EFFECTIVENESS OF GEOGEBRA ON STUDENTS' ACHIEVEMENT IN TRIGONOMETRY

A

THESIS

BY

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IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER'S DEGREE IN MATHEMATICS EDUCATION

SUBMITED

TO

DEPARTMENT OF MATHEMATICS EDUCATION

CENTERAL DEPARMENT OF EDUCATION

UNIVERSITY CAMPUS, KIRTIPUR

TRIBHUVAN UNIVERSITY

KATHMANDU, NEPAL

2022

Letter of Certification

This is to certify that **Mr. Kushal Bagale** a student of academic year **073/075** with the campus Roll No. **276/073**, thesis no **1620**, Exam Roll No. **7328392**, T.U., Registration Number **9-2-284-290-2012** has completed this thesis under supervision of Prof. Dr. Bed Raj Acharya during the period prescribed by the rules and regulations of Tribhuvan university, Nepal. The thesis entitled, **"Effectiveness of GeoGebra on students' achievement in Trigonometry"** embodies the results of his investigation conducted during the period of 2021 to 2022 under the Department of Mathematics Education, University campus, Central Department of Education, Kirtipur, Kathmandu. I recommend and forward that his thesis be submitted for the evaluation for awarding the degree of master of Mathematics Education.

…….

Prof. Dr. Bed Raj Acharya

Date: 6th March 2022

Recommendation for Acceptance

This is certify that **Mr. KUSHAL BAGALE,** has completed his M.Ed. thesis entitled, **"Effectiveness of GeoGebra on students' achievement in Trigonometry"** under my supervision during the period prescribed by the rules and regulation of Tribhuvan University, Kritipur, Kathmandu Nepal. I recommend and forward his thesis to the Department of Mathematics Education to organize final viva- voce.

……

Prof. Dr. Bed Raj Acharya

(Supervisor)

Date;……..

Letter of Approval

This thesis entitled **"Effectiveness of GeoGebra on students' Achievement in Trigonometry"** submitted by **Mr. Kushal Bagale** in partial fulfillment of the requirements for the Master's Degree of Master of Education.

Committed for Viva- Voce	Signature
Prof. Dr. Bed Raj Acharya	……
(Chairman)	
……..	……
(External)	
……..	……
(Member)	

Date: ……

Declaration

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

…….

Kushal Bagale

Dedicated

To My respected parents:

Durga Prasad Bagale and Gyanu Bagale

Acknowledgement

First of all, I want to thanks Department of Mathematics Education, Central Department of Education, Kritipur, for providing me support and opportunity to carry out the research work.

I, as researcher of this study, would like to acknowledge the generous help given by my respective teachers and colleagues who were directly and indirectly involved carrying out this. Firstly, I would like to extend my sincere gratitude to my respected Gure and Supervisor Prof. Dr. Bed Raj Acharya, and Head of Department of Mathematics Education, T.U. Kirtipur, from whom I have got invaluable suggestions, encouragement, insightful comments and appreciable guidance with constitute the foundation for this study.

I would like to offer my deep gratitude to my respected all teachers of Department of mathematics Education, for given valuable encouragement, suggestion and inspiration to completed this research work and my Master's degree.

I wish to acknowledge my sincere appreciations to the school family of sampled grade X students. I must extend my hearty thanks to Head teacher, mathematics teachers and students of Gorkha District for their valuable suggestions, facilitating reference mathematics, advices and encouragement during my research work.

At last, I would like to express deep thanks to my family and friends for providing me their valuable time sharing, experience and inspiration to completed this thesis.

Date:…….

…….

Kushal Bagale

Abstract

The purpose of this study was to investigate the Effectiveness of GeoGebra on Students; Achievement in Trigonometry Teaching on grade X. The investigator took the pre-test, post-test of quasi-experimental research deign was used to compare the achievement of two groups experimental and control. The researches choose X-grade 36 school learners from Shree Shail Putri Secondary School as the experimental group and same grade 39 school students from Shree Surya Jyoti Secondary School as the control group. After completion of the targeted chapters, researchers collected the data from mathematics achievement test and a set of questionnaire related to five point Likert scale. The mathematics achievement test was used for objective: comparing the achievement of the students taught by using GeoGebra and traditional method in Trigonometry of Height and Distance and questionnaire was used for objective: analyzing the students view on GeoGebra in learning Trigonometry of Height and Distance.

The results indicated that there was a significant difference between the average achievement score of experimental and control groups on post-test. This finding illustrated that the students in the experiment group performed better when using GeoGebra than the control group with the traditional teaching method. Additionally, a set of questionnaire related to Likert Scalewas used to explore the student view on GeoGebra in learning Height and Distance. This questionnaire was administered to only experimental group. The result of questionnaire showed that students gave positive feedback or view about GeoGebra software in learning Height and Distance of Trigonometry.

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Abbreviations

ACE: Activities, Classroom discussion and Exercise

APOS: Action, Process, Objects and Schema

CAS: Computer Algebra System

CDC: Curriculum Development Centre

DGS: Dynamic Geometry Software

ICT: Information and Communication Technology

MOE: Ministry of Education

NCTM: National Council of Teacher of Mathematics

i.e.: That is

d.f.: Degree of freedom

P: Difficulty level

D: Discrimination index

F: F-distribution

t: *t*-distribution

TU: Tribhuvan University

r: Reliability of coefficient

r_{xy}: Pearsons's correlation coefficient

α: Level of significance

%: Percentage

Fre: Frequency

Chapter I

INTRODUCTION

Background of the Study

The teaching system is a complex, made up of several elements mutually interacting around the three poles: the teacher, the students and the institutions. The teaching/learning trend has been changed due to the development of technology in the last few years. The integration of technology for teaching and learning, particularly in mathematics education, is becoming useful due to the different kinds of features of ICT which are not available through pencil and paper. Technology is becoming one of the popular means for mathematics-intensive educational fields which try to address the teacher, students and the knowledge at the same level, because technology can transform the teaching of mathematical concepts by engaging pupils in interaction demonstrations, constructions and explorations.

GeoGebra was designed to combine geometry, algebra and calculus in one dynamic environment. GeoGebra is free mathematics software created by Markus Hohenwatrer in 2001 for his masters' thesis project at the University of Salzburg, Austria. GeoGebra is dynamic math software that provides for an interactive learning environment enabling users to create mathematics objects and interact with them. GeoGebra users, mostly teachers and student, Can use this environment to explore, explain and model mathematics concepts and the relationship between them (Hohenwarter, M. & Preiner, J., 2007). One of the important advantages of public domain DGS is that students can use it even at home and explore their ideas in the absence of their teachers. This implies that even without teachers students can learn mathematics by looking, observing, manipulating things. The DGS programs promote student-directed inquiry and collaborative work by offering students opportunities to formulate theories and to draw their own conclusions (cf. Hannafin *et al*, 2001).

DGS not only helps students to learn in effective way, but also helps teachers to change their role in the classroom. With DGS teachers can prepare lesson materials in which they use it as a cooperation, communication, and representation tool for mathematics. Thus DGS is a versatile tool for mathematics education. It can be used for demonstration and visualizations of objects, as well as for discovering mathematics, even beyond geometry (Hohenwarter and Lavica, 2004). DGS can

transform the teaching of mathematical concepts into a style in which students are engaged in interactive demonstrations, constructions and explorations. Offering new tools that are unavailable in paper and pencil geometry, use of DGS widens the range of accessible geometrical constructions and solutions.

