well.

GeoGebra for visualization of mathematical problems. There were fifteen episodes of experimental classes for the teaching "Area of Triangles and Quadrilaterals". Each episode was visualized. Students were able to see the mathematical content not only practice of problems.

Respondents were feeling excited and said "*Angles, sides, triangles, parallelograms are moving and overlapping, how? Can we extend the geometrical figure as our wish? We haven't seen moving of geometrical figure till now."*

GeoGebra is visualizing software. It has the properties that every geometrical concept can be taught in visualizing. The researcher found that visualization of mathematical contents helps to the students for better understanding and conceptual learning. Not only the area of triangles and quadrilaterals, but we can also visualize circle, trigonometry, probability, algebra, statistics, etc.

GeoGebra as a self-study tool and motivator for Geometry learning. In the GeoGebra assist class, students were enrolled in the GeoGebra classroom. They were involved in interaction and solving mathematical problems with friends as well as teachers. They were interested in practice problems of mathematics. Respondents say *"We like to practice mathematics through the GeoGebra classroom and applets. Also, asked that 'Is it possible for all topics of mathematics to learn through the GeoGebra classroom? How did you make these videos? Is it possible to make videos through GeoGebra Classroom? Can we interact audibly and visually?"*

Motivation is also a major part of learning. Without motivation, there is not any good possibility of mathematics learning. Deci and Ryan (2000) said that "*To be motivated means to be moved to do something"*. So, students should be motivated in learning.

Without motivation, learning is not possible. Students' perception of success in learning mathematics is highly related to their motivational attitudes. Teachers' actions, attitudes, and instructional design quality for mathematics lessons have greatly influenced students' motivation (Middleton & Spanias, 1999). This shows that GeoGebra motivates students in learning mathematics. Also, it provides self-study materials too. If the students are motivated, they start to do self-study. It increased the faculty level of students in mathematics. All topics of geometry may not be drawn by

pen and paper. In such a case, GeoGebra can provide a clear concept of such topics by visualization. GeoGebra software helps learners to develop geometrical reasoning skills and geometrical concepts. The students were motivated by the teacher as they would feel that the mathematics class becomes interesting. When the teacher uses only board and marker or online teaching tools, students may not be motivated to study always. For the improvement of student's achievement, there must provide a concept of the topics and students should be given self-study tools and materials. The teacher should provide a clear concept about the mathematical contents.

Students of the twenty first century, are not passive listeners and only receivers. They want to participate and need the value of learning in the classroom which is very good in teaching-learning. They are much updated on the development of science and technology. We should provide them technological knowledge too for their learning. Project work, individual presentation, visualization of the topic, interaction, recognition in the class should be given to the students. GeoGebra is the most essential software to be a tactful teacher. It also encourages students in learning mathematics as well as other subjects too.

GeoGebra is a bridge to link Geometrical concepts to another field of Mathematics. Mathematics is a multi-dimensional subject. Each and every subject is linked with mathematics. Students were asking excitedly about GeoGebra assist teaching that "*Sir, is it possible to learn arithmetic, algebra, statistics, probability, etc. with the help of GeoGebra?"*

It shows that students were wanted to find out the relation between geometry and other topics of mathematics. With the help of GeoGebra, there are very possibilities of finding the relations between mathematical topics.(www.bartely.com ,2015), Mathematics is a core subject for children to study in school. It is a subject where the skills that you acquire will equip you for the rest of your life. In mathematics, there are many different areas of the curriculum, and teachers across the country use different methods to teach. However, these methods would not be as effective if the teachers did not have a good experience of teaching mathematics and being confident with the subject knowledge. It is also important to have a positive attitude towards mathematics and high expectations for your children if they are to succeed.

GeoGebra for student's participation in learning. GeoGebra is dynamic software for teaching-learning mathematics. While GeoGebra assists the class run by the researcher, all the students participated in teaching-learning activities. Students were interested to learn more topics in most of the episodes. They have shared their views with the researcher that "*Sir, keep using this software in mathematics class for other chapters if possible. I enjoy doing mathematics work with applets of the GeoGebra classroom. Will you teach us other mathematics topics also by using GeoGebra?"*

It ensures that there was well participation of students in learning. Most of the students used to submit their answers to the teacher in the Google classroom. In the experimental class, there wasn't a homework-related problem. Students were self-motivated to do their tasks regularly. So, they used to involve in classroom activities actively. There was very good co-operation and interaction between students to students and students to teacher. GeoGebra helped to make the positive attitudes of students towards learning mathematics.

Students have positive perceptions towards GeoGebra assist teaching. The researcher taught for fifteen episodes in the experimental group. There were many more changes in students' behavior, such as; active participation in the classroom, interest in doing classwork, regular homework submission, submission of classwork, interaction with friends to friends, and as a teacher as well. The researcher asked the respondents about their perception towards the GeoGebra assist teaching and learning. One of the respondents: C said *"I feel GeoGebra software is very effective in learning mathematics. It has given us a very clear concept about the area of triangles and quadrilaterals. I hope we'll do better in the upcoming secondary school examination (SEE). It would be better if we could learn always by using GeoGebra in mathematics class."*

So, it ensures that research found that students were very satisfied and happy learning mathematics with GeoGebra software. They enjoy the GeoGebra classroom to practice themselves as well.

They were sharing that they understood the mathematical content very well. Students can understand mathematics by using GeoGebra applets as visual materials.

The use of materials has positive effects on learning mathematics. When students were asked how the software affected them, they had many positive things to say, such as it made them more curious, engaged in the learning, and enabled them to think at higher levels.

Discussion

In summary, the respondents whose views were positive towards the use of GeoGebra in mathematics teaching and learning, their performance was also better in posttest than that of in pretest. The average score of the students of the experimental group who were taught by using GeoGebra is more than the students of the control group taught by the conventional method. There is not an only better result of respondents of the experimental group who were taught by using GeoGebra; also, their involvement in classroom activates were far better than the students of control group taught by the conventional method. The researcher got the students of the experimental group who were taught by using GeoGebra to be motivated in self-study through GeoGebra applets in the GeoGebra classroom as well. In a similar study, Kemp (2006) found that high ability Year 9 boys felt the lesson was interesting, and students were able to explore their learning beyond what was assigned by the teacher and were happy and engaged in the study. Furthermore, a study by Leong (2013) on form six students in a Malaysian secondary school discovered that using Geometer's Sketchpad software had positive effects on students‟ achievement and attitude toward mathematics. We conclude that GeoGebra software is effective in secondary level mathematics teaching and there is a very positive perception of students towards the use of GeoGebra in mathematics teaching-learning.

CHAPTER V

FINDINGS, CONCLUSIONS AND IMPICATIONS

This chapter gives the summary of the study, finding, conclusion, and recommendation for educational implication and recommendation for further study. This is experimental research based on the topic "Effectiveness of GeoGebra in teaching mathematics in the virtual environment." To analyze and interpret the effectiveness of GeoGebra, two objectives were conducted; to compare the achievement of the students in teaching geometry taught by using GeoGebra and without GeoGebra and to explore the perception of students towards GeoGebra software in the teaching area of triangles and quadrilaterals. This study was based on a quantitative research design where the researcher had selected quasi-experimental design as pre-test, treatment and post-test non-equivalent design. To analyze the objective of this research study on the effectiveness of GeoGebra software, the researcher had selected two private schools Creative Academy for experimental groups and Ujjwal Shishu Niketan Academy for the control groups at Kirtipur Municipality in Kathmandu district. Mathematics achievement tests and interviews were used as data collection tools. At first, a pre-test was conducted on both groups and found the same achievement score on both groups. Post-test was conducted after fifteen teaching episodes in the experimental group by using GeoGebra software and the traditional method in the control group. Mathematics achievement tests and interviews were used as data collection tools. The reliability of the tools was determined by using the validity of the test tools was insured by expert judgment and supervision of the supervisor of this study. The reliability of these tools was determined by using statistical formulae. The data obtained from the pre-test and post-test were analyzed through statistical tools such as mean, standard deviation, variance, and t-value.

From the analysis of data obtained by pre-test, post-test, and interview to students, the researcher found that students were very satisfied and happy learning mathematics with GeoGebra software. They enjoy the GeoGebra classroom to practice themselves as well.

They were sharing that they understood the mathematical content very well. Students can understand mathematics by using GeoGebra applets as visual materials

in the virtual environment. The use of materials have positive effects on learning mathematics in virtual platform. When students were asked how the software affected them, they had many positive things to say, such as it made them more curious, engaged in the learning, and enabled them to think at higher levels. The average score of the students of the experimental group who were taught by using GeoGebra is more than the students of the control group taught by the conventional method.

Finding of the Study

After analyzing the data obtained by pre-test, post-test, and interviews, the researcher found the following points as the finding of the study:

- In pre-test, the mean score of GeoGebra assist learning was 19.666 out of 30. The standard deviation of 5.504 and that of the conventional learning group was 19.566 out of 30 with a standard deviation of 5.250.
- The calculated t-value of the above data of pre-test was 0.032. This shows that $|t|=0.032$, which was less than the table value 1.96 at 0.05 level of significance.
- The GeoGebra assist learning group and conventional learning groups were at the same level of achievement at the start of the study.
- In post-test, the mean score of GeoGebra assist learning was 35.66 out of 30 with the standard deviation of 3.83 and that of the conventional learning group was 30.8 out of 30 with a standard deviation of 7.62.
- The calculated t-value of data of posttest was found 3.607. It shows that $|t|=3.607$, which is greater than the table value 1.96 at 0.05 level of significance. Which shows that there is significance difference between the mean achievements of the experimental group or GeoGebra assisted group and the conventional group.
- The p-value was found 0.001. The p-value $0.001<0.05$ implies that there is significance difference between the mean achievement of the experimental group or GeoGebra assisted group and the conventional group.
- The null hypothesis is rejected and concluded that there is a significant

difference between the achievements of students taught by GeoGebra assist teaching and conventional or traditional method of teaching.

- The researcher found that visualization of mathematical contents helps the students for better understanding and conceptual learning in the virtual learning environment.
- GeoGebra increased the faculty level of students in mathematics.
- GeoGebra software helps learners to develop geometrical reasoning skills and geometrical concepts.
- The students were motivated by the teacher as they would feel that the mathematics class becomes interesting.
- GeoGebra is also important to have a positive attitude towards mathematics and high expectations for your children if they are to succeed.
- It ensures that research found that students were very satisfied and happy learning mathematics with GeoGebra software. They enjoy the GeoGebra classroom to practice themselves as well.
- Students can understand mathematics by using GeoGebra applets as visual materials.
- The respondents whose views are positive towards the use of GeoGebra in mathematics teaching and learning, their performance is also better in posttest than that of in pretest.
- The average score of the experimental group students who were taught by using GeoGebra is more than that of the control group taught by the conventional method.
- Researcher got the students of the experimental group who were taught by using GeoGebra were motivated in self-study through GeoGebra applets in GeoGebra classroom as well.
- GeoGebra software is effective in secondary level mathematics teaching and there is a very positive perception of students towards the use of GeoGebra in mathematics teaching-learning.

