EFFECTIVENESS OF GEOGEBRA IN LEARNING GEOMETRY

A

THESIS

BY

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

SUBMITTED

TO

DEPARTMENT OF MATHEMATICS EDUCATION

CENTRAL DEPARTMENT OF EDUCATION

TRIBHUVAN UNIVERSITY

KIRTIPUR, NEPAL

2020

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Letter of Certificate

This is to certify that Ms. Sita Pokharel, a student of academic year 2071/072 with Exam Roll No. 28710332, T.U. Regd. No. 9-1-50-2282-2006 and Thesis No.1390 has been completed during the period prescribed by the rules regulation of Tribhuvan University, Nepal. The thesis entitled "Effectiveness of Geogebra in Learning Geometry" embodied the result of her investigation conducting the period 2020 at the Department of Mathematics Education, Central Department of Education, University Campus, Kirtipur Kathmandu. I hereby, recommended and forward that her thesis be submitted for the evaluation as the partial requirement to as ward the Degree of Masters of Education.

February 10, 2020

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Letter of Approval

This thesis submitted by Ms. Sita Pokharel entitled "Effectiveness of Geogebra in Learning Geometry" has been approved for the partial fulfilment for the requirement of Master Degree in Mathematics education.

Viva-Voce Committee	**Signature**
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Prof. Uma Nath Pandey (External)	…….
Krishna Prasad Adhikari (Supervisor)	……..

B.S.: 2076-10-23

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Recommendation for Acceptance

This is to certify that Ms. Sita Pokharel has completed her thesis entitled "Effectiveness of Geogebra in Learning Geometry" under my supervision during the period prescribed by the rules and regulations of Tribhuvan University, Kirtipur, Kathmandu, Nepal. I Recommend and forward her thesis to the Department of Mathematics Education to organize final viva- voice.

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Declaration

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

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Sita Pokharel

February, 2020

Acknowledgements

I am heavily indebted to my supervisor Krishna Prasad Adhikari, Department of Mathematics Education, Central Department of Education, Kirtipur, Kathmandu for his valuable and constructive suggestions, instruction and scholarly guidance during the research without his constant supervision and intellectual guidance it would never have been appeared in this form. However, I have not found any such word to express my deep gratitude to him for his kind help. Therefore, I am heavily indebted to him for painstaking effort to bring this thesis in this form.

Similarly, my sincere gratitude goes to Prof. Dr. Bed Raj Acharya, Head, Department of Mathematics Education and other respected members of Department of Mathematics Education who directly or indirectly encouraged and helped me to complete this research work. I would also like to thank parents, students, head teacher, mathematics teacher and other staffs of Mangal Secondary School and Janasewa Secondary School, who provided me their valuable time and appropriate environment to collect the data for this study.

I would like to extend my heartfelt gratitude to my parents Mr. Durgadatta Pokharel and Tama Kumari Pokharel and better half husband Pashupati Ghimire for their blessing motivation and inspiration to bring me in this stage of my academic tenure.

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Sita Pokharel

February, 2020

Abstract

This study entitled "Effectiveness of GeoGebra in Learning Geometry". The objectives of this study is to analyse the achievement of student with and without using GeoGebra in teaching geometry and to explore the perception of student towards GeoGebra in learning geometry at grade X. This study employs quasi-experimental design with constructivist approach. For this purpose two public school were selected by purposive sampling method were experimental and control groups where made homogeneous group as far as possible by selecting two similar status schools with respect to physical facilities (infrastructure) and cognitive knowledge of students. Experimental and control groups were selected through lottery method out of 60 students from Mangal secondary school and Janasewa Secondary School, Kirtipur Kathmandu.

The experimental group was taught by using GeoGebra while control group was taught without using GeoGebra (traditional method) on the topic of circle and area of triangle. Pre-test and post- test were carried out simultaneously on the group using teacher made achievement test. The data was collected using achievement test and interview schedule and were analysed by inferential statistical (mean, variance, standard deviation and t-test) for quantative data while qualitative data was analysed by descriptive and thematic approach. From this study, it was found that the GeoGebra assisted teaching method was more useful to make classroom interesting, practical and live. It is recommended that teacher should incorporate GeoGebra in teaching and learning geometry.

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Abbreviations

ICT	Information Communication and Technology
ZPD	Zone of Proximal Development
MHSS	Mangal Higher Secondary School
JHSS	Janasewa Higher Secondary School
NCTM	National council for teacher of Mathematics

Chapter I

INTRODUCTION

Background of the Study

Teaching and learning with the use of technology has many advantages such as providing greater learning opportunities for students, enhancing student engagement and encourage discovery learning (Roberts, 2012; White, 2010; Bennet, 1999). Geometry is a central aspect of the school mathematics curriculum and is crucial in the mathematics education of our children from the perspective of providing them with the opportunity to develop spatial awareness and geometric thinking. Geometry is an important study field of mathematics. Geometry not only does help students to associate geometric patterns in the universe with several branches of mathematics but also enables students to apply the knowledge they learned through geometry topics on problem-solving, daily life and other courses. Apart from the mentioned benefits, learning geometry contributes to improving the basic skills of students like analyzing, comparing and generalizing. It also equips students with scientific thinking skills like examining, researching, being critical, schematizing thoughts, being tidy, careful and patient, and expressing thoughts clearly (Kutluca, 2013).

In teaching and learning mathematics, especially geometry it is important for students to be able to imagine, construct and understand the construction of shapes in order to connect them with related facts. Therefore, a computer will assist students in imagining and making observations (Dogan, 2010). A number of technological tools are available now such as interactive whiteboard, graphic calculator and GeoGebra. In geometry, teaching and learning ability to construct geometric shapes, graphs, length,

and concepts are important to each learner for understanding. Construction of shapes with subsequence steps in order to connect them within the required situation i.e. for meaningful learning and teacher for making geometry teaching for understanding which is influenced by teaching materials used by a teacher in the classroom. To design effective lessons in geometry for understanding and better construction, there is the availability of various computer-based software or ICT tools such as GeoGebra, Mathematica, mat lab, etc. That helps teacher and student to demystify the geometric construction and concepts dynamically and in the visualization manner.

The multi-platform, free software GeoGebra is one of the mathematics software that can be used to encourage investigation and discovery and experimentation of the classroom. By using GeoGebra in the teaching geometry, the student can learn through exploring, investigation and discovering. GeoGebra enhances student's higher-order thinking skills in mathematics. It is an effective tool for both teachers as well as students.

According to Hohenwarter (2008), GeoGebra is a dynamic mathematics software for schools that joins geometry, algebra, and calculus. On the one hand, GeoGebra is an interactive geometry system. We can do constructions with points, vectors, segments, lines, polygons, circle, and conic sections as well as functions while changing them dynamically afterward. On the other hand, equations and coordinates can be entered directly. Thus, GeoGebra has the ability to deal with variables for numbers, vectors, and points.

Statement of the Problem

In the teaching and learning geometry, it has been often realized that students still lack the cognitive and process abilities in the understanding of circle and area of

the triangle in the geometry lesson. Although the teacher delivers the required knowledge to assist in students understanding the concept of circles and area of a triangle in the geometry. A student seems to face a challenge in applying this knowledge to a given task. It is as though something more is required to guide students so that they are able to manipulate circle and triangle and other geometry construction.

ICT is the most important factor for integrating teaching and learning mathematics the developing and developed countries. So, the effect of ICT is being prominent all around the world especially in the field of education. But the knowledge of using ICT in Nepal has slow progress in the field of education. The Government of Nepal, Ministry of education (ICT master plan,2013) through a national curriculum framework has introduced ICT as a subject as well as ICT as a tool for instruction in school education but the technology has minimal to a non-existent role at school level in Nepal.

Very few schools have access to technologies and among them, few mathematics teachers have been using technology in their teaching and learning at the secondary level in Nepal. In fact, the school education system is based on a traditional approach in Nepal. Despite this there is low achievement anxiety, rote learning system.

In the context of Nepal, Lamichhane (2017) did a research Effectiveness of GeoGebra on student achievement in area of parallelogram and circle at secondary level. Thanet (2019) did a research Effectiveness of using GeoGebra Software teaching Mensuration and construction at secondary level. They were did a research in Tanahu district and Nawalparasi district respectively. So, my research was going to another location in Kathmandu district. Comparatively level of student is found

different in different district. So, this study the effectiveness of using GeoGebra was conducted how it can be beneficial to improve educational system in Nepal. The traditional method of teaching is replaced by virtual classroom activities like as GeoGebra. Mainly in our context student have inscribed formulae, and try to rote this formulae, and depend upon rule learning by problem solving. Also, this study was concern about the effectiveness of using GeoGebra in the theorem related to circle and area of the triangle of geometry at grade X. In this study, researcher chose Kathmandu district. Because researcher wanted to study what is the different between the achievement of students at the same level on the capital city as full facilated area and developing area as terai region. Here researcher found that GeoGebra software is too much effective for the students' to learn geometry by studying the above thesis Therefore, this study concentrated on answering the following research questions:

- Is the GeoGebra embedded instruction more effective than the traditional method of instruction on teaching and learning geometry?
- What are the perceptions of students about GeoGebra in learning geometry?

Objective of the Study

This study was concerned to investigate the effectiveness of using GeoGebra on students' in learning circle and area of the triangle in geometry at grade X. for this reason, the following objectives were formed;

- To analyze the achievement of students with and without GeoGebra in teaching Geometry.
- To explore the perception of students towards GeoGebra in learning geometry.

Hypothesis of the Study

Hypothesis means a mere assumption or some supposition to be proved or disproved. It related an independent variable to some dependent variable. The two types of hypothesis were formulated in this study; they are as follows:

Research Hypothesis

The GeoGebra assisted instruction is more effective to increase the achievement in geometry in comparison to traditional method.

Statistical Hypothesis

The null and alternative hypothesis of this study are as follows:

- H_o: There is no significant difference between the mean achievement score of experimented and control groups in post-test i.e. $\mu_1=\mu_2$
- H_1: The average achievement of the students at the geometry of the experimental group will significantly higher than the average achievement of the students of control groups on post-test i.e. $\mu_1> \mu_2$

  (Where μ_1 and μ_2 are the average achievements of the student of the experimental group and control group respectively.)

Justification of the Study

In order to educate students to be life-long learners and successful contributors to the new global market, educators must change the way they teach and the way students learn. The existing curriculum of Nepal is silent about the use of technology in teaching and learning mathematics at the secondary level. ICT should be a tool for educational transformation. So this study would be helpful for the knowledge gap of a pedagogical content, further research and policy maker for:

Pedagogical content: This study provides a resourceful tool for mathematics educators to reflect on practice and further develop new ways to connected, extend and enrich their instructional activities. And they were able to apply student centred learning process. Also they reflect their old taxonomy for the pedagogical usages of GeoGebra in geometry teaching.

Researcher: This study will support the researcher to find out the effectiveness of GeoGebra in other fields of mathematics.

Policymaker: This study will support educational planners and policymakers in choosing appropriate teaching methods and conceptualize a policy for the integration of ICTs in mathematics teaching and learning from the basic level to a higher level.