Statement of the Problem

In the teaching and learning of trigonometry, it has been often realized that students still lack the cognitive and process abilities in the total understanding of trigonometry. Although the teacher delivers the required knowledge to assist students in understanding the concepts of right angle triangle, students seem to face a challenge in applying this knowledge to a given task. For this more is required to guide students so that they will be able to manipulate and visualize the properties of right angle triangle solve the problems related to trigonometry. This perception is supported by research (Battista, Mitchelmore & White, 1999) whereby students faced challenges in understanding trigonometry and many struggle to grasp the concepts and required knowledge. The world Trigonometry is derived from the Greek word. It is three side measurements. Trigonometry is the study of relationship between the lengths, heights and angles of a triangle.

The factors that influence students' attitudes towards Mathematics are the teaching materials, when teacher uses the teaching materials the GeoGerba is one of the best tool and teaching material for teachers, the other factors are classroom management, teacher content knowledge and personality, relating the topics with real life situation and teaching methods. Learning Mathematics involves understanding the theories and formulas to describe something. In the typical classroom, the challenge for the students is to explore complex problems. With advances in multimedia technology, learning difficulties can be overcome. The challenge is more complex in teaching and learning of Mathematics, where teachers have to balance the mental, stationery and digital tools for teaching and learning that involve abstract mathematical concepts that is difficult to understand by students. Technology plays an important role in the development of the educational process. Existing technology equipment such as GeoGebra, Geometer's Sketchpad and Mathematica should be used maximum by the educators. The use of technology is important because it serves as an object of education, which affect the learning content and objectives, and as a medium to improve the teaching and learning process.

Therefore, a study on the Effectiveness of GeoGebra on students' Achievement in Trigonometry has to be conducted to see how it can be beneficial to improve the education system in Nepal. There is much controversy over the past two decades about the effects of using the tools of technology (calculators and computers) in the teaching and learning of Mathematics. Therefore, this study aimed to prove the extent to which technology tools can impact the teaching and learning of mathematics.

Objectives and Research Questions

The main objective of this study is to find GeoGebra on trigonometry teaching, particularly:

1. To compare the achievement of the student in trigonometry teaching with GeoGebra and without using GeoGebra.
2. To analyse the students view on GeoGebra in learning Height and Distance of Trigonometry.

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 hypotheses were formulated in this study, they are as follows:

Research Hypothesis

The dynamic geometric software yields effective result in terms of the achievement of mathematics then the achievement of the students taught without using GeoGebra.

Statistical Hypothesis

The null and alternative hypothesis as follow:

a. H_0: There is no significance difference between the average achievement score of experimental and control groups i.e. $\mu_1 = \mu_2$ on pre-test
   H_1: The average achievement score of experimental group is not equal to the control i.e. $\mu 1 \neq \mu 2$ on pre-test
b. H0: There is no significance difference between the average achievement score of experimental and control groups i.e. $\mu 1 = \mu 2$ on post-test

H1: The average achievement score of experimental group is higher than the control group i.e. $\mu 1 > \mu 2$ on post-test

Justification of the Study

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

Mathematics Teachers

Result of the study may be helpful to mathematics teachers to adopt the effective teaching method using ICT. And also choose the best way of teaching trigonometry using ICT.

Schools

School can utilize the ICT for teaching tool with help of this study.

Researchers

This study helps researchers to find out the effectiveness of using ICT in other field of mathematics.

Curriculum Designers

This study helps curriculum designers to find the importance of ICT in teaching geometry at secondary level and integrate the ICT as a material in curriculum.

Delimitation of the Study

The study was delimited under the following ways:

- The researcher of this study has utilized programmer GeoGebra Classic 5.0
- This study is based on grade ten students only.
- This study is based on the trigonometry teaching only.
- This study was conducted on only two Government schools of Gorkha District.

- In experimental group 36 students of Shree Shaila Putri Secondary School were for the study. In which researcher was taught in experimental group by using GeoGebra software.
- In control group 39 students of Shree Suya Jyoti Secondary School were for the study. In which researcher was taught in control group by using traditional method.
- The experimentation period of this research was based on completion of targeted chapters.
- Achievement test and questionnaire are tools to collect the data.
- Tests have been made by researcher himself with help of subject teacher, expert, and supervisor.

Operational Definition of the Key Terms

The key terms of this study were defined as below:

GeoGebra: Geogebra is software that integrates dynamic geometry and computer algebra features into one math education instrument. It enables a closer attachment between the functions of symbolic manipulation and visualization and dynamic changeability. Geogebra was used as a material in this research to teach the chapter 'trigonometry'.

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

Effectiveness: The measure of effectiveness for this study is: Increase in the average achievement of the students' in mathematics.

Achievement: In this study, the term "achievement" is defined in terms of the scores obtained by the students on the achievement test prepared by the researcher.

Government School: Government schools are those schools which receive the government grant for the salary of teacher and other all the purpose.

Education Technology: The hardware, software and other digital technologies to advance learning, teaching and interaction in educational settings. These are the tools we need in educational technology.

Experimental Group: A group of students, which had exposed and use of GeoGebra (treatment) regularly, while teaching.

Control Group: A group of students who had given regular instruction in Trigonometry, without using GeoGebra.

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

Chapter-II

REVIEW OF RELATED LITERATURE

Literature Review

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

Review of Empirical Literature

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

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

Acharya (2015), conducted the study on *"Effectiveness of GeoGebra software on mathematics achievement",* with objective to compare the achievement of the students in mathematics by using GeoGebra software with the achievement of students taught without using GeoGebra software and another objective to elicit students' perception in learning circles using GeoGebra software. Researcher used pre-test and post-test non-equivalent design of experimental research. The researcher chooses 28 students of grade X as experimental group and 25 students as control group. After one week of experiment research gathered data from mathematics

achievement test and mathematics perception test. The result of this study indicated that students in the experimental group have better achievement then control group.

And five point Likert type of scale was used to elicit students' perception on the use of GeoGebra. Result of the questionnaire response indicates a positive perception of using GeoGebra in mathematics learning.

Review of these two literatures indicates that the using GeoGebra in teaching and learning geometry is helpful for students and also it increases the students' achievement. The result of questionnaire of above study gave positive perception about GeoGebra software. Therefore, GeoGebra based learning is better than the traditional method for the better understanding.

Honenwarter, Honenwarter and Lavicza (2008), conducted the study entitled *"Introducing dynamic mathematics software to secondary school teachers: the case of GeoGebra".* With describes a study aimed to identify most common impediments related to the introduction of an open-source mathematical software package GeoGebra. This study based on school teachers in Florida. And identified challenges participants face during workshops three week and evaluated the difficulty level of GeoGebra tool. Finding of the study, complexity criteria of software tool and commonly occurring difficulties, provided the basis for the development of several new mathematics assisting workshops activities and contributed to the improvement of introductory GeoGebra workshops.

Sapkota (2015), did a research on *"Effectiveness of information communication technology integrated pedagogy at secondary level"*. With the aim to find the effectiveness of information communication technology integrated pedagogy in the existing educational system among students in the experimental and control group of grade X. 46 students of two public secondary school of Kathmandu districts were selected for the study. She concluded that information communication integrated pedagogy brings the effective result in terms of the achievement of mathematics in comparison to the existing pedagogy as well as students taught by ICT are more motivated towards mathematics instruction.

Herceg and Herceg (2010)**,** conducted a study on two groups of students. One group used applets only, whilst the other used the GeoGebra software and applets. The study tested how to incorporate computer-based learning to reduce the working

process of numerical integration. The results of this study showed that the GeoGebra experimental group gained more knowledge and skills than the control. This study also suggested that GeoGebra use is helpful for students who face difficulty in solving mathematical problems since they do not have to spend so much time solving by hand. According to Erhan (2013) dynamic software improves students' understanding of mathematics; students were able to explore and form conjectures and therefore had better overall scores.