Conclusion

This study aims to compare the achievement of students taught by using GeoGebra with the achievement of students taught by using conventional/traditional methods and explore the student's perceptions towards the use of GeoGebra in teaching-learning mathematics. This research is valuable researches in mathematics teaching. GeoGebra plays a significant role in the improvement of achievement in teaching mathematics. The achievement of the experimental group was better than the control group. Students have a positive perception towards GeoGebra assist teaching. Students were motivated in learning mathematics. GeoGebra helped students with conceptual learning and for revision by self-study. The use of GeoGebra in the learning area of triangles and quadrilaterals increased overall student motivation, engagement, and achievement. There was in-depth participation of students in classroom interaction and problem-solving. GeoGebra plays the role of ZPD of the student and the level of understanding was increasing. GeoGebra helped students to unlock their hidden talent. It would be better if the curriculum development center includes the GeoGebra at the secondary level. The use of GeoGebra in the teaching area of triangles and quadrilaterals has proven the best strategy in geometry teaching in a virtual environment for better construction and better understanding than the conventional approach in the context of Nepal. The use of GeoGebra software is very effective in the virtual teaching-learning environment in the present context of the world.

Implications of the study

After analysis the data, derive the finding and conclusion of this research, the major implications of this study are listed below:

- This study will be useful to the different schools and institutions.
- This type of research can be done in other primary, basic and higher level of education.
- The teacher should motivate the weak students and praise them to participate in teaching learning activities by using the GeoGebra.
- This software can be used in the other branch of mathematics such as

arithmetic, algebra and statistic etc.

- This software can be used as the instructional materials in teaching learning activities in mathematics class.
- The GeoGebra software can be used as a interactive teaching-learning material in the virtual environment.
- GeoGebra software can be used as the pedagogy of teaching.
- Teachers, students, researcher, educationist study this research and they can design the teaching method by using GeoGebra.
- It can be used for the education policy maker.

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APPENDICES

Appendix: A

Table 1: Design of the study

Groups	**Pre-test**	**Treatment**	**Post-test**
Experimental	P_1	T_1	P_2
Control	P_3	T_2	P_4

Table 2: Comparison of Achievement of Students in the Pretest

Group	Sample	Mean	Standard Deviation .	Calculated t-value	Decision
Experimental	30	19.666	5.504	0.032	There is no significance difference.
Control	30	19.566	5.250		

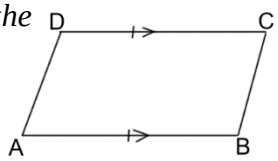
Table 3: Comparison of the Achievement of Student in Post-test

Group	Sample	Mean	Standard Deviation	Calculated t-value	Sig. (2-tailed)	Decision
Experimental	30	35.66	3.83	3.607	0.001	There is significant difference.
Control	30	30.8	7.62			

Appendix:B

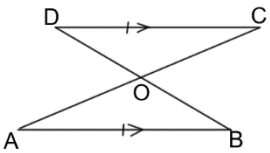
Items For Pre-Test: [FM: 32× 1=32]

1) *In quadrilateral ABCD, AB∥DC and AB = DC. What is the Relation between AD and BC?*



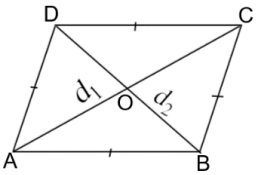
   a) *AD∥BC*
   b) *AD = BC*
   c) *Options a) and b) both*
   d) *None of above*

2) *In the figure alongside, AB∥DC and AB = DC. What is the relation between AC and BD?*



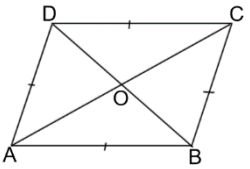
   a) *AC = BD*
   b) *AC⊥BD*
   c) *BD* $=\frac{1}{2}AC$
   d) *AC and BD bisect each other at O.*

3) If d_1 *and* d_2 be the lengths of diagonals of parallelograms given alongside, what is the formulae to calculate the area of the parallelogram?



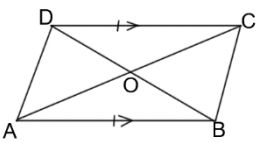
   a) $\frac{1}{2}d_2^2$
   b) $\frac{1}{2}d_1 \times d_2$
   c) $\frac{1}{2}d_1^2$
   d) Options a) and c) both

4) *In the figure alongside, ABCD is a rhombus. What is the relation between diagonals AC and BD?*



   a) *AC and BD bisect each other*
   b) *AC = BD*
   c) *AC⊥BD*
   d) *Option a) and c) both*

5) *In the figure alongside, AB∥DC, AB = DC. If AC and BD bisect each other, what forms ABCD?*



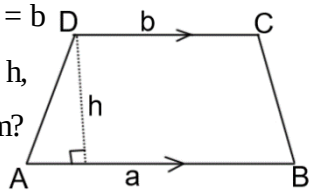
   a) *Quadrilateral*

b) Parallelogram

c) Rhombus

d) Trapezium

6) In the figure, ABCD is a trapezium. If AB = a, DC = b and perpendicular distance between parallel lines is h, what is the formula to calculate area of the trapezium?



a) $\frac{h}{2}\ ab$

b) $a \times b$

c) $\frac{h}{2}(a+b)$

d) $\frac{h}{3}(a+b)$

7) If base of a triangle is x cm and height of the triangle is y cm, how much is the area of the triangle?

a) $xy\ cm^2$

b) $\frac{1}{2}xycm^2$

c) $2xycm^2$

d) $\frac{1}{3}xy\ cm^2$

8) If the length of a side of a equilateral triangle is a cm then how much is the area of the triangle?

a) $\frac{\sqrt{3}}{4}\ a^3cm^2$

b) $\frac{\sqrt{3}}{4}\ a^5\ cm^2$

c) $\frac{\sqrt{3}}{4}\ a\ cm^2$

d) $\frac{\sqrt{3}}{4}\ a^2\ cm^2$

9) If base of a parallelogram is a cm and height of the parallelogram is b cm, how much is the area of the parallelogram?

a) $ab\ cm^2$

b) $\frac{1}{2}abcm^2$

c) $2abcm^2$

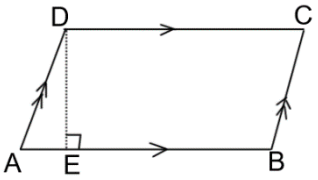
d) $\frac{1}{3}ab\ cm^2$

10) *If there are x cm and y cm long diagonals in a rhombus then how much is the area of the rhombus?*

a) $xy\ cm^2$ *c)* $2xy\ cm^2$

b) $\frac{1}{2}\ xy\ cm^2$ *d)* $\frac{1}{3}xy\ cm^2$

11) In the figure alongside, ABCD is a parallelogram. If $DC = 8\ cm$ and area of the parallelogram is $28\ cm^2$, Find the length of DE.



a) 6 cm c) 4 cm

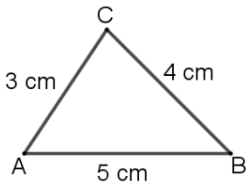
b) 5 cm d) 7 cm

12) *If the length of a side of a equilateral triangle is 3 cm then how much is the area of the triangle?*

a) $3.8\ cm^2$ *c)* $3.89\ cm^2$

b) $3.9\ cm^2$ *d)* $3.98\ cm^2$

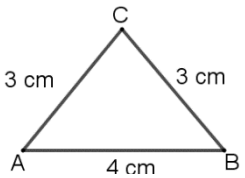
13) *How much is the area of given triangle alongside?*



a) $6\ cm^2$ *c)* $6.11\ cm^2$

b) $6.10\ cm^2$ *d)* $6.01\ cm^2$

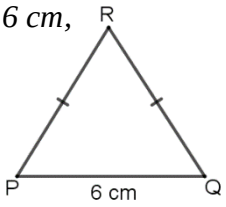
14) *How much is the area of triangle given alongside?*



a) $4.57\ cm^2$ *c)* $4.37\ cm^2$

b) $4.47\ cm^2$ *d)* $4.67\ cm^2$

15) *If the area of an isosceles* $\Delta\ PQR$ *is* $12\ cm^2$ *and base PQ is 6 cm, find the length of equal Sides of the triangle.*



a) 4 cm *c) 2 cm*

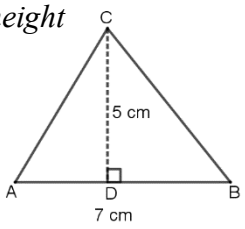
b) 3 cm *d) 5 cm*

16) *If the area of equilateral triangle ABC is* $16\sqrt{3}\ cm^2$ *then how long is the side of the triangle ABC?*

a) 8.01 *cm* *c)* 8.1 *cm*

b) 8.001 cm *d)* 8 *cm*

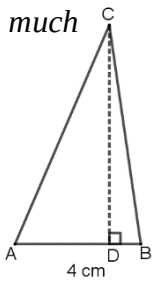
17) *In the figure given alongside, base of* Δ *ABC is 7 cm and height is 5 cm. How much is the area of* Δ *ABC?*



a) $17.5\ cm^2$ c) $17.005\ cm^2$

b) $17.05\ cm^2$ d) $17.0005\ cm^2$

18) *If the area of* ΔABC *is* $14\ cm^2$ *and length of* AB *is* $4\ cm$, *how much Is the height of the* ΔABC?



a) 7.5 cm c) 7 cm

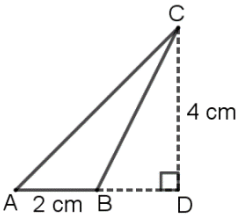
b) 7.05 cm d) 7.005 cm

19) *If the length and breadth of a rectangular land is 15 m and 10 m respectively, find the area of the land.*

a) $25\ m^2$ c) $125\ m^2$

b) $150\ m^2$ d) $105\ m^2$

20) *How much is area of triangle ABC given alongside?*



a) $8\ cm^2$ c) $2\ cm^2$

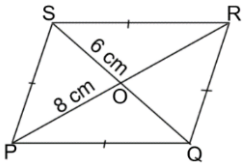
b) $4\ cm^2$ d) $4.5\ cm^2$

21) *If the altitude of a triangle is 5 cm and base is* $4\sqrt{2}\ cm$ *then how much is the area of the triangle?*

a) $20\sqrt{2}\ cm^2$ c) $5\sqrt{2}\ cm^2$

b) $10\sqrt{2}\ cm^2$ d) $40\sqrt{2}\ cm^2$

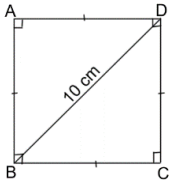
22) *In the figure given alongside, PQRS is a rhombus. If diagonals PR = 8 cm and QS =6 cm, how much is the area of the rhombus?*



a) $24\ cm^2$ c) $48\ cm^2$

b) $12\ cm^2$ d) $6\ cm^2$

23) *If base and height of a parallelogram are 6 cm and 5 cm respectively, how much is the area of the parallelogram?*



a) $30\ cm^2$ c) $20\ cm^2$

b) $15\ cm^2$ d) $10\ cm^2$

24) *In the figure alongside ABCD is a square. If the length of diagonal AC Is 10 cm, find the area of the square ABCD.*

a) $25\ cm^2$ c) $60\ cm^2$

b) $30\ cm^2$ d) $50\ cm^2$

25) Area of a parallelogram is 48 cm^2. If base of the parallelogram is 6 cm then how much is the height of the parallelogram?