Delimitation of the Study

This research has following delimitations,

- This study was focused on a quasi-experimental design with the purposive sampling method.
- It was delimited to the two government schools of Kathmandu district.
- In the experimental group, the researcher taught the students of the Mangal Secondary School and control group was taught the students of Janasewa Secondary School in Kirtipur, Kathmandu in the geometry lesson circle and area of the triangle.
- This study was focused on the effectiveness of GeoGebra only.

Definitions of Key Words

GeoGebra: GeoGebra is free dynamic mathematics software for schools and colleges that joins geometry, algebra, and calculus.

Effectiveness: The term effectiveness in this study is considered as the increment of student's achievement in geometry.

Experimental group: Group of students taught by using GeoGebra while teaching area of triangle and circle of geometry.

Control group: A group of student those had been taught by the researcher without using GeoGebra while teaching area of triangle and circle of geometry.

Traditional method: The traditional teaching method indicates the existing methods of teaching.

Chapter II

REVIEW OF RELATED LITERATURE

A Literature Review is "a systematic, explicit, and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars', and practitioners". (Arlene Fink, 2005). Its purpose is to create familiarity with current thinking and research on a particular topic and may justify future research into a previously overlooked or understudied area. So this chapter encompasses the empirical review, theoretical framework and conceptual framework of the study.

Empirical Literature

Ayub, Baker, Luan & Tarmizi (2015) study on "Effects of GeoGebra on mathematics performance of the students with different spatial visualization." This study was conducted the quasi-experimental, pre-test-post-test control group design. The total number of 71 students from two intact groups were involved in the study. They were in two groups and each group was randomly assigned to the experimental group (36 students) and control group (35 students). A spatial-visual test to identify students with high or low visualization and a mathematics performance pre-test was administered at the initial stage of this study.

The finding of this study showed that a group of students who were access to GeoGebra achieved significantly better test scores in the post-test as compared to the group which followed the traditional methods, and suggested that the using GeoGebra had helped the students to score better in the posttest. However, there is no significant difference in mathematics performances on students with different types of spatial

visualization. This study indicated that GeoGebra is useful in enhancing the teaching and learning of mathematics.

Sadaan & KwanEu (2013) conducted a study entitled “Effectiveness of the use of GeoGebra on student understanding in learning circles” in order to investigate the effectiveness of using GeoGebra on students’ understanding circles, students’ perception about GeoGebra in the learning circles. A quasi-experimental design with pre-test and post-test had been completed to control and experimental group considering nine years’ students in Selangor. Their finding indicates that the use of GeoGebra in the learning circle has a positive impact on student understanding.

The finding of this study showed that GeoGebra as an effective tool for teaching circles focusing on students’ understanding. In addition, technology has become a motivational tool in the learning circle. Thus use of GeoGebra in geometric construction may be beneficial to both students and teachers for better positive perception in geometric lessons.

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

Leong (2013) conducted a study on “The effect of using the dynamic software Geometer’s Sketchpad (GSP) in the teaching and learning of graph function”. This study was conducted among six students in a Malaysian secondary school. A quasi-

experimental design using intact sampling was employed. A significant difference was observed in the achievement of the experimental group as compared to the control. Leong indicates that the dynamic software (GSP) had a positive effect on student achievement and attitude towards learning graphs of function.

Moila (2006) entitled “The use of Educational Technology in Mathematics Teaching and Learning: An Investigation of a South African Rural Secondary School”. A mixed-method approach was used. This study was focusing on the relationship between the use of ICT tools and learners’ achievements in Mathematics which involves generating theory and confirming. The aim of this study was to investigate the use of ICTs in Mathematics teaching and learning at Phacelia Secondary School and compare the ICTs usage with learners’ achievements in Mathematics. The finding of this study shows that the use of educational technology tools in Mathematics teaching and learning effectively for the development of higher-order thinking skills.

Dogan and Icel (2011) conducted an experimental research design study entitled “The role of dynamic geometry software in the process of learning: GeoGebra example about triangles”. By aiming to evaluate the student’s achievement in learning mathematics using GeoGebra software. It was a twelve-hour course for two weeks involving two eighth grade classes. The result of this study showed that computer-based instruction can be used effectively in the teaching-learning process and GeoGebra software encourages higher-order thinking skills. In addition, this study observed that the positive consequence of motivating students toward learning and remembering their knowledge for a longer period.

Sapkota (2015) did research on the “information communication technology integrated pedagogy at secondary level”. This research finds that the effectiveness of

information and communication technology integrated pedagogy in the existing educational system among students in the experimental and control group of grade ix 46 students of the public secondary school of Kathmandu district were selected for the study. She concluded that ICTIP brings that effect result in termination of the achievement of mathematics in comparison to the existing pedagogy as well as a student taught by ICTIP are more motivated towards mathematics instruction.

Bhandari (2015) conducted research entitled “Effectiveness of GeoGebra assisted Instruction in Mathematics at the secondary level” in order to find out the effectiveness of GeoGebra on secondary level students’ achievement reflection and rotation. The data were collected from 48 students from two public schools in Kathmandu district using the quasi-experimental design by the way of test items and questionnaires. The reliability of these tools was ensured through the split-half method. The result of this study showed that GeoGebra assisted instruction improves the students’ achievement in mathematics in the comparison of subsisting pedagogy.

Shrestha (2019) conducted a research on “Effectiveness of GeoGebra in teaching mathematics at the secondary level” in order to find out the achievement of student triangles and its properties. The data were collected from 50 students of two public schools in Tanahu district using the quasi-experimental design by the way of test items and interview schedules. The result of this study showed that GeoGebra helps the student for conceptual and visualizing learning, and this software need to use for mathematics teaching at the secondary level.

From review of these literatures, it seems clear that much research has focused on determining effectiveness of GeoGebra on student achievement regarding a specific content of geometry (Bhandari, 2015, Sapkota Ayub, Baker et al, 2010, Saddan & EU, 2013) but there is still gap that where GeoGebra helps to foster

teaching geometry for better construction together with steps to learn basic concept allied to area of triangle and circle of geometry. While many researchers research parallelogram, menstruation and construction, trigonometry that use of GeoGebra in geometry lesson foster motivation towards learning environment (Lamichhane 2017, Thanet 2019, Leong, 2013) in Safar as it is pointed out that GeoGebra discovers the resolution strategy of problems through geometrical concept is positive. Thus, use of GeoGebra in geometry construction is necessary for underscoring teaching geometry for better construction and understanding.

The existing trends were technologies are increasing day by day very rapidly and in this the context education sector also going too improved. That is obviously improved by using ICTs workshop and among them freely available software. In the context of Nepal, there is a poor achievement in mathematics especially geometry lesson so researcher chose this topic how we can improve their achievement by using GeoGebra in teaching geometry. In this context, researcher to research in the area of triangle and circle of Geometry 2D and 3D shapes where these reviews directly supporting in my research.

Theoretical Framework

This study was based on the constructivism approach to learning. According to this theory “Constructivism is a learning theory that describes the process of knowledge construction”. The construction of knowledge is an active process, not passive. In the field of mathematics, this is because mathematical learning based on constructivist theory provides the knowledge that is not only stored in the minds of students but also actively building new knowledge from experience and knowledge. Effective learning of mathematics requires that students understand what they know and need to learn. The constructivist theory was chosen because it builds on prior

knowledge: students use what they already know to make connections to new material. When students make these connections, they are learning new material and relating it to what they already know (Dewey, 1916). Social constructivism not only acknowledges the uniqueness and complexity of the learner but actually encourages, utilizes and rewards it as an integral part of the learning process.

Piaget (1950) believed that assimilation and accommodation are the two processes through which knowledge is internalized by learners. He suggested that humans construct new knowledge through their experiences. When individuals assimilate new knowledge they add it to an existing framework, without changing its structure. Accommodation is the process of changing the internal mental structure to fit new experiences. Constructivist teaching creates motivated learners. All school subjects involve constructing new ideas. Teachers should create environments in which students can construct their own ideas and understanding. Constructivist teachers encourage students to assess how classroom activities help them gain understanding.

According to the burner, constructivism theory learning is an active process. Learners select and transform information. Learners make appropriate decisions and postulate hypotheses and test their effectiveness. Learners use prior experience to fit new information into the pre-existing structures.

Vygotsky developed a “Zone of Proximal Development” (ZPD) which was the difference between what a child was taught together. He believes that children learn through social interaction and by learning to solve problems with others, he named this process is “scaffolding” (Vygotsky, 1978). According to constructivist learning theory, three fundamental assumptions apply:

- Knowledge cannot be passively taken from external sources, but it is actively built on by the cognizing subject.
- Understanding appears in the form of adaptation where a person understands a subject by utilizing his own experiences and previous knowledge.
- Knowledge is enhanced as a consequence of interaction; the language and the social environment play an important role in such interaction.

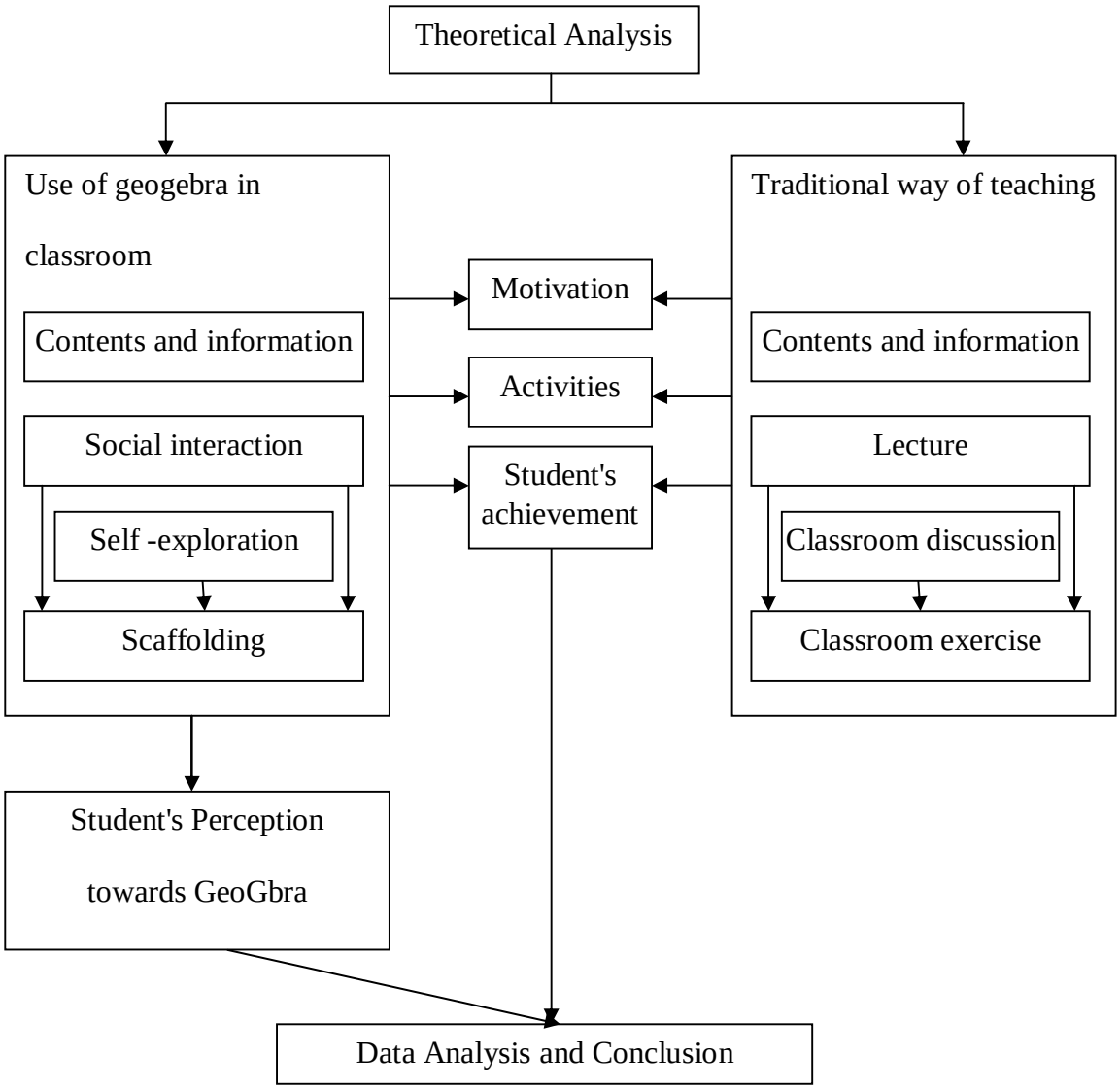
In constructivism learning theory students actively participate in the teaching and learning process while teachers as a facilitator in such conditions. While using GeoGebra in learning geometry students can visualize such relation related to geometry like center angle, circumference angle, radius, arc, tangent line, the relation between tangent line and circle, properties of the triangle, area of the triangle, etc. And they may able to avoid misconception and construct new knowledge by connecting that concept with their prior knowledge, interacting with others and they reflecting on own experience.