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

According to the last four literature reviews above, mathematical courses taught using ICT software are more efficient than traditional training methods. Researchers use experimental research design in this research to compare the achievement of two experimental and control groups. But few numbers of researchers are investigating the efficacy of GeoGebra in the mathematics subject. This research was concerned about the efficacy of GeoGebra in trigonometry associated to grade-X.

Theoretical Framework

This study adopted APOS theory of constructivism as a theoretical framework. APOS theory proposes that an individual deal with mathematical problem situation by constructing and applying mental structure in their effort to understand mathematical concept. The mental structures refer to the likely action, processes, objects, and schema required to learn the concept.

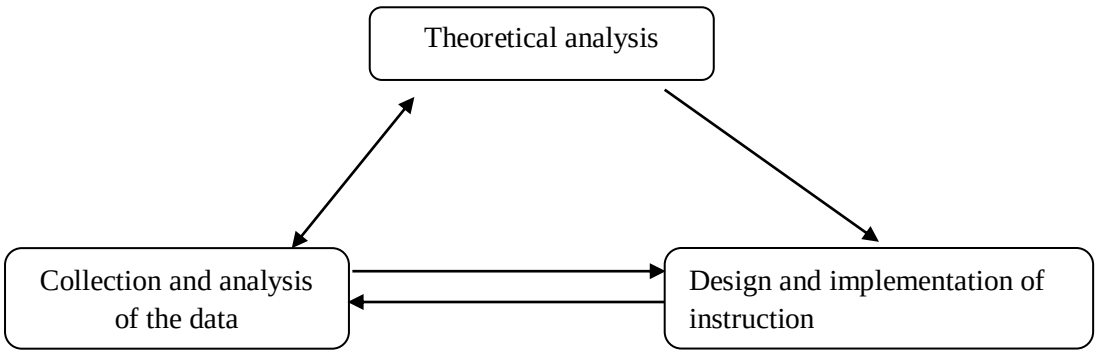
APOS-based research and curriculum development has focused mainly on learning mathematics by students in secondary and post-secondary grades (Arnonetal., 2014). The acronym APOS stands for action, process, object, and schema. A concept is first conceived as an action, that is, as an externally directed transformation of a previously conceived object. As an individual repeats and reflects on an action, it may be interiorized into a mental process. A process is a mental

structure that performs the same operation as the action, but wholly in the mind of the individual. An object is constructed from a process when the individual becomes aware of the process as a totality and realize that transformations can act on it. A mathematical topic often involves many action, process and object that need to be organized and linked into a coherent framework, called a schema.

APOS theory is a theory of how mathematical concepts can be learned. Rooted in the work of Jean Piaget, its fundamental ideas were first introduced in early 1980s (Dubinsky, 1984 as cited in Arnonet.al., 2014) and since that time, extensive development and application have been carried out the researcher, curriculum developers, and teachers in many countries throughout the world. So, this study is based on APOS theory.

Mathematical concepts are not constructed directly, it is necessary for an individual to construct mental structure to make sense of them (Piaget and Garcia, 1989). According to Asiala et.al. (1996), APOS based research involves three components: theoretical analysis, design and implementation of instruction, and collection and analysis of the data, as show in the figure below:

Figure 2.1: APOS Research Cycle



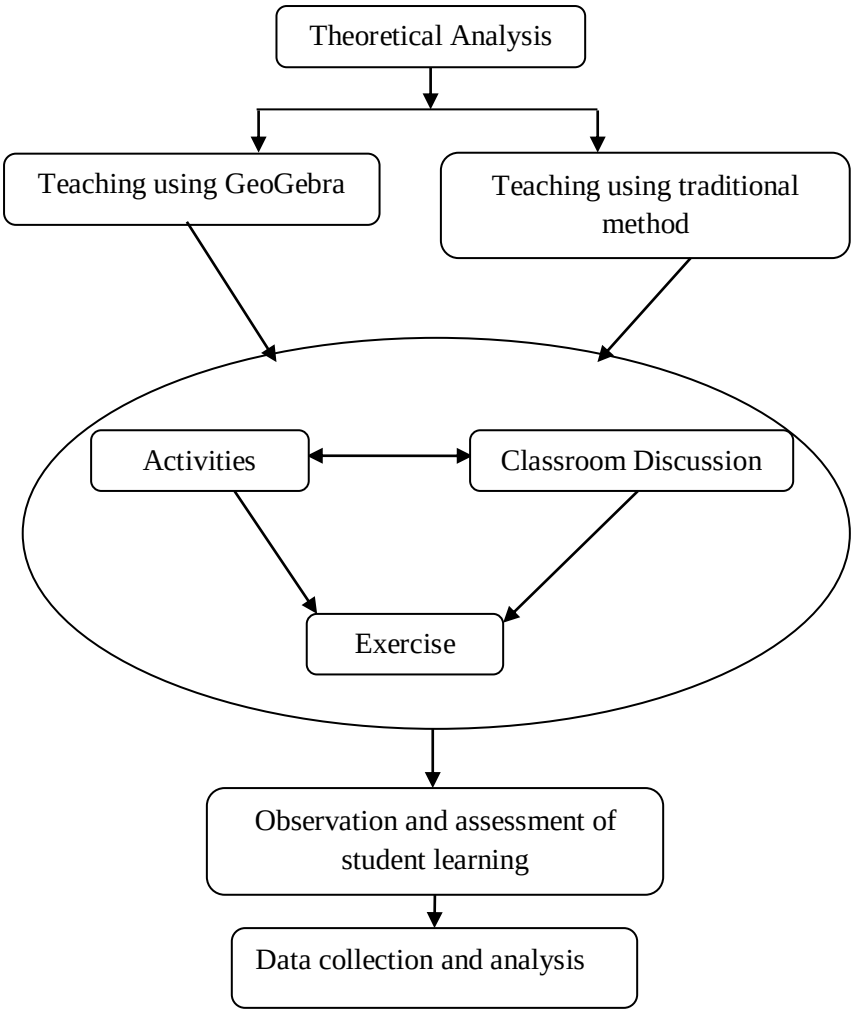
Thus, the three components of the research cycle i.e. theoretical analysis, design and implementation of instruction, and collection and analysis of the data influence each other. The theoretical analysis drives the design and implementation of instruction through activities. Activities and exercises were designed to help student's construction action, interiorize them into processes, process into objects and coordinate two or more process to construct new processes. The implementation of instruction provided an opportunity for the collection and analysis of the data, which carried out using the theoretical lens of APOS theory. The teaching cycle of APOS theory was based on ACE process (Arnon et al., 2014). The ACE teaching cycle a

pedagogical strategy that consists of three components: Activities, Classroom discussion and Exercise. The activities, which form the first step of the cycle, are designed to foster the students' development of the mental structure. In these activities, students work cooperatively. The classroom discussion is the second step of the cycle. The classroom discussion and in-class work give students an opportunity to reflect on their work. Exercise: the third step of the cycle. The exercise helps to support continued development of the mental constructions. So, APOS theory showed that, the research cycle based on above figure 1.

Conceptual Framework

This study used APOS research cycle of APOS theory to analyzing the effectiveness of using GeoGebra while teaching Trigonometry at grade X based on ACE teaching cycle. The conceptual framework of this study is show as in the figure:

Figure 2.2: Conceptual Framework



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

Developed the teaching episode was based on ACE teaching cycle. Activities, which constitute the first part of the teaching cycle, based on the fulfillment of the objectives of this study. The classroom discussion: the second part of the teaching cycle, involved instructor and students group. Activities and classroom discussion work gives students an opportunity to reflect on their work. As instructor guided the activities and discussion with provide definitions, explanations and presentation for control group using traditional method and for experimental group using GeoGebra software. Exercise, the third part of the teaching cycle, consist of fairly standard problems designed to reinforce the activities and the classroom discussion. Exercise had guided students to apply what they have learned and to consider related mathematical ideas. In this teaching cycle, instructor and students have worked together interacting each other with collaborative dialogue.