a) 16 cm *c) 6 cm*

b) 4 cm *d) 8 cm*

26) If there are 3 cm and $4\sqrt{2}$ cm lengthy diagonals in a rhombus then how much is the area of the rhombus?

a) $12\sqrt{2}\ cm^2$ *c) $24\sqrt{2}\ cm^2$*

b) $6\sqrt{2}\ cm^2$ *d) $3\sqrt{2}\ cm^2$*

27) There are 3 m and 4 m lengthy parallel lines in a trapezium. If distance between the parallel lines is 2 m then how much is the area of the trapezium?

a) $8\ m^2$ *c) $14\ m^2$*

b) $6\ m^2$ *d) $7\ m^2$*

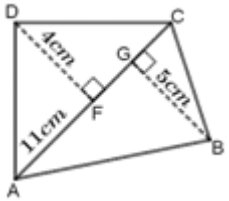
28) Area of a trapezium is $18\ cm^2$. If there are 3 cm and 6 cm lengthy parallel lines in the trapezium then how much is the distance between the parallel lines?

a)

b) 3 cm *d) 4 cm*

c) 6 cm *e) 2 cm*

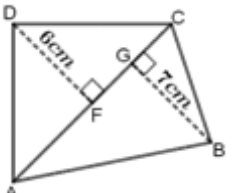
29) How much is the area of the quadrilateral given alongside?



a) $44\ cm^2$ *c) $27.5\ cm^2$*

b) $55\ cm^2$ *d) $49.5\ cm^2$*

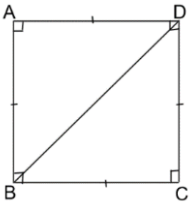
30) If area of the quadrilateral ABCD is $52\ cm^2$, FD = 6 cm and BD = 7 cm then how long is the diagonal AC?



a) 4 cm *c) 6 cm*

b) 8 cm *d) 9 cm*

31) If the area of a square ABCD is 144 cm^2, find the length of side Of the square.



a) 10 cm c) 12 cm

b) 11 cm d) 14 cm

32) If the area and perimeter of rectangular land are 240 m^2 and 62 m respectively, find the length and breadth of the land.

a) l = 24 m and b = 10 m

b) l = 40 m and b = 6 m

c) l = 60 m and b = 4 m

d) l = 20 m and b = 12 m

Appendix : C

Score of Pre-Test

S.N.	Score of Experimental Group	S.N.	Score of Conventional Group
1	16	1	23
2	21	2	20
3	12	3	15
4	22	4	26
5	8	5	21
6	12	6	14
7	26	7	27
8	22	8	16
9	24	9	24
10	16	10	25
11	25	11	17
12	28	12	23
13	23	13	28
14	22	14	22
15	25	15	13
16	15	16	19
17	26	17	12

18	22	18	23
19	16	19	18
20	27	20	8
21	16	21	14
22	24	22	26
23	25	23	22
24	18	24	24
25	19	25	16
26	15	26	13
27	23	27	23
28	18	28	21
29	8	29	12
30	16	30	22
SUM	590	SUM	587
Average	19.66	Average	19.56
S.D.	5.50	S.D.	5.25

Appendix : D

Score of Post-Test

S.N.	Score of Experimental Group	S.N.	Score of Conventional Group
1	39	1	23
2	39	2	39
3	39	3	28
4	37	4	38
5	38	5	39
6	39	6	34
7	39	7	27
8	36	8	39
9	33	9	40
10	39	10	38
11	34	11	32
12	32	12	35
13	37	13	36
14	34	14	17
15	38	15	31
16	39	16	21
17	31	17	36
18	34	18	28
19	38	19	29
20	39	20	30

21	39	21	23
22	38	22	30
23	37	23	37
24	29	24	27
25	28	25	15
26	39	26	39
27	38	27	35
28	30	28	39
29	31	29	25
30	27	30	14
SUM	1070	SUM	924
Mean	35.66	Average	30.8
S.D.	3.83	S.D.	7.62

Appendix: E

Items for Pilot Test: ***[FM: 44× 1=44]***

- *Thirteen MCQ to measure knowledge are as follows*:

1. *What is the relation between ▱ ABCD and ▱ ABEF if they are standing on the same base and between the same parallel lines?*
   b) Area of ▱ ABCD $= \frac{1}{2}$ *Area of ▱ ABEF*
   c) Area of ▱ ABCD = Area of ▱ ABEF
   d) Area of ▱ ABEF $= \frac{1}{2}$ *Area of ▱ ABCD*
   e) Area of ▱ ABCD $= 2$ *times area of ▱ ABEF*
2. *What is the relation between ▱ ABCD and* ΔABE *if they are standing on the same base and between the same parallel lines?*
   a) Area of ▱ ABCD $= \frac{1}{2}$ *Area of* Δ *ABE*
   b) Area of ▱ ABCD = Area of ΔABE
   c) Two times area of ▱ ABCD = Area of ΔABE
   d) Area of ▱ ABCD $= 2$ *times area of* ΔABE

3. *What is the relation between* Δ *MNO and* Δ *MNP if they are standing on the same base and between the same parallel lines?*
   a) *Area of* Δ *MNO* $= \frac{1}{2}$ *Area of* Δ *MNP*
   b) *Area of* Δ *MNP* $=$ *2 times area of* Δ *MNO*
   c) *Area of* Δ *MNO* $=$ *Area of* Δ *MNP*
   d) *Area of* Δ *MNO* $= 2$ *times area of* Δ *MNP*
4. *Area of* Δ *PQR is* $4\sqrt{7}\ cm^2$ *. If* Δ *PQR and* Δ *PQS are standing on the same base and lying between the same parallel lines, how much is the area of* Δ *PQS ?*

   a) $2\sqrt{7}\ cm^2$ c) $\sqrt{7}\ cm^2$

   b) $4\sqrt{7}\ cm^2$ d) $8\sqrt{7}\ cm^2$

5. *Area of a parallelogram is ABCD is* $22\ cm^2$*. If the parallelogram ABCD and a square CDMN are standing on the same base and between the same parallels, then how much is the area of the square CDMN?*
   a) $11\ cm^2$ c) $22\ cm^2$
   b) $44\ cm^2$ d) $5.5\ cm^2$
6. *Area of a rhombus is PQRS is* $29\ m^2$*. If the rhombus PQRS and a a parallelogram RSCD are standing on the same base and between the same parallel lines, then how much is the area of the parallelogram?*
   a) $58\ m^2$ c) $7.25\ m^2$
   b) $14.5\ m^2$ d) $29\ m^2$
7. *Area of a parallelogram is LMNT is* $32\sqrt{3}\ cm^2$*. If the parallelogram LMNT and a rectangle RSTN are standing on the same base and between the same parallel lines, then how much is the area of the rectangle?*

   a) $16\sqrt{3}\ cm^2$ c) $8\sqrt{3}\ cm^2$

   b) $32\sqrt{3}\ cm^2$ d) $64\sqrt{3}\ cm^2$

8. *What is the relation between* $\square$ *ABCD and* $\square$ *PQRS if they are standing on the equal base and between the same parallel lines?*
   a) *Area of* $\square$ *ABCD* $= \frac{1}{2}$ *Area of* $\square$ *PQRS*
   b) *Area of* $\square$ *ABCD* $=$ *Area of* $\square$ *PQRS*
   c) *Area of* $\square$ *ABEF* $= \frac{1}{2}$ *Area of* $\square$ *PQRS*
   d) *Area of* $\square$ *ABCD* $= 2$ *times area of* $\square$ *PQRS*
9. *What is the relation between* $\square$ *MNOP and* Δ*ABE if they are standing on the same base and between the same parallel lines?*
   a) *Area of* $\square$ *MNOP* $= \frac{1}{2}$ *Area of* Δ *ABE*

b) *Area of* $\square$ *MNOP* $=$ *Area of* ΔABE
c) *Two times area of* $\square$ *MNOP* $=$ *Area of* ΔABE
d) *Area of* $\square$ *MNOP* $= 2$ *times area of* ΔABE

10. *What is the relation between* Δ *ABC and* Δ *PQR if they are standing on the equal base and between the same parallel lines?*
a) *Area of* Δ *ABC* $= \frac{1}{2}$ *Area of* Δ *PQR*
b) *Area of* Δ *ABC* $= 2$ *times area of* Δ *PQR*
c) *Area of* Δ *ABC* $=$ *Area of* Δ *PQR*
d) *Area of* Δ *PQR* $= 2$ *times area of* Δ *ABC*

11. *Area of* $\square$ *LMNO is* $64\ cm^2$ *. If* $\square$ *LMNO and* Δ *PQR are standing on the equal base and lying between the same parallel lines, how much is the area of* Δ *PQR?*
a) $64\ cm^2$
b) $128\ cm^2$
c) $32\ cm^2$
d) $16\ cm^2$

12. *Area of* $\square$ *PQRS is* $100\ cm^2$ *. If* $\square$ *ABCD and* $\square$ *PQRS are standing on the equal base and lying between the same parallel lines, how much is the area of* $\square$ *ABCD?*

a) $50\ cm^2$
c) $25\ cm^2$
b) $200\ cm^2$
d) $100\ cm^2$

13. *Area of* Δ *PQR is* $8\sqrt{11}\ cm^2$ *. If* Δ *PQR and* Δ *LMN are standing on the equal base and lying between the same parallel lines, how much is the area of* Δ *LMN?*

a) $4\sqrt{11}\ cm^2$
c) $2\sqrt{11}\ cm^2$
b) $8\sqrt{11}\ cm^2$
d) $16\sqrt{11}\ cm^2$

- *Nine MCQ to measure understanding are as follows*:

14. *If the length of a side of a equilateral triangle is 3 cm then how much is the area of the triangle?*

a) $3.8\ cm^2$
c) $3.89\ cm^2$
b) $3.9\ cm^2$
d) $3.98\ cm^2$

15. *If there are 3 cm and* $4\sqrt{2}$ *cm lengthy diagonals in a rhombus then how much is the area of the rhombus?*