GeoGebra helps the student motivated towards learning and explore new knowledge and they make clear concept about related studies. The dynamic software GeoGebra provides as a key element of learning geometry through visualization, estimation, conjecture, discovery, and proof, etc. GeoGebra may help to fulfill the scaffolding and develop the Zone of proximal development (ZPD), ie GeoGebra may help to attain the gap between what a student can do on her/his own prior knowledge and what s/he can do with help of others. GeoGebra is found to be very efficient in mathematics education and it is widely used in teacher training and students' learning. Thus, GeoGebra may be an important tool in mathematics education and for better Students' achievement and understanding by visualization approach.

Conceptual Framework

This study tried to intervene by introducing GeoGebra to enhance relational understanding in specific areas in Geometry which are core areas in the secondary school curriculum. In GeoGebra based instruction, a student is a center point of the learning process, since the use of GeoGebra in learning geometry construction gives a chance to internalize the new knowledge and experience to each individual student. Each has the scenarios that had been completed into three terms self -learning, social interaction, visualization and understanding. In this study, GeoGebra was introduced as a scaffold to bridge the ZPD.

Fig. 1: Conceptual Framework



Vygotsky's view is closely related to the learning environment and emphasizes the theme that social interaction and the cultural environment contribute to the cognitive development of the child. Briefly, the whole study had followed the following framework. In this research, it was studied about the effectiveness of using GeoGebra in learning geometry. The achievement test was taken and analyzed in both group experimental and control groups. From experimental group was chosen for an interview to know how they feel in learning geometry while using GeoGebra.

In terms of input from both group members. Here the higher ability students played a bigger role in helping the lower ability students reach their ZPD. The higher ability students also benefit through the insights gained from their peers. GeoGebra gave the students an opportunity for peer interaction to enhance the understanding and visualization of the concept of circle and area of the triangle. The major terminologies used in the conceptual framework are explained as;

Use of GeoGebra: It is an independent variable of the study. It might play a role bridge to reach the ZPD. It was involved in the process of teaching and learning.

Social interaction: allows that students interact with own peers, teacher, and other students to reach their potential level. It was also involved in the teaching and learning environment.

Self-exploration: It is a process of knowing oneself and through that, knowing the entire existence. It is a process of recognizing one's relationship with every unit in existence and fulfilling it to reach its potential level.

Scaffolding: Scaffolding is a process in which teachers model or demonstrate how to solve a problem, and then step back, offering support as needed. The theory is

that when students are given the support they need while learning something new, they stand a better chance of using that knowledge independently.

Student perception towards using GeoGebra: It is the dependent variable of the study. It was measured from students' views (interview) about GeoGebra.

Students' achievements: It is also the dependent variable of the study which is measured from the cognitive tool.

Finally, the researcher had helped as a facilitator to fill ZPD, for the experimental group and on the other hand, for the control group the researcher, taught the student by traditional (chalk and talk) method every day following lecture, discussion, and exercise. The teacher observed and notated that students' perception by the behaviour's showed by them towards the use of GeoGebra software for the experimental group.

Chapter III

METHODS AND PROCEDURES

Research methodologies are the most important part of the research work. It is a bridge to achieve the objectives of the study in a systematic way. This chapter provides a clear concrete direction to answer the research question and the test hypothesis. This chapter presents the methods and producers that were used in conducting the study. In addition, this chapter includes research design, population, and a sample of the study, different variables which appear in the study, data collection tools, data collection procedures, analysis and interpretation of data, Hence, the primary purpose of this chapter is to discuss and design framework of the research.

Research Design

The main aim of this research was to investigate the effectiveness of GeoGebra on learning geometry in circle and area of a triangle at grade X. This research was based on quasi-experimental design and researcher adopted pre-test and post-test of achievement test. This design was involved non-equivalent homogeneous groups where I participated in two groups namely experimental and control groups and compare their understanding and achievements. According to the hypothesis, the pre-test had taken to find the students' achievement before treatment and after treatment, the post-test was taken to compare the achievement between these two groups. In addition, interview schedule was used as the only experimental group to fulfil the second objective.

Table 1: Design of the Study

Group	**Pre-test**	**Independent variable**	**Post-test**
Experimental	T_1	Teaching geometry using GeoGebra	T_2
Control	T_1	Teaching geometry through traditional method	T_2

The above table shows that two groups of students are selected for this study. In this design, T_1, the test that was administered to the subject before the independent variable was applied which is called pre-test and T_2, the test which was administered to the subject after the independent variable is applied which is called post-test. Thus T_1 and T_2 referred to as the pre-test and post-test of the experimental and control group respectively.

Population and Sample of the Study

In this study, the student of two public schools in Kirtipur Municipality of the academic year 2076 was taken as the population of the study. These two schools were selected purposive sampling methods. Among them one is Mangal Secondary School (MSS) and another Janasewa Secondary School (JSS) where sample size was made non- equivalent homogeneous group as possible as by selecting school of similar status with respect to physical facilities (infrastructure) and as per as possible groups were made with focusing same cognitive structure of students from two public school. Experimental groups and control groups of schools selected through lottery procedures. There were altogether 30 students from MSS and 30 students from JSS. The experimental group was taught by using GeoGebra and the control group was taught by the traditional method.

The Instrument for the Data Collection

For this research, the researcher used two instruments for the purpose of data collection. Which are an achievement test (pre-achievement and post-achievement test) and a semi-structured interview schedule.

Achievement Test

Two achievement tests were prepared. Pre-test and post-test, for pre-test the achievement test paper was developed on the geometry of the circle and area of the triangle of grade X students. This test consisted of ten questions to be solved.

The post-achievement test also contained ten questions that have slightly different from the questions in the pre-achievement test, but the question was in the same structure.

A post-achievement test was used to measure the student's achievement after using GeoGebra-assisted instruction. There involved both experimental and control groups.

Interview Shadule

Interview is the process of communication in which the subject or interviewees gives the needed information verbally in face to face situation. The interview was taken to the students to know the opinion about the effectiveness of teaching geometry by using GeoGebra.

Item Analysis of the Test

The difficulty level and discrimination index of mathematics achievement test were computed to the quality of test items. Mainly difficulty index (P-value) and discrimination index (D-value) was computed to the standardized test items. The

researcher conducted 20 questions of pilot test students of Kirtipur Secondary School in Kirtipur. Then the researcher checked the answer sheets of each student. Then divide the total number of students into two groups which appeared in a pilot test by 50% of high score and 50% of lower score students from the total. Out of them P-value and D- the value of each item was calculated from tabulated upper 27% students and lower 27% students. The items were analyzed and find that the difficulty level of P-value which lied between 26% to 74% and D-value of each item which value lied between the ranges 0.2 to 1. The other items will reject and modify.

Validity and Reliability of Tool

To make a significant contribution to the development of knowledge and good quality of test (tool) must be valid which truly assessed the skill and abilities as indicated by the given learning outcomes. The validity of the achievement test and interview schedule was established by the help of subject teacher, expert, and supervisor.

The pilot test has also conducted the reliability of each test item. The researcher conducted the pilot test students of Kirtipur Secondary School in Kirtipur. In this study, the split-half method was used to estimate the reliability of test items. After piloting achievement test seven questions are modified and re-corrected which shown in appendix 7, then is taken the achievement test it was found that the reliability coefficient of this test was 0.98. Thus the achievement test was reliable.

Data Collection Procedure

This study was mainly based on the quantitative data obtained from the achievement test and qualitative data obtained from the interview schedule. Before starts the class, the researcher met the principal and subject teacher and took

permission for experimentation. After selecting the school then the researcher conducted the pre-test (achievement test) of grade X students in both experimental and control groups. The result of the per-test analyzes quantitatively then I started the regular treatment of GeoGebra in the geometric lesson in the experimental group and give the regular treatment of the control group without using GeoGebra. After ten days experiment, post-test (achievement) administered within the same groups. After that quantitative analysis of the result of post-test was calculated. Finally, a closed and open form of the interview was conducted within an experimental group only.

Independent, Dependent and Control Variables

Variables are key ideas that the researcher seeks to collect information on to address the proposed study. Also, variables are characteristic or attribute of an individual or an organization that researcher can be measure or observe and varies among individuals or organizations studied (Creswell, 2012).

Dependent Variable

The dependent variable is the condition or characteristics that appears, disappears or changes as an experimenter introduces, removes or changes an independent variable. In this study, the dependent variable is the students' test score on mathematics achievement test (post-test) and students' view on GeoGebra in the learning circle and area of the triangle of geometry.

Independent Variables

An independent variable is a variable that is manipulated to determine the value of a dependent variable. The independent variable is that process or activity believed to make a difference in performance and which is manipulated by the

experimenter. In this study independent variable is using GeoGebra software while teaching theorem of circle and area of the triangle of geometry.

Control Variables

The variables except than experimental variables which may have a significant influence on student's achievement were controlled as soon as possible. Many research conclusions are questionable because of the influence of these control variables.