After completed the above teaching cycle, researcher collects the data from observation and assessment of students learning and data analysis was based upon method and procedures of this study. Soon after data analysis, theoretical analysis was carried out. Theoretical analysis was based on Thambi and KwanEu (2013) study for comparing the achievement score. Also theoretical analysis was based on Denbel (2015) study and Shadaan and KwanEu (2013) study for analyzing students view about GeoGebra.

Chapter-III

METHODS AND PROCEDURES

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

Research Design

Research design is the design of path about how does the research was conduct. It is the detail path of the investigation. Thus, research design comprises the overall strategy followed in collecting and analyzing data (Gay et al., 2012).

To meet the objectives of the study, the researcher used experimental design. According to Gay et al. (2012), in experimental research the researcher manipulates at least one independent variable, controls other relevant variables, and observes the effect on one or more dependent variables. It involves a comparison of two groups like experimental and control group.

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

Table 3.1: Design of the Study

Groups	**Pre-tests**	**Treatment**	**Post-test**
Experimental	O_1	T_1	O_2
Control	O_3		O_4

To fulfill the objective of this research, two groups of students were formed from homogenous as possible as by selection school of similar status focusing same cognitive structure of students.

In this design, O_1 and O_2 represented the pre-test and post-test for experimental group, and O_3 and O_4 represented the pre-test and post-test for control

group. Both groups were given the same achievement test (pre-test) before treatment. Pre-test has used to assess similarities between groups. After pre-test, the experimental group of students had been taught by regularly using GeoGebra software known as treatment T_1. But the control group of students had been taught by regularl using traditional method. Here traditional method also includes teaching without using GeoGebra software. And their activities were noted by regular observation. At the end of the experimentation time, achievement test (post-test) have been conducted to both group and their score were compared and analyzed. And scale of students view on GeoGebra software has been conducted only experimental group and their view were analyzed.

Population and Sample and Sampling Strategy

In this research work, Gorkha district was selected as a research site. Students of class X of Gorkha district have been considered as population. Using purposive and convenience sampling and selected two government school of Gorkha district students of class X have been preferred as sample.

In particularly, 36 students of Shail Putri Secondary School and 39 students of Surya Jyoti Secondary School were sample of the study. These two schools located in Barpark Sulikot Rural Municipality, Gorkha. Two groups of students were formed homogeneous as possible as by selecting school of similar status and focusing same cognitive structure of students.

Table 3.2: Composition of Sample

Group of students	**No. of students**	**Percentage**
Experimental	36	48%
Control	39	52%
Total	**75**	**100%**

Variables

Variables are key ideas that researcher seek to collect information on to address the purpose of their study. A concept which can take on different quantitative values is called a variable. Also variables is a characteristic or attribute of an

individual or an organization that researcher can measure or observe and varies among individuals or organizations studied (Creswell, 2012).

Different variables used in educational research. An independent variable is an attribute or characteristic that influences or affects an outcome or dependent variable. A dependent variable is an attribute or characteristic that is dependent on or influenced by the independent variable (Creswell, 2012). It means if one variable depends upon or is a consequence of the other variable, it is termed as a dependent variable, and the variable that is antecedent to the dependent variable is termed as an independent variable. Variables that are not related to the purpose of the study, but may affect the dependent variable are termed as extraneous variables. The variables in this study were classified as:

- Independent variable: In this study, using GeoGebra software while teaching problem of height and distance of trigonometry is known as independent variable.
- Dependent variables: in this study, students' score on mathematics achievement test (post-test) and student view on GeoGebra in learning height and distance of trigonometry are considered as dependent variable.
- Extraneous variable: Selection of student, instructor/teacher, subject matter, group, experimental time, test, scoring, students' labour and home environment are considered as extraneous variables in this study.

Some Major Affecting Variables Controlled in the Experiment

Selection of School: Such two schools were selected in sample which is similar in status like socio-economic, facilities, result of student etc.

Instructor/Teacher: Researcher himself was taught for the experimental and control group.

Subject Matter: In experimental period the chapter trigonometry of grade X was taught for the both groups.

Group: Experimental and control group of students have been made by naturally assembled.

Experimental Time: Researcher had provided equal time to both groups.

Test: Same test paper had conducted for the both groups before and after the time of experimentation.

Scoring: Researcher himself had gave the score of students in text paper appeared by the students.

Some Uncontrollable Affecting Variables in the Experiment

Student's Labour: Students may labour more or less than expected by the researcher and self-study of the students may affect in the result of research, which is out of control.

Student's Home Environment: Student's home environment has great effect on student's behavior and attitude but it cannot be controlled by the researcher.

Experimental Stages

Experimental stage was categorized into three stages in this study, which as follow:

Pre-experimental Stage

In the pre-experimental stage, the researcher developed the test item and questionnaires. The test item was related to the height and distance of Trigonometry of grade X. And test item included the both objective and subjective questions. The questionnaire related to five point Likert scale was based upon the students view about GeoGebra software. After developed test items, mathematics achievement test items were piloted on the group of students that are not included in sample for pre-test and post-test. And analyzed the result of pilot test and select the pre-test and post-test item of mathematics achievement test. After selected test item of mathematics achievement test, pre-test was administered among the students of experimental and control groups for the purpose of group comparable. The pre-test consisted of 10 objective questions and 6 subjective questions.

Experimental Stage

In this stage, researcher himself was taught for the experimental and control group regularly two weeks. The experimental group of students was taught by using GeoGebra software but the control group of students was taught by using traditional method. In the experimental process, teaching episode was developed for experimental group (see teaching episode in Appendix-1 and 2). And also the observation of students in both groups was done regularly for the time of experimentation.

Post-Experimental Stage

In post-experimental stage, the post-test was administered among both groups. The post-test consisted of 10 objective questions and 6 subjective questions. Also a set of questionnaire was administered only on experimental groups. It consisted 10 statements related to students view about GeoGebra software. After collecting the students answer and response, the data was analyzed.

Sources of Data

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

Primary Source: The primary source only based on test items and questionnaires. The questionnaire was related to Likert scale.

Secondary Source: The secondary source based on articles, journals, previous research related for analyzing data.

Data Collection Tools and Techniques

To success the research work within time, research tools and techniques would be necessary and appropriate for particular research work. The researchers of this study were used the following data collection tools and techniques:

Mathematics Achievement test

The achievement test was developed by the researcher himself with help of pilot test. Pilot test was administered at Bar Peepal Secondary School, Neelakantha municipality-11, salle, Dhading. The pre-achievement test (pre-test) was used to determine the achievement level of students in both groups. This test consists of 10 objective and 6 subjective questions, where objective question was of the weight one marks, 2 subjective questions was of the weight two marks and 4 subjective questions was of the weight four marks. The tool was used as a pre-test for group comparable. This was administered before the experimentation process. At the end of experimental time post-achievement test (post-test) was administered for the purpose of this study. Post-test was included same question of pre-test with same weight. See the both pre-test questions in Appendix-3 and 4.

Questionnaires

The questionnaire related to five point Likert scale was used to analyse the students view on GeoGebra in learning height and distance of Trigonometry. In this study, the set of questionnaire contains 10 statements using Likert scale of '1-Strongly disagree, 2-Disagree, 3-Undecided, 4-Agree and 5-Strongly agree' for positive statement and for negative statement the scoring process was reversed. (See the questionnaires in Appendix-10). This questionnaire was adapted on modified based on Denbel (2015) study and Shadaan and KwanEu (2013) study.