$a)\ 12\sqrt{2}\ cm^2$ $c)\ 24\sqrt{2}\ cm^2$

$b)\ 6\sqrt{2}\ cm^2$ $d)\ 3\sqrt{2}\ cm^2$

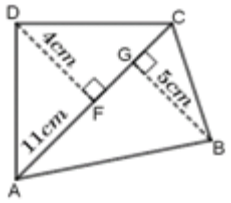
16. *How much is the area of the quadrilateral given alongside?*

$a)\ 44\ cm^2$

$b)\ 55\ cm^2$

$c)\ 27.5\ cm^2$

$d)\ 49.5\ cm^2$



b) *Area of ▱ RSTU is* $54\ cm^2$ *. If ▱ RSTU and* Δ *RSM are standing on the same base and lying between the same parallel lines, how much is the area of* Δ *RSM?*

$a)\ 54\ cm^2$
$b)108\ cm^2$
$c)\ 27\ cm^2$
$d)\ 13.5\ cm^2$

17. *Area of ▱ RSTU is* $84\ cm^2$ *and length of base is* $7\ cm$. *If ▱ RSTU and* Δ *RSM are standing on the same base and lying between the same parallel lines, how much is the height of the* Δ *RSM?*

$a)\ 12cm$

$b)\ 6\ cm$

$c)\ 7\ cm$

$d)\ 24\ cm$

18. *Area of* Δ *LMN is* $44\ cm^2$ *and base of that* Δ *is* $11\ cm$. *If ▱ LMNT and* Δ *LMN are standing on the same base and lying between the same parallel lines, how much is the height of the ▱ LMNT ?*

$a)\ 8\ cm$

$b)\ 22\ cm$

$c)\ 4\ cm$

$d)\ 16\ cm$

19. *Area and base of ▱ PQRS are* $90\ cm^2$ *and* $10\ cm$ *respectively. If ▱ PQCD and ▱ PQRS are standing on the same base and lying between the same parallel lines, how much is the height of ▱ PQCD?*

$a)$ 10 cm

$b)$ 4.5 cm

$c)$ 18 cm

$d)$ 9 cm

20. Area of ▱ LMNO is $64\sqrt{2}\ cm^2$ *. If ▱ LMNO and* Δ *LMR are standing on the same base and lying between the same parallel lines where base is 8 cm, how much is the height of* Δ *LMR?*

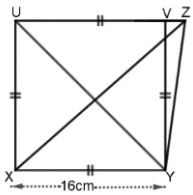
$a)$ $8\sqrt{2}cm$

$b)$ $2\sqrt{2}\ cm$

$c)$ $4\sqrt{2}\ cm$

$d)$ $16\sqrt{2}\ cm$

21. In the figure alongside, XYVU is a square. If XY = 16 cm, find the area of Δ *XYZ.*



a) 256 cm^2
b) 128 cm^2
c) 44 cm^2
d) 144 cm^2

- *Nine MCQ to measure application skill are as follow*:

22. If the area of equilateral triangle ABC is $16\sqrt{3}\ cm^2$ *then how long is the side of the triangle ABC?*

b) 8.01 cm

$b)$ *8.001 cm*

$c)$ 8.1 cm

$d)$ 8 cm

23. *If the altitude of a triangle is 5 cm and base is* $4\sqrt{2}$ *cm then how much is the area of the triangle?*

   a) $20\sqrt{2}$ cm^2

   b) $10\sqrt{2}$ cm^2

   c) $5\sqrt{2}$ cm^2

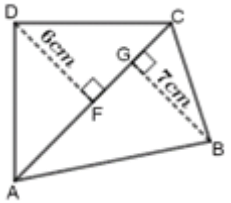
   d) $40\sqrt{2}$ cm^2

24. *Area of a parallelogram is 48* cm^2*. If base of the parallelogram is 6 cm then how much is the height of the parallelogram?*
   e) 16 cm
   f) 4 cm
   g) 6 cm
   h) 8 cm

25. *There are 3 m and 4 m lengthy parallel lines in a trapezium. If distance between the parallel lines is 2 m then how much is the area of the trapezium?*
   e) $8\ m^2$
   f) $6\ m^2$
   g) $14\ m^2$
   h) $7\ m^2$

26. *Area of a trapezium is* $18\ cm^2$*. If there are 3 cm and 6 cm lengthy parallel lines in the trapezium then how much is the distance between the parallel lines?*
   f) 3 cm
   g) 6 cm
   h) 4 cm
   i) 2 cm

27. *If area of the quadrilateral ABCD is* $52\ cm^2$*,* $FD = 6$ *cm and* $BD = 7$ *cm then how long is the diagonal AC?*



   e) $4\ cm$
   f) 8 cm
   g) 6 cm
   h) 9 cm

28. *Area and base of* Δ *PQR are* $24\ cm^2$ *and* $4\ cm$ *respectively. If* Δ *PQR and* Δ *PQS are standing on the same base and lying between the same parallel lines, how much is the height of* Δ *PQS ?*

   a) $4\ cm$

$b)\ 3\ cm$

$c)\ 6\ cm$

$d)\ 2\ cm$

29. *Area of a rhombus ABCD is* $35\sqrt{5}\ cm^2$. *If the rhombus ABCD and a triangle CDM are standing on the same base and between the same parallel lines, then how much is the area of the triangle?*

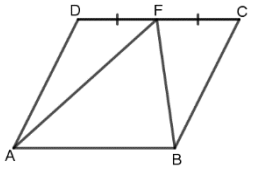
$a)\ 35\sqrt{5}\ cm^2$

$b)\ 70\sqrt{5}\ cm^2$

$c)\ \frac{35\sqrt{5}}{4}\ cm^2$

$d)\ \frac{35\sqrt{5}}{2}\ cm^2$

30. *Area of a square ABCD is* $43\sqrt{3}\ cm^2$. *If the square ABCD and a triangle ABE are standing on the same base and between the same parallel lines, then how much is the area of the triangle?*



$a)\ 43\sqrt{3}\ cm^2$

$b)\ \frac{43\sqrt{3}}{2}\ cm^2$

$c)\ 86\sqrt{3}\ cm^2$

$d)\ \frac{43\sqrt{3}}{4}\ cm^2$

31. *Area of a rectangle LMNO is* $25\sqrt{2}\ cm^2$. *If the rectangle LMNO and a triangle NOG are standing on the same base and between the same parallel lines, then how much is the area of the triangle?*

a) $25\sqrt{2}\ cm^2$

b) $50\sqrt{2}\ cm^2$

c) $\frac{25\sqrt{2}}{2}\ cm^2$

d) $\frac{25\sqrt{3}}{4}\ cm^2$

- *Thirteen MCQ to measure higher ability are as follow*:

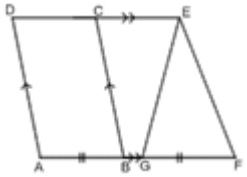
32. *Area of a* Δ *XYZ is* $102\ cm^2$ *and altitude of that is* $12\ cm$. *If the* Δ *XYZ and rectangle WXYZ are standing on the same base and between the same parallel lines, then how much is the length of the rectangle?*
    a) 12 cm
    b) 17 cm
    c) 6 cm
    d) 8.5 cm
33. *Area of a* Δ *ABC is* $84\ cm^2$ *and height of that is* $14\ cm$. *If the* Δ *ABC and rhombus MBCN are standing on the same base and between the same parallel lines, then how much is the base of the rhombus?*
    a) 6 cm
    c) 14 cm
    d) 7 cm
    e) 12 cm
34. *Area of a* Δ *XYZ is* $72\ cm^2$ *and altitude of that is* $12\ cm$. *If the* Δ *XYZ and square WXYZ are standing on the same base and between the same parallel lines, then how much is the length of the square?*

    a) 12 cm

    b) 6 cm

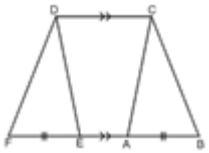
    c) 24 cm
    d) 18 cm
35. *In the figure alongside, if the area of* Δ *ABC is* $13\ cm^2$, *find the*

area of Δ *DFE.*



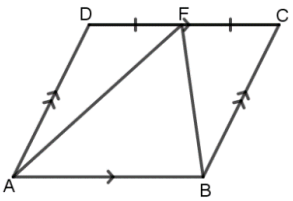
a) $10\ cm^2$
b) $26\ cm^2$
c) $13\ cm^2$
d) $16\ cm^2$

36. *In the figure alongside, if area of the* Δ *GFE is* $23\ cm^2$*, find the area Of parallelogram ABCD.*



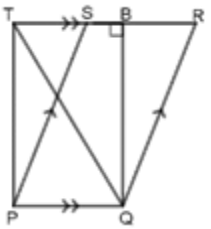
a) $46\ cm^2$
b) $23\ cm^2$
c) $11.5\ cm^2$
d) $69\ cm^2$

37. *In the given figure, ABCD is a land in the shape of parallelogram and F is the mid-point of the line segment DC. If the area of the land is* $48\ cm^2$*, find the area of land which is in the shape of quadrilateral ABCF.*



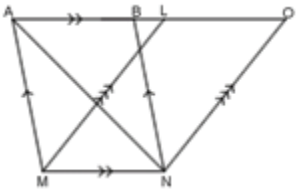
a) $24\ cm^2$
b) $12\ cm^2$
c) $48\ cm^2$
d) $36\ cm^2$

38. *If* $PQ = 5\ cm$ *and* $BQ = 8\ cm$*, then find the area of* $\Delta\ PQT$.



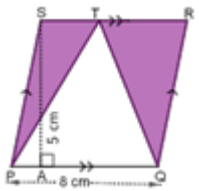
a) $40\ cm^2$
b) $20\ cm^2$
c) $10\ cm^2$
d) $15\ cm^2$

39. *In the figure alongside, the area of* $\square$ *LMNO is* $44\ cm^2$*. Find the area of* Δ *ABN.*



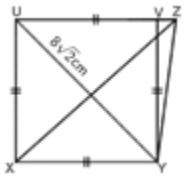
a) $44\ cm^2$
b) $11\ cm^2$
c) $22\ cm^2$
d) $33\ cm^2$

40. *If* $PQ = 8\ cm$ *and* $AS = 5\ cm$, *then find the area of shaded region.*



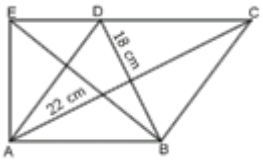
a) $40\ cm^2$
b) $30\ cm^2$
c) $10\ cm^2$
d) $20\ cm^2$

41. *In the figure alongside,* $XYVU$ *is a square with it's diagonals* $UY = 8\sqrt{2}\ cm$ *where* UV *is produced to* Z *and* Z *is joined with* Y. *Find the areas of the square* $XYVU$ *and* ΔXYZ.