In this study, GeoGebra-assisted instruction was independent variables but students' achievement in the circle and area of the triangle in geometry was dependent variables. Also, the selection of school, subject matter, group, experimental time, test, scoring, and instructor/teacher, teaching materials, tuition classes of outsides of school, student's labor, and home environment are non – experimental variables. To ensure the equivalency of the experimental and control group the mean, variance, standard deviation of two groups was calculated on the basis of their marks on the pre-test was applied to ensure whether there was a significant difference between the two groups.

In practice, it would be difficult to control all the variables on the child's educational achievement. For example, it would be difficult to control variables that have happened in the past. A researcher can only control the current environment of participants, such as time of day and noise levels. Which are as follows;

- Students in both groups were facilitated by researcher own self as a teacher.
- The same content was used in both groups-experimental group and control group.

- The set of the question was tasted on the same day in both groups at the period of pre-test and post-test.
- The analysis process of this data from both groups was alike.
- Physical facilities, the achievement level of the school, school area and other infrastructure were made the same as far as possible.

Data Analysis and Interpretation Procedures

Data analysis and interpretation is important part of the study. For this purpose, two types of achievement tools were used to analyze the data. Among them, one is the achievement test of students (pre-test and post-test) and another is semi-structured interview schedule which was used to observe the perception of students about the GeoGebra.

Analysis and interpretation of the data were based upon the data collection tool and techniques. Collected data were analyzed by using descriptive and inferential statistical analysis methods. Descriptive statistics like; mean, variance and standard deviation and t-value were calculated. That t-test with a two-tailed test at 0.05 level of significant value was used in a comparison of pre-test and post-test results. Where this test was calculated by split-half methods. It was used to test for the statistically significant difference between the experimental group and the control group.

The semi-structured interview was used to know the perception of students about GeoGebra. A researcher collected answers given by the student from interview. This qualitative data was analyzed by the descriptive and thematic code method. Here the students' views on interviews taken as qualitative data.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

This chapter deals with the analysis and interpretation of data. Quantitative data were explained and analyzed by statistical methods. While qualitative data were explained and found the summary by coding and descriptive method. For the fulfillment of goal, the data were organized, tabulated, analyzed and interpreted under the following headings;

- Comparison of the achievement of students in the experimental group and control group in the pre-test.
- Comparison of the achievement of students in the experimental group and control group in the post-test.
- Explore the perception of the students about GeoGebra in teaching geometry.

(Teaching episodes are included in Appendix 1).

Analysis of Pre-test Result

The pre-test score of students of experimental and control groups have been presented in appendix-8. The purpose of this pre-test was to compare the achievement between the experimental and control groups. The data were computation of mean, standard deviation, variance, and t -value on the pre-test result was shown in the following table,

Table 2: Comparison of Students' Achievement in pre-test

Group	Sample	Mean	S.D	Variance	Calculated t-value	Decision
Experimental	30	14.4	3.37	11.35	0.57	There is no significant difference.
Control	30	12.1	2.86	8.16		

The above table presents the mean, standard deviation, and variance of both experimental and control groups on the pre-test. The mean score of experimental and control group was 14.4, and 12.1 respectively the standard deviation was 3.37 and 2.86 and variance was 11.35 and 8.16 out of 60 students. The calculated t-value of the above data is 0.57. This shows that t=0.57, which is less than 1.96 at 0.05 level of significance. This indicated that the difference between these two groups was not significantly different at the 0.05 level of significance. Therefore, these two groups were at the same level of achievement at the start of the study. It shows that Prior knowledge of both groups of students' has the same level and both groups were nearly equal in ability.

Analysis of Post-test Result

The post-test score of students and control groups have been presented in appendix-9. After the completion of the experimental phase, with a gap of 10 days' post-test was taken. The purpose of the post-test was to compare achievement between two groups. The post-test score of the student of the experimental and control group with work involved in the computation of mean, standard deviation and variance of the marks obtained by using formula. The calculated mean, standard deviation, variance, and calculated t-value on the post-test result are shown in the following table,

Table 3: Comparison of Student Achievement in Post Test

Group	Sample	Mean	S.D	Variance	Calculated t-value	Decision
Experimental	30	16	4.74	22.47	2.29	There is significant difference.
Control	30	14.27	4.15	17.26		

The above table presents the mean, standard deviation, and variance of both experimental and control groups on the post-test. The mean score of the experimental and control group was 16, and 14.27, standard deviation was 4.74 and 4.15 and variance was 22.47 and 17.26 out of 60 students. The calculated t- value was found 2.29, hence the methods of pooled variance for the test were applied. This shows that t=2.29, which is greater than the table value 1.96 at 0.05 level of significance. So, the null hypothesis is rejected and concluded that there is significance difference between the achievement of students of experimental and control groups. Hence, the average achievement score of the experimental group had better than the control group on the post-test. Thus, the students who were taught by using GeoGebra is better and so higher achievement than the traditional method of teaching.

So, it is concluded that applying GeoGebra in teaching geometry is found more effective than the traditional methods of teaching.

Analysis of the Student Perception on the Use of GeoGebra

GeoGebra is dynamic software for learning mathematics. The researcher used GeoGebra software for 10 episodes of teaching Geometry ‘circle and area of a triangle’. Students were very excited about learning and participating in classroom activities. To find out the student perception researcher took semi-structured

interviews with the eight students with an experimental group only. The perception of students presented by the sample student ware discussion on the following headings;

- GeoGebra for conceptual learning.
- GeoGebra for visualization of the geometrical problems.
- GeoGebra as a bridge to link the geometrical concepts and other areas of mathematics.
- GeoGebra for student's participation in geometry learning.
- GeoGebra as a motivator for geometry learning.
- Students have a positive perception of GeoGebra assist teaching.

GeoGebra for Conceptual Learning

The researcher used GeoGebra Software for all episodes. While asking students, "What difference did you get using GeoGebra tool in teaching theorems whereas using a traditional way of teaching?

Students answered,

It is more clearer than the traditional way of teaching. I learned mathematics by understanding. I can remember theorems for a long time without practice much. Also, earlier classes were boring but it was more interesting, encouraging and concept also clear.

From the above view, it indicated that GeoGebra software provides the opportunity to learn visually which is not possible through the traditional way of learning. They found that GeoGebra based instruction is much clear, then traditional methods.

Likewise, the response of the next students was,

"I am very excited in learning mathematics in the GeoGebra assisted class, because I can easily understand the proof of theorems and I easily remember formula learned in the classroom".

This shows that GeoGebra assiststed teaching was becoming very helpful to the learner for the conceptual development of knowledge. They were able to say, statement and formula without looking book and copies. We can see the visual of mathematical concepts. It is an area of innovation in the field of mathematics teaching.

GeoGebra for Visualization of Geometrical Problem

Visual learning is higher-order thinking skills to learn Geometry meaningfully. It helps students to distinguish one concept to another. The researcher asked the students, "Did the software help you a better understanding concept in geometry"? The student answered,

Why not, it has made us able to recognized statement of each theorem and visualized in more than more methods. We are always confusing arc, radian radius, supplementary angle, complementary angle and so on. But the use of GeoGebra demystified such a concept which has helped us to prove our theorem and related problems.

This indicated that, the use of dynamic mathematics software GeoGebra not only visualization learning it is also improving visual thinking, students' performance but also sources of motivation. Furthermore, it is found that GeoGebra based instruction helped them to think critically and creatively.

GeoGebra for Student Participation in Learning Geometry

GeoGebra is a dynamic software for teaching and learning mathematics. While GeoGebra assists class run by the researcher, most of the students participated in teaching and learning activities. The student was more interested to learn more topics on the same day. They shared their views, Mam, nowadays the mathematics period is very short. We don't care that mathematics is also an interesting subject. "Will you teach us other mathematics topics by using GeoGebra?"

It shows that there was a huge participation of students in learning. Most of the students used to show their answers to the teacher in the classroom. In the experimental class, there wasn't homework doing a problem. Students were motivated to learning. So they were involved in the classroom activities. There was good co-operative between student to student and student to teacher. GeoGebra helped to make positive altitudes of students towards learning mathematics.

GeoGebra as a Motivator for Self -exploration of Geometry Learning

Motivate is defined as a desire for knowledge which is a central part of curiosity. In the GeoGebra assist class students were involving and interacting with solving the mathematical problem with a friend and as well as a teacher. The researcher asked a student, "what extent did you think GeoGebra has aroused your curiosity?"

The student answered,

Certainly, GeoGebra had reconstructed our basic idea, concept, and knowledge related to constructed figure better which motivated us to solve the geometrical problem and their application in the proving theorem. Moreover, we would like to learn more geometric concepts through GeoGebra because the dynamic

platform of GeoGebra was very interesting for better understanding to extend of our self- learning.

These views regards GeoGebra has motivating tools for better understanding and sustainable knowledge for the student. They were motivated to solve the problem and proving related theorem also. The use of GeoGebra helped the student to reconstruct their existing state of knowledge and enforce them to engage in inquiry-based activities. Cohen et al. (2013) describe that constructivism learning theory searches for meaning, looking for the whole as well as part of considering curiosity and inquiry as important principles. GeoGebra has become a motivational force and important motivational tool for geometrical learning (Eu and Sydan, 2013).

GeoGebra as a Process of Social Interaction

The theory of constructivism, Knowledge is not taught but is learn by the learner themselves through constructing new knowledge on the base of old knowledge, under certain settings, with the help of teacher or study partner and utilizing certain study resources. Students being the centre of teaching and learning while the teacher works as an organizer, facilitator, and motivator, utilizing setting, cooperation, and dialogue to motivate student's activity and creativity (Liu, 2010). Furthermore, the researcher had asked the student: "Did you join the group discussion in your classmates or received support from your teacher when you are confusion any problem?"

The student answered,

I get the help of my friends if I get any confusion also I get the support of my teacher for the same problem.

Another student answered,

When I have any confusion then I discuss in my classroom after getting more confidence I discuss with my teacher.

In the above mentioned shows that they are discussing with the group of learners and their teacher. They like to learn from interaction with friends on a specific topic. They feel easy in learning through interaction.

The social interaction plays a fundamental role in the development of cognition. Vygotsky (1978) states “Every function in the child cultural appears twice, first between people and then inside the child logical memory and formation of concepts. All the higher function originates as actual relationships between individuals.”

The second aspect of Vygotsky's theory is the idea that the potential for cognitive development depends upon the “zone of proximal development (ZPD).” A level of development attention when students engage in social behavior. The full development of ZPD depends on open full social interaction. The range of skills that can be developed with adult guidance or peer collaboration exceeds what can be attained alone. In social interaction higher level of students play a big role in helping the lower ability students to reach their ZPD. The higher-level student also benefits through the new idea and views of their peers.

GeoGebra as a Bridge to Link Geometrical and Other Areas of Mathematics

Mathematics is a multidimensional subject. Each and every subject is the link to mathematics. A student was excited and asked about me ‘Mam’ it is possible to learn other areas of mathematics Algebra, Trigonometry, sets, mensuration and so on 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. Mathematics is the core subject in school. It is a subject where the skill that acquires will equip for the rest of life. It is not beneficial in all mathematical problems and exercise but it helps us to understand abstract and basic mathematical concepts diametrically.