Item Analysis of the Test

In item analysis, the difficulty level (P-Value) and discrimination index (D-value) of the test was computed to cheek which item accept for achievement test and also to cheek quality of the test item. The researcher conducted the pilot Testamong 25 students of Bar Peepal Secondary School Neelakantha municipality-11, salle, Dhading. After collected student's response, first divide the total number of students into two groups which were appeared in pilot test by 50% of high scorer students and 50% of low scores students from total. Out of them choose 27% high scorer students and 27% low scores students out of 25 students. The table of item analysis of the test is given in Appendix-5 and Appendix-6. By using statistical formula, only those item were selected whose P-value was ranging between 26% to74% and D-value was ranging between 0.20 to 1.00. The other items were rejected and modified. The 9 items were rejected from 20 objective questions and 3 items were rejected from 10 subjective questions. After cancelling and modifying the items, the refined instrument of achievement test was prepared (see Appendix-3 and 4).

Validity and Reliability of Tool

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

Reliability of the test is very important of this study. For this purpose, every test items are piloted and reliability is checked before it was administered. In this study, the mathematics achievement test piloted, involving 25 students of grade X in Shree BarPeepal secondary School Neelakantha Municipality-11, salle, Dhading. The

response of the students is analyzed. Employing the split-half method of reliability of the test was determined. The test found to have r =0.95 (See Appendix-7). It indicates that the mathematics achievement test was highly reliable.

Intervention

For the intervention, Height and Distance of trigonometry at grade X were planned to be taught by using GeoGebra software to the experimental group. The teacher was the researcher. The traditional teaching method was used by a teacher in the control group. The intervention was preceded by a pre-test, as a baseline (see Appendix-3 and 4 pre-test). After the pre-test the intended classroom activities were implemented. The classroom teaching, which was the main part of the intervention, covered trigonometry lessons each of which was 45 minute period. At the beginning of intervention, teacher prepared the teaching episode (see Appendix-1 and 2).

In the first period, first few minutes the teacher introduced to the dynamic mathematical software GeoGebra to the students in the experimental group, and teacher explained the problem related to trigonometry with help of GeoGebra software. After that researcher/teacher and students both interaction each other and proved the trigonometry problems (see teaching episode-1). This problem to be taught by traditional method in the students of control group.

See other teaching strategy in teaching episode 2,3,4 and 5 in Appendix-1 and 2. At the end of the intervention, post-test (see appendix-3 and 4) was administered in both group and questionnaire (see Appendix-10) was administered only the experimental group. Thereafter, in order to evaluated the intervention.

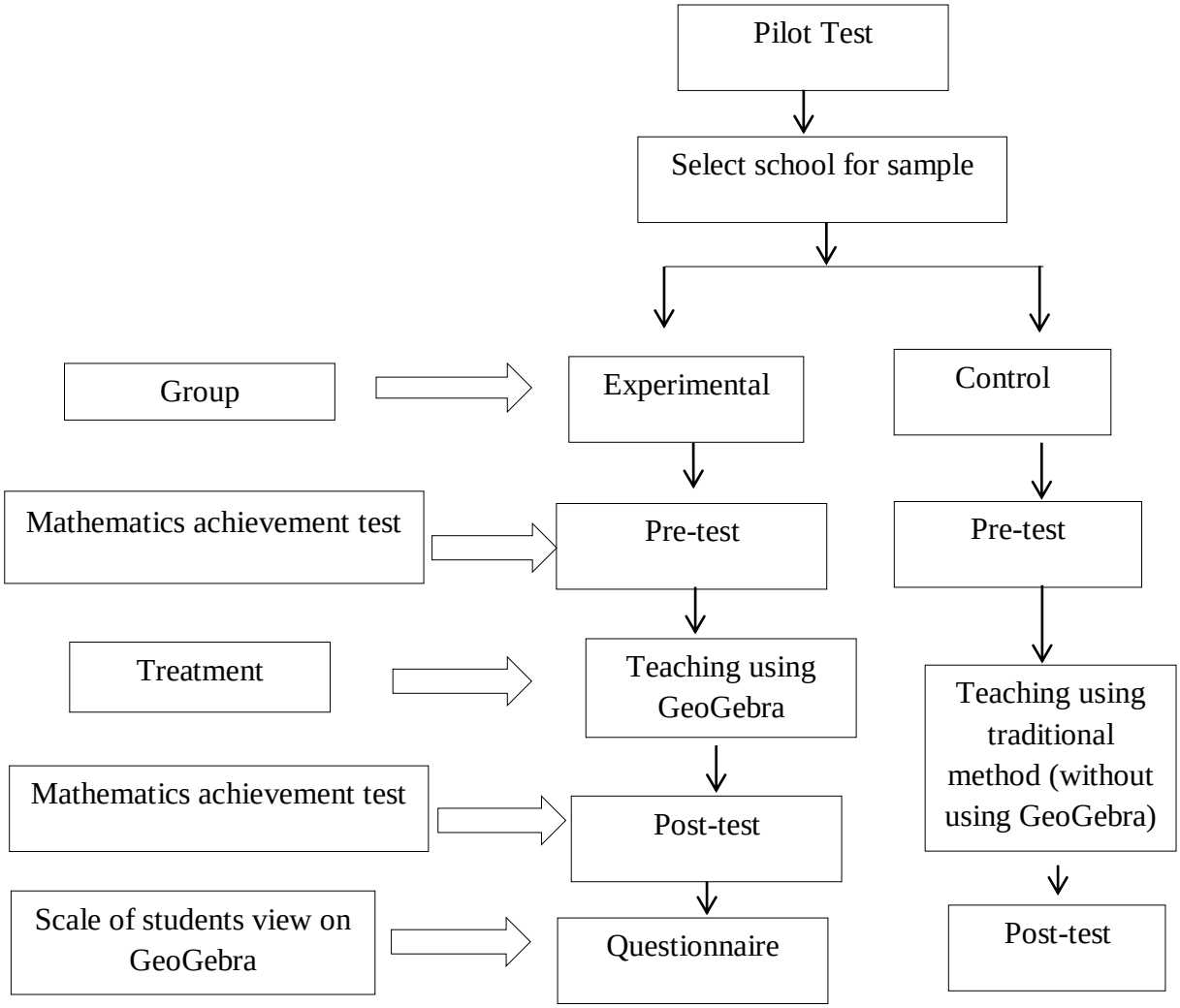
Data Collection Procedures

In the present study, data collection procedure was very important. The procedures of data collection describe how the relevant information was gathered. This study is manly based quantitative data obtained from mathematics achievement test and questionnaire related to five point Likert scale. Before administering pre-test, pilot test was administered at Shree Bar Peepal Secondary School. The scores on each item obtained by the students were calculated P-Value and D-Value in items of statistical analysis (see Appendix-5 and 6). And researcher was developed test items (see Appendix-3 and 4) and also reliability of achievement test (see appendix-7) was found.

In this study, after the standardization of the test, the collection of data from mathematics achievement test was done by following process. Before start experimentation, the researcher meets the principal and subject teacher and took permission for experimentation. After select sampled school, the achievement test (pre-test) was administrated to X grade students of school in the sample. In the examination, there were 36 students of Shree Shaila Putri Secondary School, which is known as experimental group and 39 students of Shree Surya Jyoti Secondary School, which is known as control group. Then the score of these students were tabulated (see Appendix-8) .The pre-test was administered for group comparable.