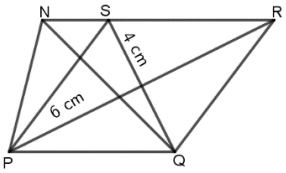
a) *Area of square* $UXYZ$ *is* $64\ cm^2$ *and area of* ΔXYZ *is* $32\ cm^2$
b) *Area of square* $UXYZ$ *is* $38\ cm^2$ *and area of* ΔXYZ *is* $19\ cm^2$
c) *Area of square* $UXYZ$ *is* $36\ cm^2$ *and area of* ΔXYZ *is* $18\ cm^2$
d) *Area of square* $UXYZ$ *is* $32\ cm^2$ *and area of* ΔXYZ *is* $16\ cm^2$

42. *In the figuure* $ABCD$ *is a rhombus where diagonals* $AC = 22\ cm$ *and* $BD = 18\ cm$. *Find the area of ABE.*



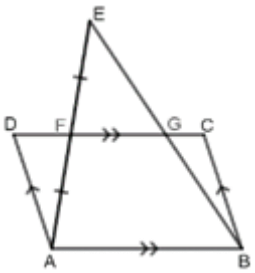
a) $198\ cm^2$
b) $99\ cm^2$
c) $49.5\ cm^2$
d) $90\ cm^2$

43. *In the figure alongside, diagonals a parallelogram PQRS are QS = 4 cm And PR = 6 cm, find the area of* Δ *PQN.*



a) $8\ cm^2$
b) $12\ cm^2$
c) $6\ cm^2$
d) $10\ cm^2$

44. *In the figure alongside, ABCD is a parallelogram whose area is 24 square cm and* $AF = FE$. *Find the area of* Δ *GEF.*



a) 12 cm^2

b) 6 cm^2

c) 16 cm^2

d) 8 cm^2

Note: For Post-test Full Marks = 40

Appendix : F

Pilot test and item analysis of pre-test of achievement test

	Roll No. of Students												R	P-value	D-Value
S.N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**			
QN															
1	1	1	1	1	1	1	1	1	0	0	1	1	10	83.33333333	0.333333333
2	1	1	1	0	1	1	1	1	1	0	0	1	9	75	0.666666667
3	0	1	1	0	1	0	0	1	1	0	0	1	6	50	0.333333333
4	0	1	0	1	0	1	1	0	0	0	1	0	5	41.66666667	0
5	1	1	1	1	1	1	0	0	0	1	0	1	8	66.66666667	0.333333333
6	1	1	1	1	0	1	0	1	0	0	1	1	8	66.66666667	0.333333333
7	1	1	1	1	1	1	1	1	0	1	0	1	10	83.33333333	0.333333333
8	1	1	1	1	1	1	1	1	0	0	1	1	10	83.33333333	0.333333333
9	1	1	1	0	0	0	0	0	0	0	0	0	3	25	1
10	1	0	0	0	1	0	0	0	0	1	0	0	3	25	1
11	1	1	1	1	1	1	0	0	1	0	0	1	8	66.66666667	0.666666667
12	1	1	1	1	1	1	0	1	1	0	1	1	10	83.33333333	0.333333333
13	1	0	1	0	0	1	0	0	0	0	1	0	4	33.33333333	0.333333333
14	1	0	0	0	1	1	1	0	0	0	0	1	5	41.66666667	0
15	1	1	1	1	1	1	0	0	0	0	1	1	8	66.66666667	0.333333333
16	0	1	1	1	0	1	1	1	0	0	0	1	7	58.33333333	0.333333333
17	1	1	1	1	0	1	0	1	0	0	0	1	7	58.33333333	0.666666667
18	1	0	1	1	1	1	1	1	0	0	0	1	8	66.66666667	0.333333333
19	1	1	1	1	1	1	1	1	1	1	1	1	12	100	0
20	0	1	1	1	0	0	0	0	0	0	0	0	3	25	1
21	1	0		0	1	1	0	0	0	0	1	0	4	33.33333333	0.333333333
22	1	1	0	1	0	1	0	0	1	1	0	1	7	58.33333333	0.666666667
23	1	1	0	1	1	0	1	1	1	1	1	1	10	83.33333333	0.333333333
24	0	1	1	0	0	0	1	0	0	0	0	0	3	25	1
25	1	0	1	0	0	0	0	0	0	1	1	0	4	33.33333333	0.333333333
26	1	1	1	0	0	1	0	1	0	1	0	1	7	58.33333333	0.666666667
27	1	0	1	1	1	1	1	1	0	0	0	1	8	66.66666667	0.333333333
28	1	1	1	1	1	1	0	0	0	0	0	0	6	50	1
29	0	1	1	1	1	1	0	1	0	1	0	1	8	66.66666667	0.333333333
30	1	0	1	1	1	1	1	1	1	0	1	1	10	83.33333333	0.333333333
31	0	1	0	1	0	1	1	1	0	1	0	1	7	58.33333333	0.666666667
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Where, R=No. of Correct answer															
QN. 19 and 32 are eliminated.															

Appendix : G

Pilot test and item analysis of post-test of achievement test

	Roll No. of Students												R	P-value	D-Value
S.N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**			
QN															
1	1	0	0	0	1	1	1	0	0	0	0	1	5	41.66666667	0
2	1	1	1	0	1	1	1	1	1	0	0	1	9	75	0.666666667
3	0	1	1	0	1	0	0	1	1	0	0	1	6	50	0.333333333
4	0	1	0	1	0	1	1	0	0	0	1	0	5	41.66666667	0
5	1	1	1	1	1	1	0	0	0	1	0	1	8	66.66666667	0.333333333
6	1	0	0	0	1	1	1	0	0	0	0	1	5	41.66666667	0
7	1	1	1	1	1	1	1	1	0	0	1	1	10	83.33333333	0.333333333
8	1	1	1	0	0	0	0	0	0	0	0	0	3	25	1
9	1	1	1	1	1	1	0	0	1	0	0	1	8	66.66666667	0.666666667
10	1	1	1	1	1	1	1	1	0	0	1	1	10	83.33333333	0.333333333
11	1	1	1	1	1	1	0	1	1	0	1	1	10	83.33333333	0.333333333
12	1	1	1	1	1	1	0	0	1	0	0	1	8	66.66666667	0.666666667
13	1	0	0	0	1	1	1	0	0	0	0	1	5	41.66666667	0
14	1	1	1	0	1	1	0	0	1	0	1	1	8	66.66666667	0.333333333
15	0	1	1	1	0	1	1	1	0	0	0	1	7	58.33333333	0.333333333
16	1	0	1	1	1	1	1	1	0	0	0	1	8	66.66666667	0.333333333
17	1	1	1	0	1	1	0	0	1	0	1	1	8	66.66666667	0.333333333
18	0	1	1	1	0	0	0	0	0	0	0	0	3	25	0.666666667
19	0	1	1	0	1	0	0	1	1	0	0	1	6	50	0.333333333
20	1	1	1	1	1	1	1	1	1	0	0	1	10	83.33333333	0.666666667
21	1	1	1	1	1	1	0	1	0	0	1	1	9	75	0.333333333
22	0	1	1	0	1	1	1	1	0	0	0	1	7	58.33333333	0.333333333
24	1	1	1	1	1	1	1	0	1	1	0	1	10	83.33333333	0.333333333
25	1	1	1	1	1	1	0	0	1	0	0	1	8	66.66666667	0.666666667
26	1	1	1	1	1	1	0	0	1	0	0	1	8	66.66666667	0.666666667
27	0	1	1	0	0	1	0	0	1	0	1	0	5	41.66666667	0.333333333
28	1	1	1	0	1	1	1	0	0	0	1	1	8	66.66666667	0.333333333
29	1	1	1	1	1	1	0	1	0	0	1	1	9	75	0.333333333
30	1	1	1	1	1	1	0	0	1	0	0	1	8	66.66666667	0.666666667
31	1	1	1	1	1	1	1	1	1	0	0	1	10	83.33333333	0.666666667
32	0	1	1	0	1	0	0	0	0	0	0	1	4	33.33333333	0.333333333
33	1	1	1	1	1	1	0	0	1	0	0	1	8	66.66666667	0.666666667
34	0	1	0	0	0	1	0	1	1	0	1	0	5	41.66666667	0.333333333
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	1	1	1	1	1	1	0	0	1	0	0	1	8	66.66666667	0.666666667
38	1	1	1	1	1	1	0	0	1	0	0	1	8	66.66666667	0.666666667
39	1	1	1	0	0	0	0	0	0	0	0	0	3	25	1
40	1	1	1	1	1	1	1	1	1	0	0	1	10	83.33333333	0.666666667
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	1	1	1	1	1	1	1	1	1	0	0	1	10	83.33333333	0.666666667
43	1	1	1	1	1	1	0	0	1	0	0	1	8	66.66666667	0.666666667
44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	30	35	34	24	33	33	16	17	22	2	11	34			
										Where, R=No. of Correct answer					
															QN. 35, 36, 41 and 44 are eliminated.

Appendix : H

Teaching Episodes

Teaching Episode: 1

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Area of Triangles and Parallelograms

Topic: Concept of area of triangles.

1.Specific objectives:

After completion of this topic, students will be able to:

i) tell the formula of area of triangles.

ii) calculate area of triangles.

2. Teaching Materials:

Usual materials like text book, smart board and formulae chart etc.

3. Teaching Learning Activities:

Review: Area of triangles:

- First of all, I will show some triangular shapes as examples of triangles.
- Also, I will do question answer with students about types of triangles.
- I will ask about area of rectangle by drawing figure and I will connect it with area of right angled triangle.
- *Also, I will revise the concept of area of scalene, isosceles and equilateral triangles as well.*

4. Evaluation

Questions:

i) I will ask related formulae.

ii) Find the area of following triangles:

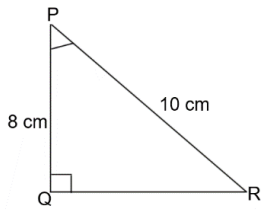
a) If the sides of scalene triangle are 4 cm, 5 cm and 7 cm, find the area of the triangle.

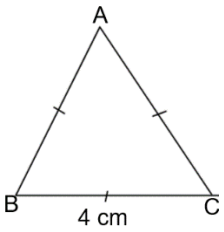
b) Find the area of equilateral triangle having length of one side 3 cm.

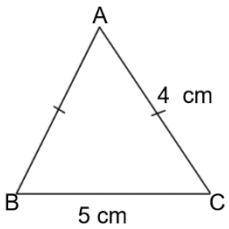
5. Homework

i) Remember the formulae of area of triangles.

ii) Find the area of following triangles.







Teaching Episode*: 2*

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Area of Triangles and Parallelograms

Topic: Concept of area of quadrilaterals.

1. Specific objectives:

After completion of this topic, students will be able to:

i) tell the formula of area of quadrilaterals.

ii) calculate area of quadrilaterals.

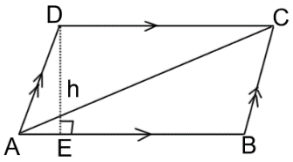
2. Teaching Materials:

Usual materials like text book, smart board and formulae chart etc.