GeoGebra Assisted Teaching

The researcher used GeoGebra for all episodes in the experimental class. There were many changes in student behavior such as interest in doing homework, classroom participation, submission of the classwork, interacting with friends and as well as the teacher. While the question asking in the interview, "How do you fell your learning either easy or more confusion while using GeoGebra?"

One student answered,

We like GeoGebra software very much for teaching geometry. It made us a very clear concept about the circle of geometry and area of the triangle. We hope we'll do better in the coming examination. We felt it will be better if we could learn always by using GeoGebra in teaching mathematics. Furthermore, the researcher asked the student "How did you think of GeoGebra? Did you enjoy it?"

Next students answered,

We are very happy, interesting and motivating thus we enjoy it a lot. This had helped us to increase our confidence level. Learning mathematics using this software was more important because we got the chance to think about every problem from different angles thereby motivating us to the different ways of solving.

This indicates that the GeoGebra is the most important tool for motivating, understanding and conceptual learning for every problem of geometry. The students

were very happy learning with GeoGebra they were sharing that they were understanding mathematics by use of visual material. In my view, GeoGebra can address the interest of the student as well as the teacher.

Students can easily solve the problem and prove the theorem in the classroom. That indicates that GeoGebra assists teaching to extend the level of confidence of the student, which is playing a vital role in the perception of a student in a positive way of applying the teaching Geometry.

In the experimental classroom activities, students were taking active participation in the learning process. Which shows that students were understanding the given content. They were asking the question to the friend and teacher also. They were sincerely solving the problems and make a new concept. School is mini-society, peer discussion had based on the theory. The theory had proven and according to our discussion, we can conclude that GeoGebra was a more effective tool for teaching geometry.

Chapter V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter deals with summary, finding, conclusion and recommendations for education implication and further research.

Summary

The researcher entitled “Effectiveness of GeoGebra in Learning Geometry”. The objective of the study was to analyze the achievement of students with and without using GeoGebra in teaching geometry and to explore the perception of students about GeoGebra in learning geometry at grade X. Mathematics achievement test and interview schedule were used as data collection tools. Extraneous variables were controlled as much as practicable.

For the reliability of the achievement test paper pilot test was conducted on thirty students of the Kirtipur secondary school in Kirtipur municipality. The test was considering of objective multiple choice type items and subjective short and long answer type of question on the area of triangle and circle of geometry. Also, find the difficult level (P) value and discrimination index (D) value. The reliability coefficient of the pilot test was found to be 0.98. And the validity of the tools was ensured by expert judgment and secondary school mathematics curriculum.

A pre-test and post-test design of the quasi-experimental design were adopted for the purpose of this study. Student of grade X of Kirtipur municipality has been considered as population. The sample school was selected through the purposive methods of sampling which were named (experimental group, MSS) and (control group, JSS) in Kirtipur. The purpose of selecting these two schools' backgrounds was similar. First, student of both groups was assessed in term of pre-test in order to find

out the level of students in the content which was going to be taught. Then, quantitative analysis was completed for the pre-test. After certain treatment both group for ten days then post-test was administered in the same group. Then, the quantitative analysis of the result of the post-test was calculated and analyzed. Moreover, Student achievement in pre-test and post-test of mathematics achievement were analyzed by using both descriptive and inferential statistics. An interview schedule was analyzed based on the thematic approach of a qualitative approach. This interview was conducted only on experimental groups and results show that students have positive perceptions by using GeoGebra in learning geometry.

Finding

On the basis of the analysis of the data obtained from the achievement test and interview. It was founded that;

- The result of the pre-test shows that the calculated t-value is 0.57 while tabulated t- value at 0.05 level of significance is 1.96. This implies that there was no significant difference in the mean achievement of the experimental and control group the mean achievement of on pre-test.
- The result of post-test shows that the calculated t- value is 2.29 while tabulated t-value at 0.05 level of significant is 1.96. This implies that there was a significance difference between the average achievement of the experimental group and the control group where the mean achievement of experimental group students was (16) higher than control group students (14.27) on the post-test.
- The teaching using GeoGebra was more effective than traditional methods in the area of triangle and circle of geometry.

- The result shows that student has a positive perception towards GeoGebra software in learning geometry.

Hence the use of GeoGebra is very effective in teaching and learning geometry at the secondary level. The finding also suggested that the GeoGebra software is a great motivational teaching instrument which is a very essential, important and interesting tool for teaching geometry and it makes the class environment is very enjoyable, friendly and motivating then compares as the control group of the class.

Conclusions

In this study, teaching and learning of the area of triangle and circle of Geometry using GeoGebra have been effective and better understanding than the traditional approach in the context of Nepal. The use of GeoGebra not only increases students' scores in a geometric problem but also helps students to become more creative, independent as well as to improve their visual thinking. The use of GeoGebra in mathematics provides an ample opportunity to each individual to unlocking creative steps through active participation. And it up-rise student's curiosity because GeoGebra helps students to reconstruct their existing prior knowledge and enforce to engage in inquiry-based activities such as searching application of problem in a theorem. Furthermore, the use of GeoGebra in geometry lessons enables students to use existing cognitive and visual skills to develop efficiency, experiences and hence confidence in their proven theorems. Thus it is necessary to the sustainable use of GeoGebra gradually into a secondary level of school geometry for the purpose of eradicating educational waste in learning and teaching mathematics.

In addition, the use of GeoGebra provides opportunities for interaction between students-students and teacher-students, during the learning scenarios and thus students are provided ample opportunities for learning through social interaction thereby supporting the constructivist's view of learning. Therefore, the use of GeoGebra in the geometry lesson is essential for teaching geometry for better understanding and for permanent learning.

Recommendations for Educational Implication

Technology is essential and necessary for teaching and learning mathematics (NCTM, 2009). Based on the result and findings of the study shows that several implications of GeoGebra-assist instruction to the educations who wish to implement Kindergarten to university level and to the researchers for future investigation. It enhances students learning Mathematics is abstract in nature and also the queen of all sciences. The study has several implications for mathematics teachers, educators, curriculum designers, and policymakers, etc.

Recommendations for Further Research

The result of these study show that teaching and learning geometry using GeoGebra has been effective but the followings recommendations are forwarded for further research:

- In a survey, studies need to be carried out to examine the- long-term effect of the use of GeoGebra in student's mathematical achievement.
- To study 'why using GeoGebra effect on student understanding towards geometry learning?'
- Analyzing the teacher's view on GeoGebra in teaching and learning Geometry.

- It is recommended that to do a similar study on the other level of school and also in private school.

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Appendix-1

Teaching Episode-1

Subject C. Mathematics

Topic: Circle

Duration of lesson: 45 minutes

Class: X

Teacher: Sita Pokhrel

Cooperating teacher:

School: Shree

I. Objectives:

At the end of this lesson student will be able to:

- Define the circle, semi-circle, circumference, center angle, angle at circumference.
- Prove the theorem the angle at the center of a circle is twice the angle at the circumference standing on the same arc.

II. Required Materials:

- Computer/Laptop, Projector, White board, Marker etc.
- GeoGebra 5.0 software required to be installed in computer /laptop.

III. **Activities and classroom discussion**:

For 5 minutes:

- Researcher will introduce GeoGebra software.

For 10 minutes:

- In first researcher will ask to students, what is circle? What is the formula of area of circle? Circumference of circle, Center angle and angle at circumference etc. After collected the student answer, then the

researcher will use GeoGebra software for definition of circle, area and concept of circle to demonstrate of figure in graphical view of GeoGebra window. After then researcher using whiteboard to teach concept of circle, circumference and center angle of circle.

- Researcher and student both interaction each other than conclude the definition, center angle and angle at circumference.

For 25 minutes:

- In second researcher will write the statement of theorem the angle at the center of the circle is twice the angle at the circumference standing on same arc.
- Researcher will use GeoGebra software to demonstrate the figure of these theorem in Graphic view of GeoGebra window. Also demonstrate the figure related to the relation between central angle and circumference angle on the same arc. Then researcher and student both interact about the figure and statement of the theorem.
- In third the researcher will prove this theorem in whiteboard. finally, the researcher will give students same theorem proved themselves and ask some question related to the circle. Then collected the student answer student and teacher both discuss and interact each other about this answer.

IV. **Homework and exercise**:

- The points A, B and C lie on the circumference of a circle with center O Prove that $2\measuredangle BAC=\measuredangle BOC$.

Teaching Episode-2

Subject C. Mathematics

Topic: Circle

Duration of lesson: 45 minutes

Class: X

Teacher: Sita pokhrel

Cooperating teacher:

School:

I. Objectives:

At the end of this lesson student will be able to:

- Prove the theorem the angle at the circumference of the circle standing on the same arc are equal.

II. Required Materials:

- Computer/Laptop, Projector, White board, Marker etc.
- GeoGebra 5.0 software required to be installed in computer /laptop.

III. Activities and classroom discussion:

For 5 minutes:

- Researcher and students discuss about angle at circumference and center angle of circle.

For 10 minutes:

- Researcher will ask to students, Circumference of circle, Center angle and angle at circumference etc. After student answer, researcher used GeoGebra software for area of circle, definition and concept of circle, demonstrate of figure in graphical view of GeoGebra window.

Researcher and student both interact each other than conclude the center angle and angle at circumference.

For 20 minutes:

- Researcher will write the statement of theorem the angles at circumference of the circle standing on same arc are equal.
- Researcher will use GeoGebra software to demonstrate the figure of these theorem in Graphic view of GeoGebra window. Also demonstrate the figure related to the circumference angles on the same arc. Then researcher and student both interact about the figure and statement of the theorem. After then researcher will proved this theorem in whiteboard. In last researcher will give questions to the student doing themselves by using whiteboard and to teach the students.

IV. Homework and exercise:

- Prove that the angles at the circumference standing on same arc are equal.
- Do the exercise 15.1 of question no. 1.

Teaching Episode-3

Subject C. Mathematics

Topic: Circle (theorem 3 and example 1)

Duration of lesson: 45 minutes

Class: X

Teacher: Sita pokhrel

Cooperating teacher:

School: Shree

I. Objectives:

At the end of this lesson student will be able to:

- Prove the theorem in a semi- circle angle at circumference is always 90 °.
- If O is the center of circle where ∡OBC=30° and $\measuredangle BAC$ =X° then find the value of x°.

II. Required Materials:

- Computer/Laptop, Projector, White board, Marker etc.
- GeoGebra 5.0 software required to be installed in computer /laptop.

III. Activities and classroom discussion:

For 10 minutes:

- Researcher will ask to students question about semi- circle, what is semi- circle? What different between circle and semi-circle? After collected the student answer, researcher used to GeoGebra software for, demonstrate of figure in graphical view of GeoGebra window. Researcher and student both interact each other than conclude that difference between circle and semi-circle.

For 20 minutes:

- Researcher will write the statement of theorem in a semi-circle angle at circumference is always 90° .
- Researcher will use GeoGebra software to demonstrate the figure of these theorem in Graphic view of GeoGebra window. Also demonstrate the figure related to the semi-circle. Then researcher and student both interaction about the figure and statement of the theorem. After then researcher will prove this theorem in whiteboard. In last researcher will give questions to the student doing themselves by using whiteboard and to teach the students.