After pre-test scores tabulated, experimental group of students was taught regularly one week by using GeoGebra software with help of teaching episode (see Appendix-1 and 2). The control group of students was taught regularly one week using traditional method (without using GeoGebra). At the end of experimentation time an achievement test (post-test) was conducted to both groups and their score was tabulated (see Appendix-9). The post-test was administered for the purpose of comparing the achievement score. Additionally, a set of questionnaire related to five point Likert scale (see Appendix-10) was administered only on experimental group and their view was recorded. The set of questionnaire was administered for purpose of analyzing the students view on GeoGebra in learning Height and Distance of trigonometry. The summary of the data collection procedures of this study was given in the figure below:

Figure 3.1: A Summary of the Data Collection Procedures



Data Analysis Procedures

Data analysis procedures based upon the data collection tools and techniques. Collected data was analysed by using descriptive and inferential statistical analysis method. Descriptive statistical like: mean, variance and standard deviation were calculated with help of Microsoft Office Excel 2010. Mean, variance and standard deviation were calculated for both groups with their obtained marks in the pre-test and post-test. Also mathematics achievement test scores analysed using inferential statistics, specifically that t-test with two-tailed test at 0.05 level of significance value was used in comparison of pre-test result. Similarly, the t-test with one-tailed test at 0.05 level of significance value was used in comparison of post-test result. For the comparison of both the results, f-test was used for comparing the variances of experimental and control groups. Additionally, for analyse the students view about GeoGebra software, the questionnaire related to five point Likert scale was used only

the students of experimental group. And students response was calculating mean, standard deviation and percentage by assigned 1 for strongly disagree, 2 for disagree, 3 for undecided, 4 for agree and 5 for strongly agree for all positive statement and for negative statement the scoring process was reversed. Finally, data was analysed and interpreted

Chapter-IV

ANALYSIS AND INTERPREATION OF DATA

This chapter deals with the analysis and interpretation of data. An experimental research was done in concern to the topic "Effectiveness of GeoGebra on students' achievement in trigonometry." The objectives of the study were 'Comparing the achievement of the students taught by using GeoGebra and tradition method in Height and Distance' and 'Analyzing the students view on GeoGebra in learning Height and Distance'. A pre-test and post-test was design for quasi-experimental was adopted for the purpose of the study. A pre-test was taken to make the group comparable. Primarily, the achievement test of the student in post-test was taken to fulfill the first objectives of the study. And for the second objectives of the study, questionnaires related to Likert scale ware used. The scores of the student were analyses using statistical method with help of Microsoft Office Excel 2010 for mean, variance and statistical deviation. And the students view on GeoGebra was analyses using Microsoft Office Excel 2010 for mean and standard deviation with based on Likert scale analysis. For fulfill our motto, the data are organized, tabulated, analyzed and interpreted as follow:

Analysis of Pre-test Result

In Appendix-8 the pre-test score of students of both groups are presented. The summary of statistical calculation for the experimental and control group on the pre-test is given in Table.

Table 4.1: Result of Pre-test

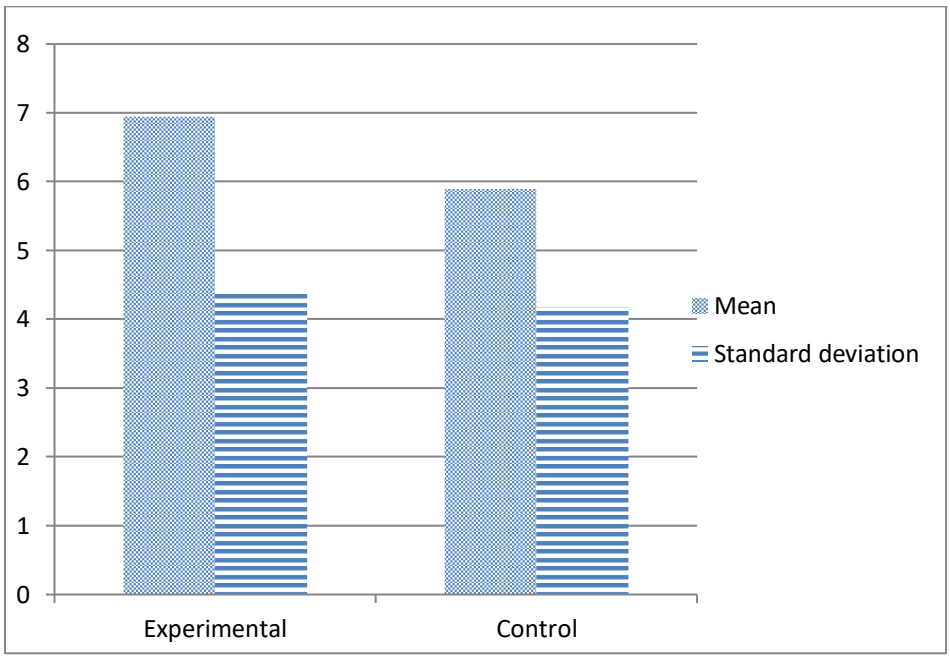
Group	N	Mean	Variance	Standard Deviation	F	Calculated t-value	Tabulated t-value
Experimental	36	6.94	19.37	4.40	1.11	1.06	1.96
Control	39	5.89	17.40	4.17			

The above Table-4.1 shows us, there were 36 and 39 number of students in experimental and control group respectively. In pre-test 30 marks of mathematics achievement test was administrated (see pre-test question in Appendix-3 and

Appendix-4 and pre-test score of students in Appendix-8). The mean, variance and standard deviation of experimental group were 6.94, 19.37 and 4.40 respectively.

Similarly, the mean, variance and standard deviation of control group were 5.89, 17.40 and 4.17 respectively. Since the value of F is 1.11, so that two groups were homogeneous therefore *t*-test for pooled variance was applied. Here tabulated *t*-value at $\alpha = 0.05$ level of significance for two tailed test with 73 degree of freedom is 1.06 but calculated *t*-value was 1.96. Calculated *t*-value was not lying in critical region i.e. $-1.96 < 1.06 < 1.96$. So, H_0 is accepted. Hence it could be concluded that there is no significance difference between the average achievement score of experimental and control groups of pre-test. Thus, both groups were nearly equal in ability.

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



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

Analysis of Post-test Result

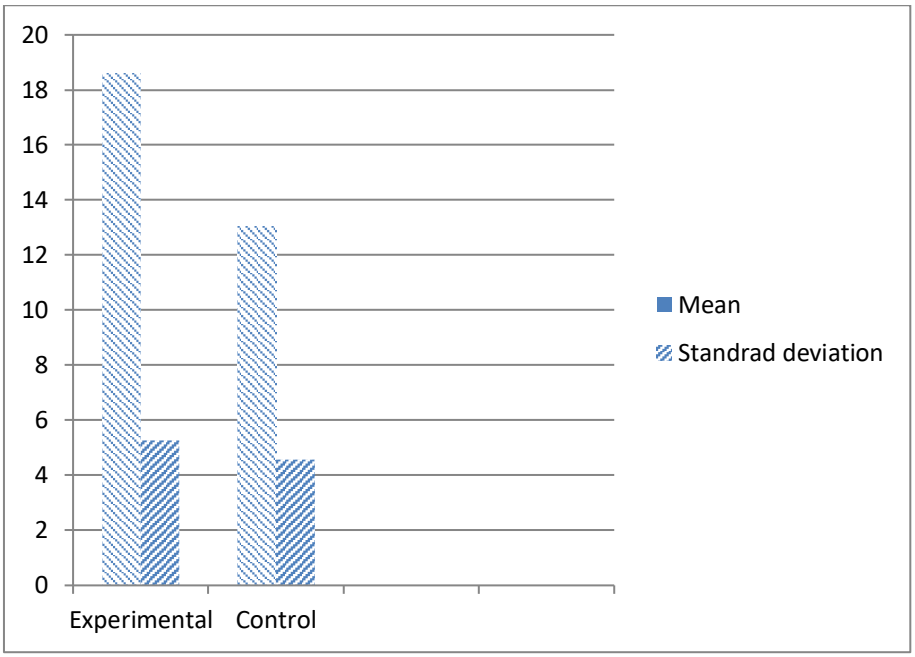
The post-test score of students of experimental and control groups have been presented in Appendix-9 and the summary of statistical calculation for the both groups on post-test is represented in the Table 4.2 and Figure 4.2 below.