3. Teaching Learning Activities:

Review: Area of triangles:

First of all, I will show some shapes of quadrilaterals as examples.
Also, I will do question answer with students about types of quadrilaterals.
I will ask about area of rectangle by drawing figure and I will connect it with area of square as shown in figure. Also, I will do the transformation of learning by connecting concept of area of right angled triangle for the concept of area of parallelogram, rhombus, trapezium, kite and quadrilateral as shown in the example.
For example:
In the figure alongside, area of Δ ABC $= \frac{1}{2} base(AB) \times height(DE)$



$i.e. The\ area\ of\ \Delta ABC = \frac{1}{2} b \times h.$

$And\ Area\ of\ \Delta ADC = \frac{1}{2}\ base(DC) \times height(DE)$

$i.e. The\ area\ of\ \Delta ADC = \frac{1}{2} b \times h. [Since, AB = DC]$

$Thus, area\ of\ quadrilateral\ ABCD = Area\ of\ \Delta ABC + Area\ of\ \Delta ADC$

$$= \frac{1}{2} b \times h + \frac{1}{2} b \times h$$

$$= b \times h$$

$\therefore The\ area\ of\ parallelogram\ ABCD = base(b) \times height(h).$

Similarliy, I will give the concept of area of rhombus, trapezium and kite as shown in the example.

4. Evaluation:
   - I will ask formulae to calculate area of quadrilaterals.
5. Homework:
   - I will give different questions related to area of quadrilaterals

Teaching Episode: 3

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Area of Triangles and Parallelograms

Topic: Theorem 1 *Parallelograms standing on the same base and lying between the same parallels are equal in area*.

1. Specific objectives:

After completion of this topic, students will be able to:

i) tell the statement of the theorem 1.
ii) prove the theorem 1 by experimental verification.

2. Teaching Materials:
   Usual materials like text book and smart board etc.
3. Teaching Learning Activities:

I will teach theorem 1 as follows:

Theorem 1:

Parallelograms standing on the same base and lying between the same parallels are equal in area.

Experimental verification:

Step 1: I will share idea to the students to draw three different figures of different sizes with parallelograms ABCD and ABEF on the same base AB and between the same parallels AB and DE.

Step 2: I will share idea to draw CN $\perp$ AB in each figure, where CN is the height (altitude) of the parallelograms.

Step 3: I will tell them to measure the base AB and height CN and then calculate the areas of $\square$ABCD and $\square$ABEF.

Step 4: We will get conclusion after analyzing the experiment.

4. *Evaluation:*
    - *I will ask the process of experimental verification to the different students.*
5. *Homework:*
    - *I will give the same theorem with different names of parallelograms to verify at home.*

Teaching Episode*: 4*

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Area of Triangles and Parallelograms

Topic: Theorem 2 *The area of a triangle is equal to half of the area of a parallelogram standing on the same base and between the same parallels.*

1. Specific objectives:

After completion of this topic, students will be able to:

i) tell the statement of the theorem 2.
ii) prove the theorem 2 by experimental verification.

2. Teaching Materials:
   Usual materials like text book and smart board etc.
3. Teaching Learning Activities:

I will teach theorem 1 as follows:

Theorem 2:

Parallelograms standing on the same base and between the same parallels are equal in area.

Theoretical proof:

Step 1 I will share the idea to draw parallelograms ABCD and ABEF are on the same base

AB and between the same parallels AB and DE.

Step 2 I will share the idea to proof the theorem by congruency of triangles.
Alternative Method:

I will share the idea to proof the theorem by alternative method too.

4. Evaluation:
    - I will ask some questions to different students related to process of proof of theorem.
5. Homework:
    - *I will give the same theorem with different names to proof theoretically at home.*

Teaching Episode*: 5*

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Area of Triangles and Parallelograms

Topic: Theorem 2 *The area of a triangle is equal to half of the area of a parallelogram standing on the same base and between the same parallels.*

1. Specific objectives:

After completion of this topic, students will be able to:

i) tell the statement of the theorem 2.
ii) prove the theorem 2 by experimental verification.

2. Teaching Materials:

Usual materials like text book and smart board etc.

3. Teaching Learning Activities:

I will teach theorem 1 as follows:

Theorem 2:

The area of a triangle is equal to half of the area of a parallelogram standing on the same base and between the same parallels.

Experimental verification:

Step 1: I will share idea to draw three different figures with a parallelogram ABCD and a triangle ABE on the same base AB and between the same parallels AB and DC.

Step 2: I will share idea to draw NF ⊥ AB in each figure. NF is the height of the ▱ ABCD and Δ ABE.

Step 3: I will tell them to measure the base AB and the height CN in each figure and to calculate the areas of ▱ ABCD and ΔABE.

Step 4: We will get conclusion after analyzing the experiment.

4. *Evaluation:*
    - *I will ask questions related to the process of experiment to the different students.*

5. Homework:
    - *I will give the same theorem with different names to verify at home.*

Teaching Episode*: 6*

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Area of Triangles and Parallelograms

Topic: Theorem 2 *The area of a triangle is equal to half of the area of a parallelogram standing on the same base and between the same parallels.*

1. Specific objectives:

After completion of this topic, students will be able to:

i) tell the statement of the theorem 2.
ii) prove the theorem 2 by experimental verification.

2. Teaching Materials:
   Usual materials like text book and smart board etc.
3. Teaching Learning Activities:
   - *I will share idea to draw ▱ ABCD and Δ ABE are on the same base and between*
   - *the same parallels AB // DE.*
   - I will share the idea to of theoretical proof.
   - Also, I will share alternative method.
   - And I will share corollary.
4. Evaluation:
   - I will ask some questions to different students related to process of proof of theorem.
5. Homework:
   - *I will give the same theorem with different names to proof theoretically at home.*

Teaching Episode*: 7*

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Area of Triangles and Parallelograms

Topic: Theorem 3 *Triangles standing on the same base and between the same parallels are equal in area.*

1. Specific objectives:

After completion of this topic, students will be able to:

i) tell the statement of the theorem 3.

ii) prove the theorem 3 by experimental verification.

2. Teaching Materials:
   Usual materials like text book and smart board etc.
3. Teaching Learning Activities:

I will teach theorem 1 as follows:

Theorem 3:

Triangles standing on the same base and between the same parallels are equal in area.

Experimental verification:

Step 1: I will share the idea to draw three pairs of triangles ABC and ABD with different sizes on the same base AB and between the same parallels AB and AD.

Step 2:I will share the idea to draw DE $\perp$ AB and CF $\perp$ AB.

Step 3: I will tell the students to measure the base AB and heights DE and DF of each figure and calculate the areas of Δ ABC and Δ ABD.

Step 4: I will tell to the students to analyze the experiment. We will get conclusion after analyzing the experiment.

4. *Evaluation:*
   - *I will ask process of experimental verification to different students.*
5. *Homework:*
   - *I will give the same theorem with different names to do experimental verification at home.*

Teaching Episode*: 8*

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Area of Triangles and Parallelograms

Topic: Theorem 3 *Triangles standing on the same base and between the same parallels are equal in area.*

1. Specific objectives:

After completion of this topic, students will be able to:

i) tell the statement of the theorem 3.

ii) prove the theorem 3 by experimental verification.

2. Teaching Materials:
   Usual materials like text book and smart board etc.
3. Teaching Learning Activities:

I will teach theorem 1 as follows:

Theoretical proof:

Step 1: I will share to draw Δ *ABC and* Δ *BCD are on the same base AB and between the same parallels AB and DC.*

Step 2: I will tell them to construct AE // BC is drawn. AE meets DC at E.

Step 3: I will connect it with theorem 2 and prove it.

Alternatively:

- *I will share idea to proof alternatively.*

Corollary:

- *I will share it's corollary.*

4. *Evaluation:*

I will ask process of proof to the students.

5. *Homework:*
    - *I will give the same theorem with different names to proof theoretically at home.*

Teaching Episode*: 9*

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Area of Triangles and Parallelograms

Topic: Find the area of triangles and quadrilaterals.

1. Specific objectives:

After completion of this topic, students will be able to:

i) find the area of triangles.
ii) find the area of quadrilaterals.

2. Teaching Materials:
   Usual materials like text book and smart board etc.
3. Teaching Learning Activities:

First of all, I will ask make classroom discussion about following questions:

i) What is the relation between parallelograms standing on the same base and lying between the same parallel lines?
ii) What is the relation between parallelogram and triangle standing on the same base and lying between the same parallel lines?
iii) What is the relation between triangles standing on the same base and lying between the same parallel lines?
iv) What are the formula to calculate area of triangles and quadrilaterals? etc.

And then I will share the idea of solving problems with different examples by problem solving and discussion method.

4. Evaluation:
    - I will give some similar questions to do in class from text book.

5. Homework:
    - I will give some related questions to practice at home.

Teaching Episode*: 10*

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Area of Triangles and Parallelograms

Topic: To proof unseen theorems.

1. Specific objectives:

After completion of this topic, students will be able to:

i) find the relation between triangles and parallelograms.
ii) Proof the the given unseen theorem.

2. Teaching Materials:

Usual materials like text book and smart board etc.

3. Teaching Learning Activities:
    - I will share idea of solve unseen theorems with examples.
    - For this purpose I will share idea to connect problems with different theorems.
    - For this, I will use group discussion method. And I will do interaction with students.
4. Evaluation:
    - I will do question answer with students and ask the idea to solve other unseen theorems.
5. Homework:

I will give some similar questions to try at home.

Teaching Episode: 11

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Geometry-Circle

Topic: Review of Circle.

1. Specific objectives:

After completion of this topic, students will be able to:

i) define terms related to circle.
ii) say relation between arcs and angles subtended by them.
iii) say the relation between equal chords of a circle and arcs subtended by them.

2. Teaching Materials:
   Usual materials like text book and smart board etc.
3. Teaching Learning Activities:
   For the fulfilment of objectives of this lesson I will do following activities:
   - First of all I will revise terms related to circle by doing discussion and answer question with students.
   - I will share the relation between arcs and angles subtended by them with figures.
4. Evaluation:
   - I will ask terms of circle to the students.
   - I will ask relation between arcs and angles subtended by them by drawing figures.
5. Homework:
   - To remember terms of circle.
   - To experiment relation between arcs and subtended angles of circle.

Teaching Episode: 12

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Geometry-Circle

Topic: Theorems of Circle.

1. Specific objectives:

After completion of this topic, students will be able to:

i) say the statement of theorem 1.
ii) do experimental verification of theorem 1.

2. Teaching Materials:
   Usual materials like text book and smart board etc.
3. Teaching Learning Activities:
   Theorem 1: Inscribed angles of a circle standing on the same arc are equal.
   Experimental verification:
   I will follow the following steps:
   - I will say and share idea to draw three different sizes circles.
   - I will say and share idea to draw two inscribed angles standing on the same arc.
   - I will say and share idea to measure inscribed angles.
   - I will say to get conclusion by analyzing the experiment.
4. Evaluation:
   - I will ask the different steps of experiment of theorem to the different students.
5. Homework:
   - I will give the same theorem with different names of circumference angles to experiment at home.