For 10 minutes:

- Researcher will write the next question and give solve to the student then after collected the students answer researcher and student both discuss about this question. Then researcher would show the figure with helps of GeoGebra software and would be proving on whiteboard.

IV. Homework and exercise:

- Prove the theorem in a semi-circle angle at circumference is always Right angle.

Teaching Episode-4

Subject C. Mathematics

Topic: Circle (theorem 4)

Duration of lesson: 45 minutes

Class: X

Teacher: Sita pokhrel

Cooperating teacher:

School:

I. Objectives:

At the end of this lesson student will be able to:

- Prove the theorem opposite angle of cyclic quadrilateral are supplementary.

II. Required Materials:

- Computer/Laptop, Projector, White board, Marker etc.
- GeoGebra 5.0 software required to be installed in computer /laptop.

Activities and classroom discussion:

For 10 minutes:

- Researcher will ask to students question about cyclic quadrilateral, supplementary angle and complementary angle, right angle, straight angle? After collected the student answer, researcher used to GeoGebra software for, demonstrate of figure in graphical view of GeoGebra window. Researcher and student both interaction each other than conclude about cyclic quadrilateral.

For 20 minutes:

- Researcher will write the statement of theorem opposite angle of cyclic quadrilateral are supplementary.
- Researcher will use to GeoGebra software demonstrate the figure of these theorem in Graphic view of GeoGebra window. Also demonstrate the figure related to the cyclic quadrilateral. Then researcher and student both interaction about the figure and statement of the theorem. After then researcher will proved this theorem in whiteboard. In last researcher will give questions to the student doing themselves by using whiteboard and to teach the students. Researcher and student both discuss about this theorem.

For 15 minutes:

- After that researcher writes some problems related to this theorem on whiteboard. Then researcher and student both interact each other about this problem and find out answer of this problem. Finally, researcher solve this problem in white board.

IV. Homework and exercise:

In a cyclic quadrilateral ABCD, prove that:$\angle A + C = \angle$B+D=180°.

Teaching Episode-5

Subject C. Mathematics

Topic: Area of triangle (Theorem 2)

Duration of lesson: 45 minutes

Class: X

Teacher: Sita pokhrel

Cooperating teacher:

School:

I. Objectives:

At the end of this lesson student will be able to:

- Prove the theorem the area of triangle is equal to half of the area of parallelogram on the same base and between the same parallels.

II. Required Materials:

- Computer/Laptop, Projector, White board, Marker etc.
- GeoGebra 5.0 software required to be installed in computer /laptop.

III. Activities and classroom discussion:

For 5 minutes:

Researcher and student discuss about the area of triangle and area of parallelogram.

For 10 minutes:

- Researcher will ask to students question about area of triangle and area of parallelogram? After collected the student answer, researcher used to GeoGebra software for, demonstrate of figure in graphical view of GeoGebra window. Researcher and student both interaction each other than conclude about area of triangle.

For 25 minutes:

- Researcher will write the statement of theorem the area of triangle is equal to half of the area of parallelogram on the same base and between same parallels on white board.
- Researcher will use GeoGebra software to demonstrate the figure of these theorem in Graphic view of GeoGebra window. Also demonstrate the figure related to area of triangle and area of parallelogram. Then researcher and student both interaction about the figure and statement of the theorem. After then researcher will proved this theorem in whiteboard. In last researcher will give questions to the student doing themselves by using whiteboard and to teach the students. Researcher and student both discuss about this theorem.

IV. Homework and exercise:

- Prove that the diagonal AC of a parallelogram ABCD divides it into two triangles in equal area.

Teaching Episode-6

Subject C. Mathematics

Topic: Area of triangle (theorem 3)

Duration of lesson: 45 minutes

Class: X

Teacher: Sita pokhrel

Cooperating teacher:

School:

I. Objectives:

At the end of this lesson student will be able to:

- Prove the theorem triangles on the same base and between the same parallels are equal in area.

II. Required Materials:

- Computer/Laptop, Projector,White board, Marker etc.
- GeoGebra 5.0 software required to be installed in computer /laptop.

III. Activities and classroom discussion:

For 5 minutes:

Researcher and students discuss about the area of standing on same base.

For 10 minutes:

- the Researcher will ask to students question about the statement of this theorem, what is formula of area of triangle? After collected the student answer, researcher used to GeoGebra software for, demonstrate of figure in graphical view of GeoGebra window. Researcher and student

both interact each other than conclude about the area of triangle standing on the same base and between the same parallels.

For 20 minutes:

- Researcher will write the statement of theorem triangle on the same base and between the same parallels are equal in area.
- Researcher will use to GeoGebra software demonstrate the figure of these theorem in Graphic view of GeoGebra window. Also demonstrate the figure related to triangles having same base and same parallels. Then researcher and student both interact about the figure and statement of the theorem. After then researcher will proved this theorem in whiteboard. In last researcher will give questions to the student doing themselves by using whiteboard and to teach the students. Researcher and student both discuss about this theorem.

For 10 minutes:

- After that researcher writes some problems related to this theorem on whiteboard. Then researcher and student both interact each other about this problem and
- find out answer of this problem. Finally, researcher solve this problem in white board.

IV. Homework and exercise:

- Prove that the area of triangle ABC and ABD standing on the same base AB and same parallels line AB and CD are equal.

Teaching Episode-7

Subject C. Mathematics

Topic: Area of triangle (Angle sum theorem)

Duration of lesson: 45 minutes

Class: X

Teacher: Sita pokhrel

Cooperating teacher:

School:

I. Objectives:

At the end of this lesson student will be able to:

- Prove the theorem the sum of interior angle of triangle is 180^0.

I. Required Materials:

- Computer/Laptop, Projector, White board, Marker etc.
- GeoGebra 5.0 software required to be installed in computer /laptop.

II. Activities and classroom discussion:

For 5 minutes:

- Researcher and students discuss about the sum of interior angle of triangle.

For 10 minutes:

- the Researcher will ask to students' can you know? How is the interior angle of triangle? After collected the student answer, researcher used to GeoGebra software for, demonstrate of figure in graphical view of GeoGebra window. Researcher and student both interaction each other than conclude about the sum of angle of triangle.

For 20 minutes:

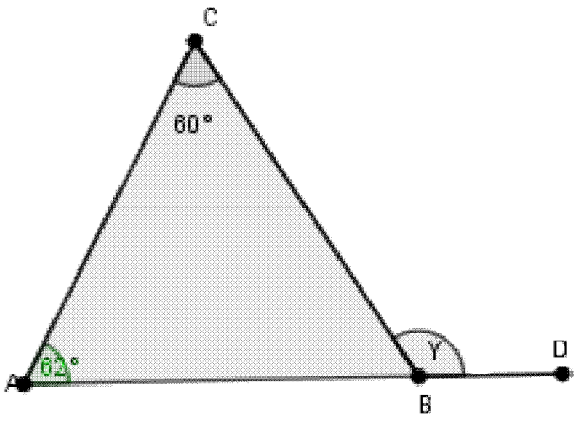
- Researcher will write the statement of theorem the sum of interior angle of triangle is 180^0.
- Researcher will use to GeoGebra software demonstrate the figure of these theorem in Graphic view of GeoGebra window. Also demonstrate the figure related to triangles having their sum. Then researcher and student both interact about the figure and statement of the theorem. After then researcher will proved this theorem in whiteboard. In last researcher will give questions to the student doing themselves by using whiteboard and to teach the students. Researcher and student both discuss about this theorem.

For 10 minutes:

- After that researcher writes some problems related to this theorem on whiteboard. Then researcher and student both interact each other about this problem and
- find out answer of this problem. Finally, researcher solve this problem in white board.

III. **Homework and exercise**:

- Prove that the sum of interior angle of triangle is 180.
- Find the value of y in the given figure.



Teaching Episode-8

Subject C. Mathematics

Topic: Area of triangle

Duration of lesson: 45 minutes

Class: X

Teacher: Sita pokhrel

Cooperating teacher:

School:

I. Objectives:

At the end of this lesson student will be able to:

- Prove the theorem a diagonal of a parallelogram divides it into two triangles of equal area.

II. Required Materials:

- Computer/Laptop, Projector, White board, Marker etc.
- GeoGebra 5.0 software required to be installed in computer /laptop.

III. Activities and classroom discussion:

For 10 minutes:

the Researcher will ask to student pre-knowledge about diagonal of parallelogram and area of parallelogram. After collected the student answer, researcher used to GeoGebra software for, demonstrate of figure in graphical view of GeoGebra window. Researcher and student both interaction each other than conclude about diagonal of parallelogram.

For 20 minutes:

- Researcher will write the statement of theorem diagonal of a parallelogram divides it into two triangles of equal area.

- Researcher will use GeoGebra software to demonstrate the figure of these theorem in Graphic view of GeoGebra window. Also demonstrate the figure related to parallelogram having their diagonal and triangle. Then researcher and student both interact about the figure and statement of the theorem. After then researcher will proved this theorem in whiteboard. In last researcher will give questions to the student doing themselves by using whiteboard and to teach the students. Researcher and student both discuss about this theorem.

For 10 minutes:

- After that researcher writes some problems related to this theorem on whiteboard. Then researcher and student both interaction each other about this problem and
- find out answer of this problem. Finally, researcher solve this problem in white board.

IV. Homework and exercise:

- Prove that the diagonal AC of a parallelogram ABCD divides it into two triangles in equal are.

Teaching Episode-9

Subject C. Mathematics

Topic: Area of triangle (theorem 1)

Duration of lesson: 45 minutes

Class: X

Teacher: Sita pokhrel

Cooperating teacher:

School:

I. Objectives:

At the end of this lesson student will be able to:

- Prove the theorem parallelogram on the same base and between the same parallels are equal in area.

I. Required Materials:

- Computer/Laptop, Projector, White board, Marker etc.
- GeoGebra 5.0 software required to be installed in computer /laptop.

II. Activities and classroom discussion:

For 10 minutes:

- the Researcher will ask to students what is the formula area of parallelogram? After collected the student answer, researcher use GeoGebra software for, demonstrate of figure in graphical view of GeoGebra window. Researcher and student both interact each other than conclude about area of parallelogram.

For 20 minutes:

- Researcher will write the statement of theorem parallelogram between same base and between same parallels are equal in area.

- Researcher will use GeoGebra software to demonstrate the figure of these theorem in Graphic view of GeoGebra window. Also demonstrate the figure related to area of parallelogram having same base and between same parallels. Then researcher and student both interact about the figure and statement of the theorem. After then researcher will proved this theorem in whiteboard. In last researcher will give questions to the student doing themselves by using whiteboard and to teach the students. Researcher and student both discuss about this theorem.

For 10 minutes:

- After that researcher writes some problems related to this theorem on whiteboard. Then researcher and student both interact each other about this problem and find out answer of this problem. Finally, researcher solve this problem in white board.

III. **Homework and exercise**:

- The parallelograms PQRT and PQSR stand on same base PQ and between the same parallels PQ and RS. Prove the area of parallelogram PQRT equal to area of parallelogram PQSR.