Table 4.2: Result of Post-Test

Group	N	Mean	Variance	Standard Deviation	F	Calculated t-value	Tabulated t-value
Experimental	36	18.58	27.79	5.27	1.34	4.82	1.645
Control	39	13.08	20.70	4.55			

The above Table 4.2 shows that there are 36 and 39 students in experimental and control group respectively. In post-test 30 marks of mathematics achievement test was administrated (see post-test question in Appendix-3 and Appendix-4 and post-test score of student in Appendix-9). The mean score of experimental and control group are 18.58 and 13.08 respectively as well as variance are 27.79 and 20.70 respectively. Also standard deviation of experimental group is 5.27 and control group is 4.55. These values were calculated by mathematics achievement test in post-test using Microsoft Office Excel 2010. Since the value of F was 1.34, so both groups were homogeneous hence the method of pooled variance for *t*-test was applied. Here tabulated *t*-value at $\alpha = 0.05$ level of significance for one tailed test with 73 degree of freedom is 1.645. But calculated *t*-value is 4.82. Here $4.82 > 1.645$ so, that H_0 was rejected and H_1 was accepted. Hence the average achievement score of experimental group is higher than the control group on post-test. Thus, the students who were taught by using GeoGebra learned more and so higher achievement than traditional method of teaching.

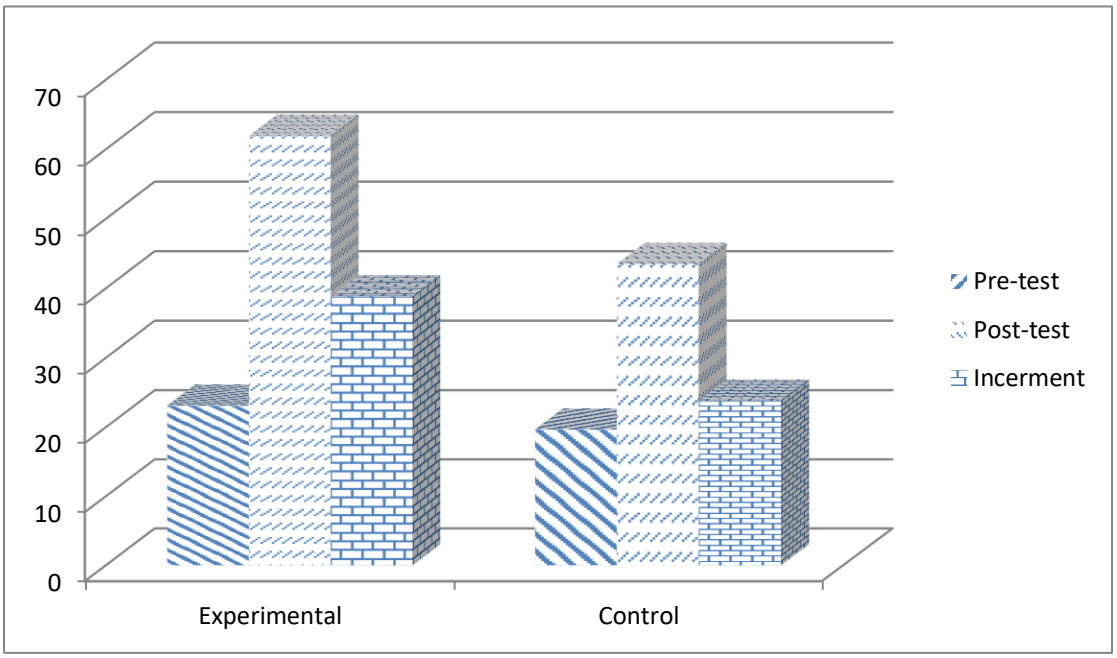
Figure 4.2: Mean and Standard Deviation Scores Distribution of Post-test Result



The mean and standard deviation scores obtained by the students of each groups in the achievement test (post-test) scores have been shown in above diagram (Figure4.2). The column of experimental group of students is longer than of control group students. This shows that there is a difference in achievement score between experimental group and control group on post-test. Since the difference between the mean, standard deviation on the post-test was 5.27 and 4.57 respectively. Therefore, the diagram (Figure4.2) indicates that the teaching using GeoGebra software is more effective than tradition method in Height and Distance of Trigonometry at grade X.

Comparison Percentage of Mean Score on Pre-Test and Post-Test

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



The above diagram (Figure 4.3) shows that percentage of mean score on pre-test of experimental and control group 23.13% and 19.67% respectively. But percentage of mean score on post-test of experimental group is 61.93% and control group is 43.5%. So 38.8% increment in mean score of experimental group but 23.83% increment in mean score of control group. Therefore, percentage of mean score of experimental group is higher than control group of students. Thus, the above diagram shows that the teaching using GeoGebra more effective than traditional method in Height and Distance of Trigonometry at class X.

Analysis of Students View on GeoGebra Result

A questionnaire related to students view about GeoGebra software was administered to 36 students of experimental group only (see the scale in Appendix-10) whose response are tabulated, the quantitative data are provided in Table 4.3 (in Likert scale). 5, 4, 3, 2 and 1 indicated strongly agree, agree undecided, disagree and strongly disagree respectively for positive statement. And 1, 2, 3, 4 and 5 indicated strongly agree, agree undecided, disagree and strongly disagree respectively for negative statement.

Below the Table 4.3, the highest mean 4.75 was the item ‘GeoGebra isessential and important from the teaching trigonometry’ and its standard deviation 0.44.

While the lowest mean was 3.28 which is obtained from the item ‘at the beginning, Idid not like GeoGebra software and its standard deviation 0.91. Other items mean were near about the highest mean. According to Denbel (2015) study and Shadaan and KwanEu (2013), a mean score of 3.0 or higher indicates a positive feedback or view about GeoGebra and the mean score lower than 3.0 indicates negative feedback or view about GeoGebra in learning trigonometry. The result from overall mean 4.39 shows that students generally gave positive feedback or view about the GeoGebra software in learning Height and Distance of Trigonometry at class X.

Table 4.3: Result of Students View on GeoGebra

Items		Strongly agree	Agree	undecided	Disagree	Strongly disagree	Total	Mean	Standard Deviation
At the beginning, I did not like GeoGebra software	Fre	0	11	4	21	0	36	3.28	0.91
	%	0	30.56	11.11	58.33	0	100		
I liked studying Geometry lessons with using GeoGebra software	Fre	16	20	0	0	0	36	4.44	0.50
	%	44.44	55.56	0	0	0	100		
GeoGebra helped me a lot to learn the trigonometry concept	Fre	21	15	0	0	0	36	4.58	0.50
	%	58.33	41.67	0	0	0	100		
GeoGebra is essential and important for the teaching trigonometry	Fre	27	9	0	0	0	36	4.75	0.44
	%	75	25	0	0	0	100		
GeoGebra software helps easy to understand Trigonometry problems	Fre	16	19	1	0	0	36	4.42	0.55
	%	44.44	52.78	2.78	0	0	100		