Teaching Episode: 13

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Geometry-Circle

Topic: Theorems of Circle.

1. Specific objectives:

After completion of this topic, students will be able to:

i) do theoretical proof of theorem 1.

2. Teaching Materials:
   Usual materials like text book and smart board etc.
3. Teaching Learning Activities:
   I will follow the following steps:
   Theorem 1: Inscribed angles of a circle standing on the same arc are equal.
   - I will say and share idea to draw three different sizes circles.
   - I will say and share idea to draw two inscribed angles standing on the same arc.
   - I will share theoretical methods with discussion and interaction.
4. Evaluation:
   - I will ask the different steps of theoretical proof of theorem to the different students.
5. Homework:
   I will give the same theorem with different names of circumference angles to proof theoretically at home.

Teaching Episode: 14

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Geometry-Circle

Topic: Theorems of Circle.

1. Specific objectives:

After completion of this topic, students will be able to:

iii) Say the statement of theorem 2.
iv) do experimental verification of theorem 2.

2. Teaching Materials:

   Usual materials like text book and smart board etc.

3. Teaching Learning Activities:

   Theorem 2: Circumference angle of a circle is half of central angle of the circle standing on the same arc.

   Experimental Verification:

   I will follow the following steps:

   - I will say and share idea to draw three different sizes circles.
   - I will say and share idea to draw two circumference angle and central standing on the same ar.
   - I will say and share idea to measure circumference angle and central angles.

   We will say to get conclusion by analyzing the experiment.

4. Evaluation:

   - I will ask the different steps of experiment of theorem to the different students.

5. Homework:

   I will give the same theorem with different names of circumference angle and central angle to experiment at home.

Teaching Episode: 15

Grade: 10 Sub: Com. Mathematics

Chapter: 12 Geometry-Circle

Topic: Theorems of Circle.

1. Specific objectives:

After completion of this topic, students will be able to:

   i) do theoretical proof of theorem 2.

2. Teaching Materials:

   Usual materials like text book and smart board etc.

3. Teaching Learning Activities:

   Theorem 2: Circumference angle of a circle is half of central angle of the circle standing on the same arc.

   I will follow the following steps:

   - I will say to draw a circle.
   - I will say to draw two circumference angle and central standing on the same arc.
   - I will share both theoretical methods with discussion and interaction.

4. Evaluation:

   - I will ask the different steps of theoretical proof of theorem to the different students.

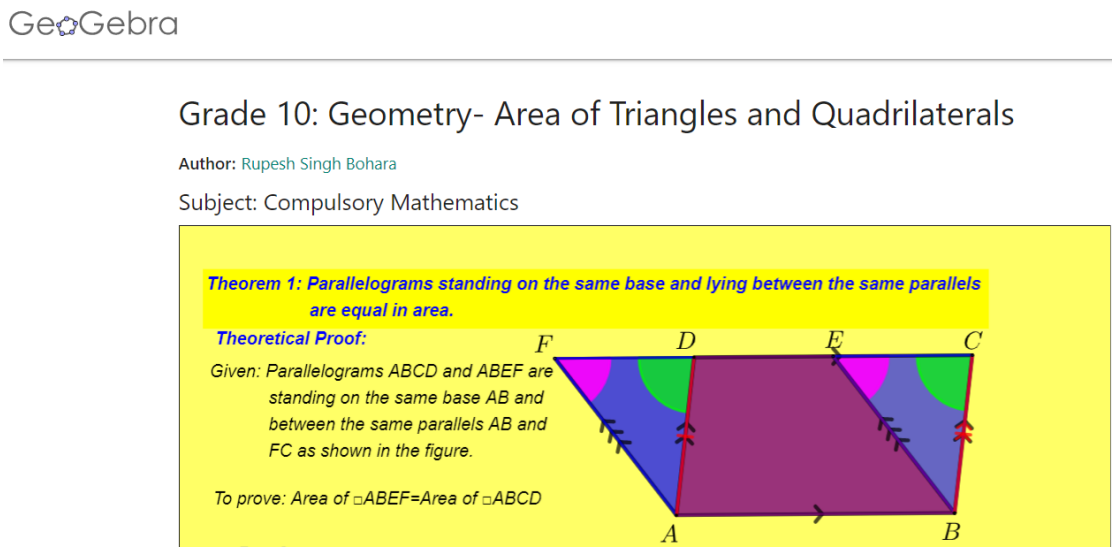
5. Homework:

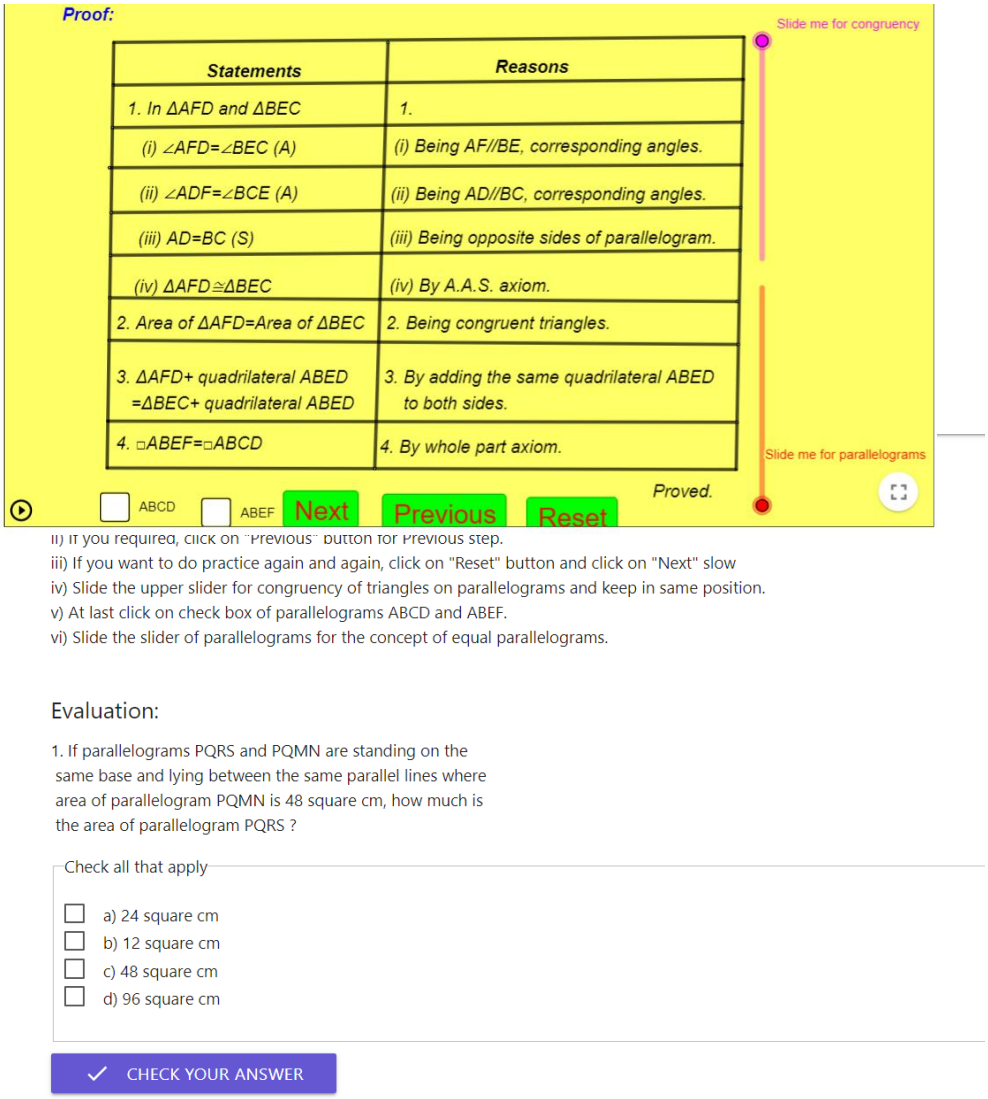
   I will give the same theorem with different names of circumference angle and central angle to proof again.

Note: For experimental group, I will use and provide related GeoGebra applet and I'll enroll the students in GeoGebra classroom for self-practice as well.

Appendix: I

Figure 5.1 GeoGebra applet Theorem 1 in GeoGebra classroom





ii) If you required, click on "Previous" button for Previous step.
iii) If you want to do practice again and again, click on "Reset" button and click on "Next" slow
iv) Slide the upper slider for congruency of triangles on parallelograms and keep in same position.
v) At last click on check box of parallelograms ABCD and ABEF.
vi) Slide the slider of parallelograms for the concept of equal parallelograms.

Evaluation:

1. If parallelograms PQRS and PQMN are standing on the same base and lying between the same parallel lines where area of parallelogram PQMN is 48 square cm, how much is the area of parallelogram PQRS ?