Teaching Episode-10

Subject C. Mathematics

Topic: Area of triangle and circle (Collection of homework and exercise)

Duration of lesson: 45 minutes

Class: X

Teacher: Sita pokhrel

Cooperating teacher:

School:

Activities and class room discussion:

- Researcher collects the homework and exercise of students.
- After collecting homework and exercise, researcher check student work individually.
- Then researcher and students discuss about their work.

Appendix-2

Objective question of Pre-test and Post-test

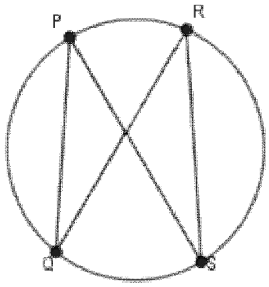
Class: X **Full mark: 20**

Subject: C. Mathematics **Time: 20 min**

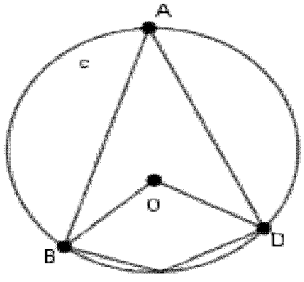
Attempt all questions **[20× 1 = 20]**

Tick (√)the best answer.

1. The angle at the center is ……. angle at the circumference standing on same arc.
    a. Equal
    b. Double
    c. Half
    d. One third
2. Angle at the circumference standing on same arc equal, which one of the following is true?



    a. $\angle PQR = \angle QPS$
    b. $\angle PQ \measuredangle = \angle QRS$
    c. $\angle QPS = PSR$
    d. $\angle QPS = \angle QRS.$
3. According to the given figure which is true?



a. ∠BAD=$\angle BOD$

b. $\angle BAD = 2\angle BOD$

c. $\angle BAD = \angle BCD$

d. $\angle BOD = \angle BAD$

4. Adjacent angle of circumference standing on same arc. Which one of the following is true?

   a. Unequal

   b. Complementary

   c. Supplementary.

5. Which one of the following is true? Opposite angle of cyclic quadrilateral are:

   a. Complementary

   b. Supplementary

   c. Both a and b

   d. None of above

6. Sum of two angle is 90^0, which is indicated that the angle of:

   a. Right angle

   b. Straight angle

   c. Complementary angle

   d. Both b and c

7. Which of the following is true?

   a. Parallelogram on same base and between same parallels are equal in area.

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

   c. The same parallels are equal in area.

   d. All of the above

8. Which one of the following indicated the supplementary angle?

   a. Sum of two angle is 90^0

   b. Sum of two angle is 180^0

   c. Both a and b

   d. None of above

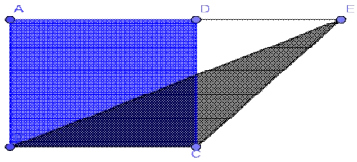
9. In the given figure ABCD is a square who's each side is 4 cm. Find the area of BCE?

   a. $16cm^2$

   b. 16cm

   c. 8cm

   d. $8cm^2$



10. Which of the following is true? Triangle on same base and between the same parallels are:

    a. Double in area

    b. Half in area

    c. Equal in area

    d. All of above

11. Which is not true?

    a. Sum of angle of triangle is 180^0.

    b. Sum of angle of triangle is straight angle.

    c. Sum of angle of triangle is two right angle.

    d. Sum of angle of triangle is 90^0.

12. Which of the following is true? In a circle, radius is always:

a. Perpendicular to the tangent line.

b. Parallel on tangent line.

c. Both a and b

d. None of above.

13. In a semi-circle, angle at circumference is always:

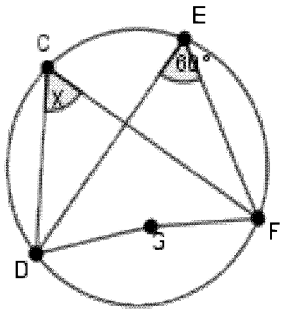
a. 360^0

b. 90^0

c. 180^0

d. All of above.

14. Find the value of X^0 in the given figure?



a. 30^0

b. 120^0

c. 90^0

d. 60^0

15. The area of triangle is:

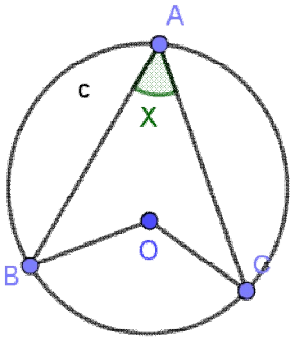
a. base ×height (b× h)

b. 2(b× h)

c. 1/2(b× h)

d. All of above

16. Find the value of ∡BAC in the given figure. Where of ∡BOC=50^0.



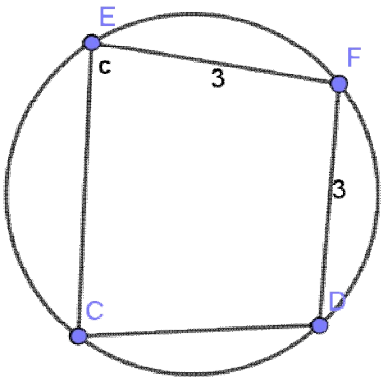
a. 25^0

b. 20^0

c. 30^0

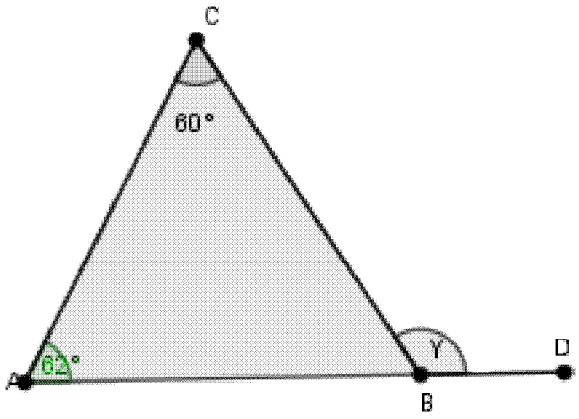
d. 40^0

17. ABCD is a cyclic quadrilateral, where $\measuredangle CBD = 40^0$, CD=BC, then find the value of $\measuredangle DAB$?



a. 80^0
b. 90^0
c. 100^0
d. 110^0

18. Find the value of y?

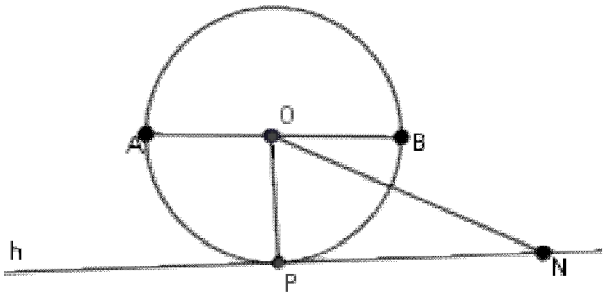


a. 100^0
b. 140^0
c. 122^0
d. 180^0

19. If radius of circle is 7 cm, then find the area of circle?

a. 5 cm2
b. 6cm2
c. 7cm
d. 7cm2

20. O is the center of circle, MN is a tangent line on a circle AB=8 cm



and ON=5 cm then find value of PN?

a. 3 cm

b. 4cm

c. 5cm

d. Both b and c

Best of Lock’s

Appendeix-3

Mathematics achievement test in pre-test and post -test of subjective questions

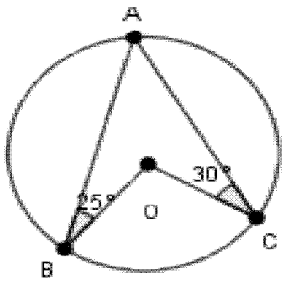
Class: X Full marks: 20

Subject: C. Mathematics

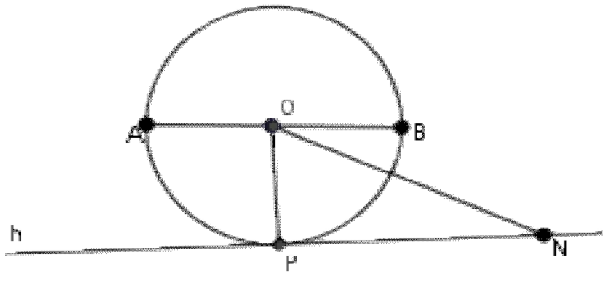
Attempt all question

Group 'A' [2×2=4]

1. In the given figure, O is the center of circle,$\angle OBA=25^0$, $\angle OCA=30^0$ Then find the value of $\angle BOC$?



2. In the given figure O is the center of circle, where AB=8cm, ON=5cm then find the length PN?



Group ‘B’ [4×4=16]

3. Prove that the angle at the circumference of a circle is half of the angle at the center standing on same arc.
4. Prove that in a semi- circle, angle at circumference is always 90^0.
5. Prove that angle on the same base and between the same parallels are equal in area.
6. Prove that angle at the circumference standing on same arc are equal.

Appendix-4

Interview schedules for students

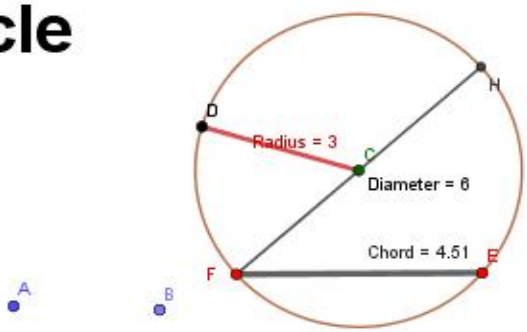
1. Did you interact with your class mates or with the teacher during the lesson?
2. Did you join the group discussion in a class?
3. Did you receive a support from your teacher when you are confusion?
4. Have you ever used ICT to learn geometry?
5. Has your teacher used GeoGebra software as a mathematics teaching tool?
6. How do you take learning circle? Either easy or difficult?
7. Do you have basic computer literacy skill?
8. Which teaching method do apply your teacher in teaching geometry?
9. Did the software help you to better understanding the concept in geometry?
10. Did you think more practice to understanding using GeoGebra software?
11. How do you fell your learning either easy or more confusion while using GeoGebra?
12. Did you enjoy using GeoGebra? Why?
13. What difference did you get using GeoGebra tool in teaching to prove theorems whereas using tradition way of teaching?

Appendix-5

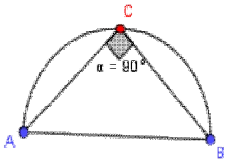
Some figure related to GeoGebra

Circle is the locus of point which is equidistance from fixed point.

Circle



Angle in a circumference of semi circle is always right angle.