Check all that apply

- ☐ a) 24 square cm
- ☐ b) 12 square cm
- ☐ c) 48 square cm
- ☐ d) 96 square cm

✓ CHECK YOUR ANSWER

Figure 5.2 GeoGebra applet of Theorem 2

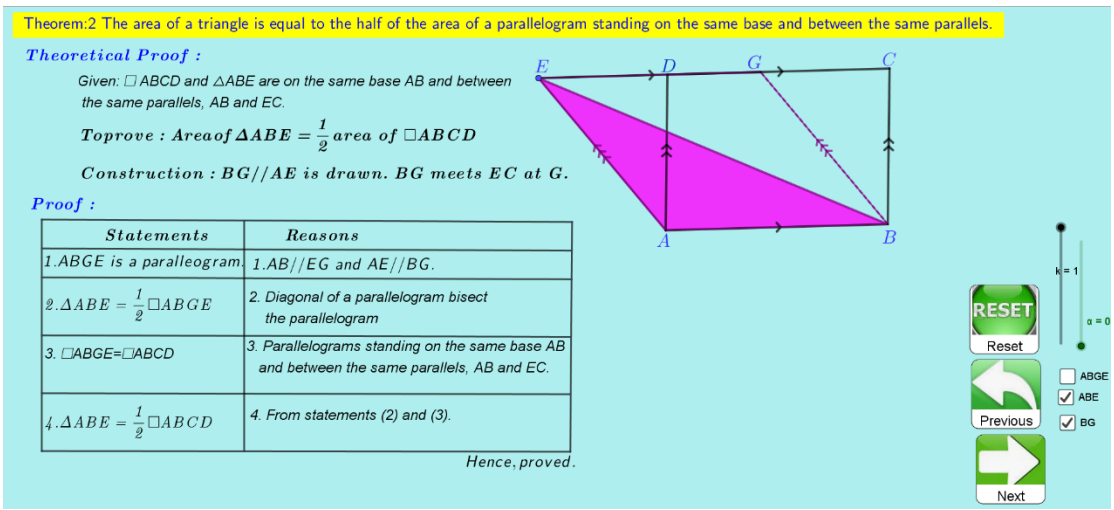


Figure 5.3 GeoGebra applet of theorem 3

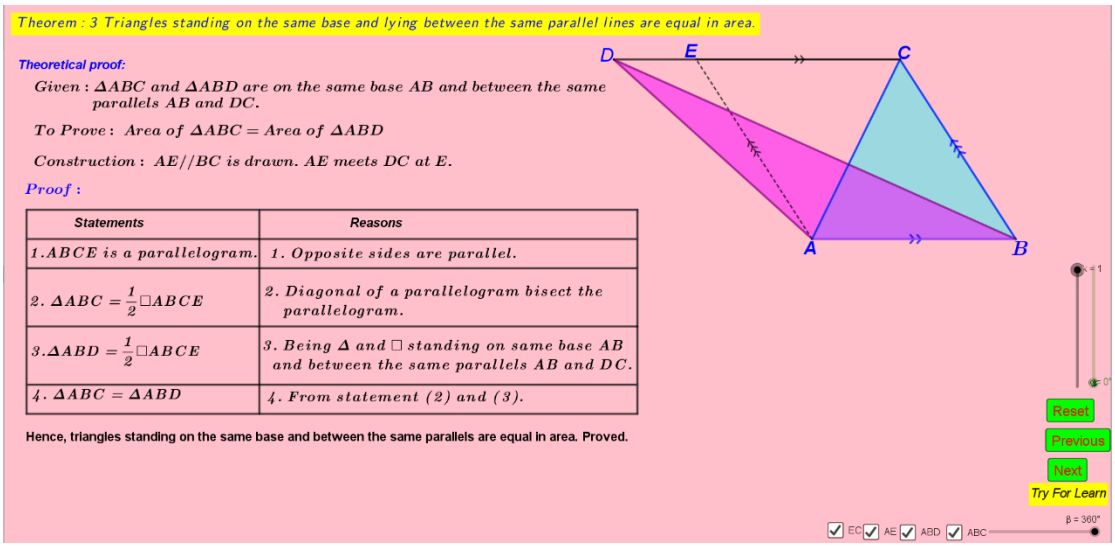
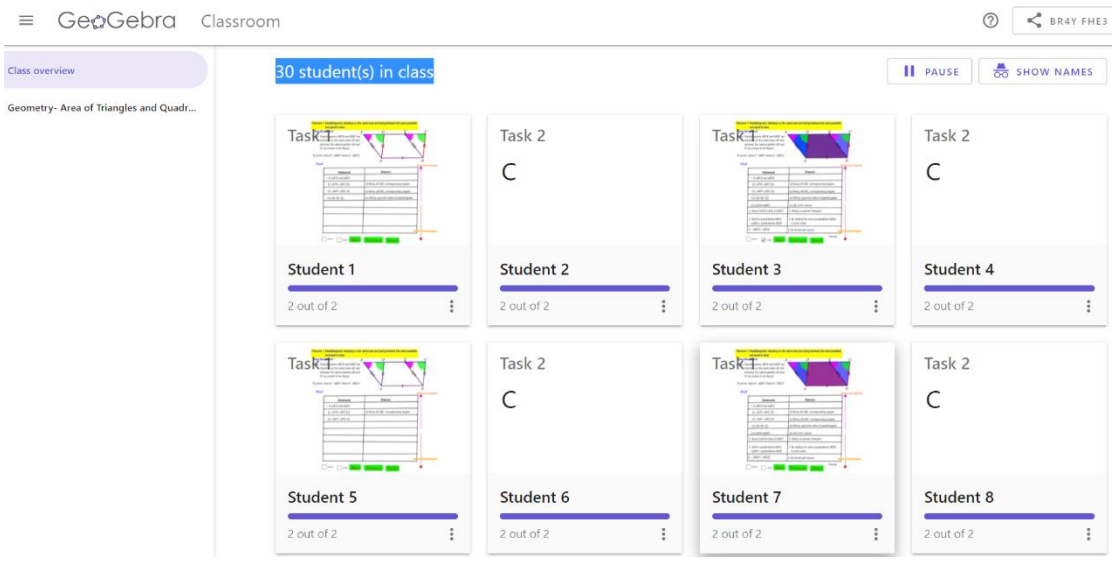
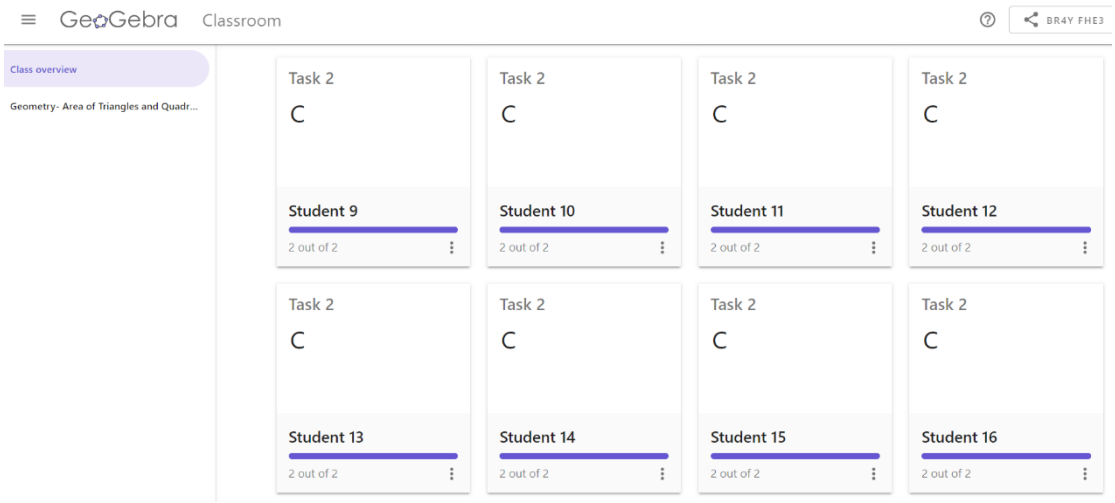
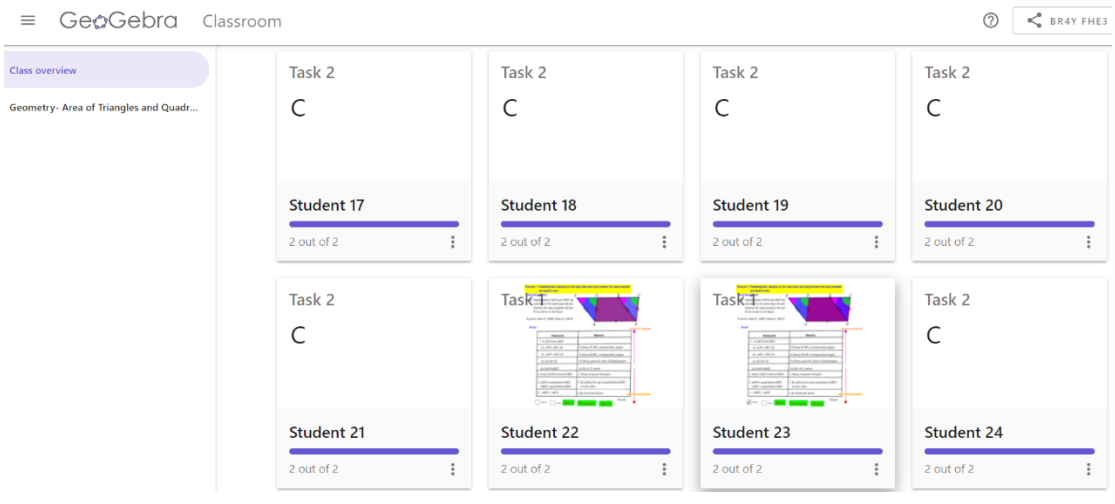
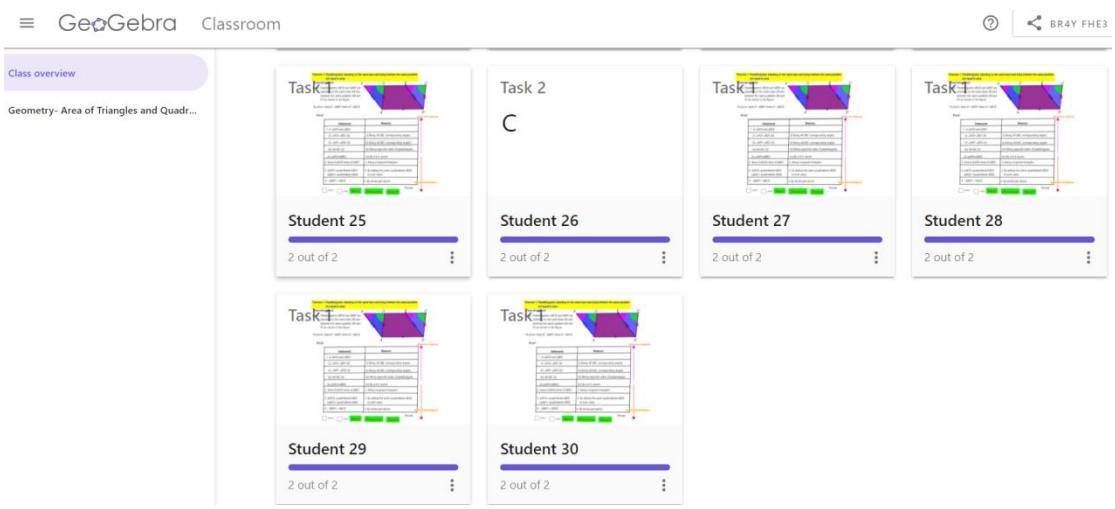


Figure 5.4 GeoGebra Classroom Overview




GeoGebra Classroom
BR4Y FHE3
Class overview
Geometry- Area of Triangles and Quadr...
Task 2
C
Student 9
2 out of 2
Student 10
2 out of 2
Student 11
2 out of 2
Student 12
2 out of 2
Student 13
2 out of 2
Student 14
2 out of 2
Student 15
2 out of 2
Student 16
2 out of 2


GeoGebra Classroom
BR4Y FHE3
Class overview
Geometry- Area of Triangles and Quadr...
Task 2
C
Student 17
2 out of 2
Student 18
2 out of 2
Student 19
2 out of 2
Student 20
2 out of 2
Student 21
2 out of 2
Student 22
2 out of 2
Student 23
2 out of 2
Student 24
2 out of 2


GeoGebra Classroom
BR4Y FHE3
Class overview
Geometry- Area of Triangles and Quadr...
Task 2
C
Student 25
2 out of 2
Student 26
2 out of 2
Student 27
2 out of 2
Student 28
2 out of 2
Student 29
2 out of 2
Student 30
2 out of 2