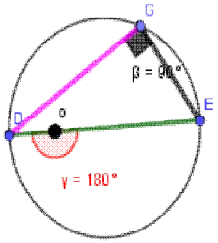


$\angle ACB = 90^\circ$

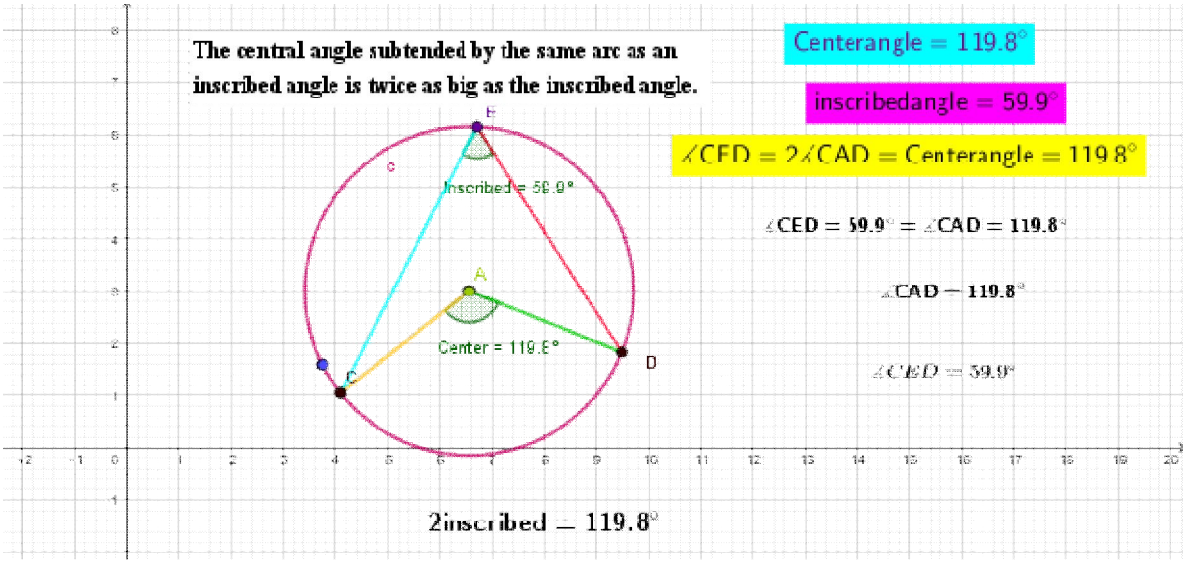
Stateangle$\angle DOE = 180^\circ$

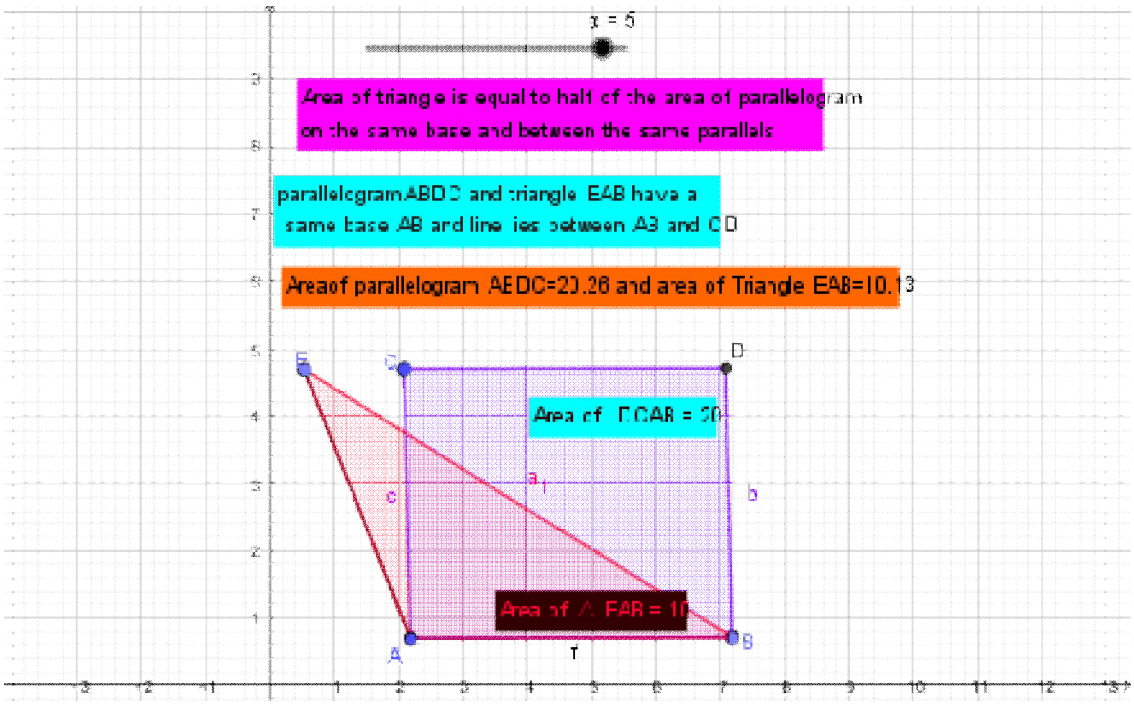
$\angle DGE = 90^\circ$

$\angle DEG = 1/2\angle DOE = 1/2 \times 180^\circ = 90^\circ$



Reason
relation between center angle and circumference angle




x = 5
Area of triangle is equal to half of the area of parallelogram on the same base and between the same parallels
parallelogramABDC and triangle EAB have a same base AB and line lies between AB and CD
Areaof parallelogram AEDC=20.26 and area of Triangle EAB=10.13
E
C
D
Area of ▱CAB = 20
a
c
b
Area of △ EAB = 10
A
B
T

Appendix 6

Item Analysis

	Upper 27%								Medium 46%														Lower 27%										
Roll No. / Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	R	P	D
1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	26	86	0.25
2	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	25	83	0.38
3	1	1	1	1	0	0	1	1	1	1	0	0	0	0	1	1	1	0	0	0	0	1	0	1	0	1	1	0	0	1	16	53	0.25
4	1	0	1	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	13	37	0.63
5	1	1	0	1	1	1	0	1	1	1	1	1	1	1	0	1	0	1	1	0	0	1	1	1	0	1	0	0	0	1	19	67	0.25
6	1	1	0	0	0	1	1	1	1	0	1	0	1	1	1	1	1	0	0	1	0	0	1	0	0	0	1	1	1	0	18	57	0.13
7	1	1	1	1	1	1	0	0	1	1	1	1	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	15	50	0.63
8	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	27	96	0.2
9	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	0	0	1	1	1	1	1	1	0	1	0	1	24	80	0.13

10	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	26	87	0.25
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	1	0	1	1	24	87	0.38
12	1	1	1	1	1	1	1	1	0	1	0	1	1	0	0	0	1	1	1	1	1	0	0	0	1	0	1	1	1	1	22	70	0.38
13	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	0	0	1	0	1	0	0	0	0	1	1	1	1	21	70	0.50
14	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	0	0	1	0	1	1	0	1	1	1	1	1	1	0	24	77	0.25
15	1	1	1	0	1	1	1	0	1	1	1	1	1	1	0	1	1	0	1	0	1	0	0	1	0	1	1	0	1	1	21	67	0.13
16	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	0	1	0	1	1	1	1	1	0	1	1	1	0	25	80	0.25
17	1	0	1	1	1	0	0	1	1	0	1	1	0	0	1	1	1	1	0	1	0	1	0	0	0	0	1	1	1	0	17	57	0.25
18	1	1	0	1	1	1	1	0	1	0	1	1	0	1	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	0	22	73	0.13
19	1	1	1	0	0	0	0	0	1	0	1	1	0	0	1	1	1	1	1	1	0	1	0	0	0	1	0	0	1	1	15	53	0
20	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	0	0	1	1	1	1	0	1	1	1	1	1	1	0	1	24	77	0.13
T	19	18	17	17	17	16	15																8	10	12	13	13	13	13	13	13		

P value Interpretation

P-value in %	Description
0-39	Very difficult
40-60	General
61-75	Substantial
76-90	Easy
91-100	Very easy

Source: Harper and Harper; 1990

Reference: Khanal, 2012 p. 245

D-value Interpretation

D-value	Interpretation	Comments
-1-0.19	Negligible	Need to remake the questions
0.20-0.29	General	Need to improve the questions
0.30-0.39	General	Good questions
0.40-1.00	Very good	Very good questions

Source: EBL and Frisble, 1991. P. 132 (as cited in Khanal 2012)

Appendix 7

Reliability of the Achievement Test

S.N.	Score on odd items (Y)	Score on even items (Y)	x^2	y^2	Xy
1	8	9	64	81	72
2	8	8	64	64	64
3	8	9	64	81	72
4	8	9	64	81	72
5	9	9	81	81	81
6	8	9	64	81	72
7	5	6	25	36	30
8	3	7	9	49	21
9	5	8	25	64	40
10	6	9	36	81	54
11	6	6	36	36	36
12	4	4	16	16	16
13	4	7	16	49	28
14	5	7	25	49	35
15	7	8	49	64	56
16	6	6	36	36	36
17	5	6	25	36	30
18	3	2	9	4	6
19	8	9	64	81	72

20	8	7	64	49	56
21	8	6	64	36	48
22	6	7	36	49	42
23	6	5	36	25	30
24	4	7	16	49	28
25	3	6	9	36	18
26	3	4	9	16	12
27	4	4	16	16	16
28	9	8	81	64	72
29	8	7	64	49	56
30	6	4	36	16	24
N=30	$\sum x = 181$	$\sum y = 203$	$\sum x^2 = 1158$	$\sum y^2 = 1475$	$\sum xy = 1323$

Correlation coefficient (r_{xy}) = $$\frac{N\sum xy - \sum x \sum y}{\sqrt{\left(N\sum x^2 - \left(\sum x\right)^2\right)}\sqrt{\left(N\sum x^2 - \left(\sum x\right)^2\right)}}$$

= 0.97

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

= 0.98

Appendix 8

Score of Pre-test

S.N.	Score of student in experimental group	Score of student in control group
1	13	12
2	16	9
3	12	8
4	10	10
5	16	12
6	15	12
7	16	11
8	16	10
9	12	8
10	17	9
11	15	12
12	11	15
13	15	14
14	16	11
15	15	15
16	16	12
17	13	12
18	11	12
19	12	4
20	10	14

21	14	17
22	13	13
23	11	11
24	12	13
25	13	13
26	18	16
27	14	18
28	9	11
29	8	15
30	13	14
	Mean $(\overline{X})=14.4$ Standard deviation (S_1) = 3.37 Variance (S_1^2) = 11.37	Mean $(\overline{X})=12.1$ Standard deviation (S_1) = 2.86 Variance (S_1^2) = 8.16

Appendix 9

Score of Post-test

S.N.	Score of student in experimental group	Score of student in control group
1	16	15
2	17	10
3	18	11
4	18	10
5	18	10
6	16	14
7	17	15
8	18	13
9	14	12
10	20	11
11	19	10
12	15	15
13	18	17
14	19	15
15	17	13
16	17	16
17	15	14
18	16	15
19	14	16
20	15	11

21	16	16
22	13	17
23	12	16
24	11	13
25	14	17
26	19	18
27	19	17
28	19	14
29	19	16
30	20	15
	Mean $(\overline{X})=16$ Standard deviation (S_1) = 4.74 Variance (S_1^2) = 22.47	Mean $(\overline{X})=14.27$ Standard deviation (S_1) = 4.15 Variance (S_1^2) = 17.26