GeoGebra software helps visualizing the problems of Trigonometry concept	Fre	21	15	0	0	0	36	4.58	0.50
	%	58.33	41.67	0	0	0	100		
GeoGebra software enhance my learning in trigonometry Lessons	Fre	27	7	2	0	0	36	4.69	0.58
	%	75	19.44	5.56	0	0	100		
GeoGebra software help to make the learning more enjoyable	Fre	14	21	1	0	0	36	4.36	0.43
	%	38.89	58.33	2.78	0	0	100		
GeoGebra makes trigonometry class boring	Fre	0	0	4	3	29	36	4.69	0.67
	%	0	0	11.11	8.33	80.56	100		
Using GeoGebra makes trigonometry more difficult for me	Fre	2	6	2	4	22	36	4.06	1.37
	%	5.56	16.66	5.56	11.11	61.11	100		
Overall Mean = 4.39									

From the above Table 4.3 about the item-1 'about the item-1 ‘At the beginning, I did not like GeoGebra software’ 30.56%, 11.11% and 58.33% of students gave agree, undecided and disagree respectively. Few students only agree and other students disagree and undecided about the item-1. Combination of strongly agree and agree was full percentage given by the students about the item-2 ' I liked studying trigonometry lessons with using GeoGebra software'. This means all students were liked the studying trigonometry with using GeoGebra software. Also the full percentage of students gave positive response about the item-3' GeoGebra helped me a lot to learn the trigonometry concept', item-4 ' GeoGebra is essential and important for the teaching trigonometry' and item-6 ' GeoGebra software helps visualizing the problems of Trigonometry concept'. In item-5 ' GeoGebra software helps easy to understand Trigonometry problems', 44.44%, 52.78%, and 2.78% of students were positive about the item-5.

The second highest 75% of students gave the strongly agree about the item-7 'GoGebra software enhance my learning in trigonometry lessons' and 19.44% of students gave agree and 5.56% of students gave undecided. Its means GeoGebra enhance students' achievement in trigonometry lesson.in item-8 ' GeoGebra software help to make the learning more enjoyable', 38.89%, 58.33% and 2.78% of students gave strongly agree, agree and undecided respectively, so, the class using GeoGebra software in teaching trigonometry was more enjoyable. The highest 80.56% of students gave strongly disagree about the item-9 'GeoGebra makes trigonometry class boring' and 8.33%, 11.11% of students gave disagree, undecided respectively. So GeoGebra makes the trigonometry class interesting and absorbing. In item-10 ' using GeoGebra makes trigonometry more difficult for me', 5.56%, 16.66%, 5.56%, 11.11% and 61.11% of students gave strongly agree, agree, undecided, disagree and strongly disagree shows that teaching using GeoGebra more effective than traditional method in height and Distance of Trigonometry at grade X.

Review by Thambi and KwanEu (2013) also showed that students in experimental group perform better when using GeoGebra than the control group with the traditional learning method. The result of this study indicates that there is significant difference between the average achievement score of experimental and control group in post-test. Based on their finding, this suggests that GeoGebra is very helpful for teaching and learning trigonometry. And the development of technology

tools GeoGebra increases the students' achievement in their learning geometry. Overly the above result shows that, the teaching using GeoGebra was more effective than traditional method in Trigonometry at grade X.

Chapter V

FINDING, CONCLUSION AND IMPLICATION

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

Summary of the Study

The research entitled "Effectiveness of GeoGebra on Students' Achievement in Trigonometry" was intended to investigate the using GeoGebra is more effective than the traditional method in trigonometry at grade X.

For the data collection of this study, pilot test was conducted on 25 students of Shree Bar Peepal Secondary School, Neelkantha Municipality-11, Dhading. The pilot test consisted of 20objectives (multiple choices) and 10 subjective type items on the area trigonometry from grade X. The researcher developed and tested the reliability of achievement test and also find the difficult level (P %) and discrimination index (D) of items before their administration. The reliability coefficient of achievement test was found to be 0.95.

A pre-test and post-test design of quasi-experimental was adopted for the purpose of this study. Students of class X ofGorkha district have been considered as population. The sample schools were selected through the purposive and convenience method of sampling which were 36 students of grade X from 'Shree Shaila Putri Secondary School' as experimental group and 39 students from 'Shree Surya Jyoti Secondary School' as control group, which was located on Barpark Sulikot Rural Municipality, Gorkha.

After teaching two week in Shree Shaila Putri Secondary School by using GeoGebra software, researcher collects the data from mathematics achievement test and students view on GeoGebra by using questionnaire related to Likert Scale of this experimental group. Also teaching two week in Shree Surya Jyoti Secondary School by using tradition method, researcher collects the data from mathematics achievement test of this control group. The experimental group contained 36 students and control group contained 39 students.

Two hypotheses were analyzed from the result of pre-test (show in Table 4.1) and post-test (show in Table 4.2). The score obtained by the students on pre-test was analyzed using *t*-test, at level of significance 0.05. Which shows that there was no

significant difference between the average achievement score of two groups. And the score obtained by post-test was also analyzed using *t*-test at level of significance 0.05, which shows that average achievement score of experimental group is higher than control group.

In this study teaching using GeoGebra more effective than the traditional method in trigonometry at grade X. The result highlighted that students in the experimental group performed better using GeoGebra than the control group that uses the traditional method. In addition, students view about GeoGebra was analysed through a set questionnaire based on Likert Scale consists of ten items. This questionnaire was distributed to only experimental group and result shows that students gave positive feedback or view about GeoGebra in teaching Height and Distance of Trigonometry.

Findings of the Study

Accepting or rejecting of the null hypotheses constructed for the study determined the effectiveness of GeoGebra software as compared to traditional method and questionnaire related to Likert Scale constructed for the analyzing students view on GeoGebra in teaching Height and Distance of Trigonometry at grade X. The findings of the study were observed from the calculated and tabulated t- value recorded in table for hypotheses to achieve the objective the objectives of the study. Also mean and standard deviation recorded in table for analyse students view on GeoGebra.

Following were the findings of the study:

- There was no significant difference between the average achievement score of experimental and control groups on pre-test.
- There was significant difference between the average achievement score of these groups on post-test i.e. the average achievement score of experimental group was higher than that of control group.
- The teaching using GeoGebra was more effective than traditional method in Height and Distance of trigonometry.
- The result shows that students gave positive feedback or view about GeoGebra software in learning Height and Distance of trigonometry.

- 75% of students of experimental group gave positive view on GeoGebra was enhanced students learning and understanding in Trigonometry lesson. And GeoGebra was essential and important for the trigonometry.
- The result shows that GeoGebra makes trigonometry class interesting and enjoyable.

Conclusions

In this research, the teaching and learning of Height and Distance of Trigonometry using GeoGebra has been effective. This was shown through the improved score of the student in experimental group. The finding highlighted that student in experimental group performed better using the GeoGebra than the control group that uses the tradition method. Students in experimental group performed better that uses traditional method. Students in the experimental group performed better in the post-test compared to the control group. Students generally gave positive feedback or view about the GeoGebra software in learning trigonometry. In addition, the GeoGebra software enhanced students learning and understanding of the Height and Distance of Trigonometry. Also GeoGebra software was essential and important for the teaching trigonometry and its make trigonometry class interesting and enjoyable.

Recommendations

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

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

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Appendix – I

Teaching episodes for experimental group

Teaching Episode – 1

Date: 2077-11-26

Subject: Introduction of Geogebra

Duration of lesson: 45 minutes

Target group: Grade X (14-16 years old)

Teacher: Kushal Bagale

Cooperating teacher: Pradip Bhatta

Prerequisites:

Students are familiar with basic computer operations. They are supposed to be able to know about mouse and keyboard as input and to monitor corresponding outputs on the screen.

I. Objectives:

- Recognize the working environment and some menu and tool bar.
- Recognize some basic tools in order to be able to draw basic geometric objects.

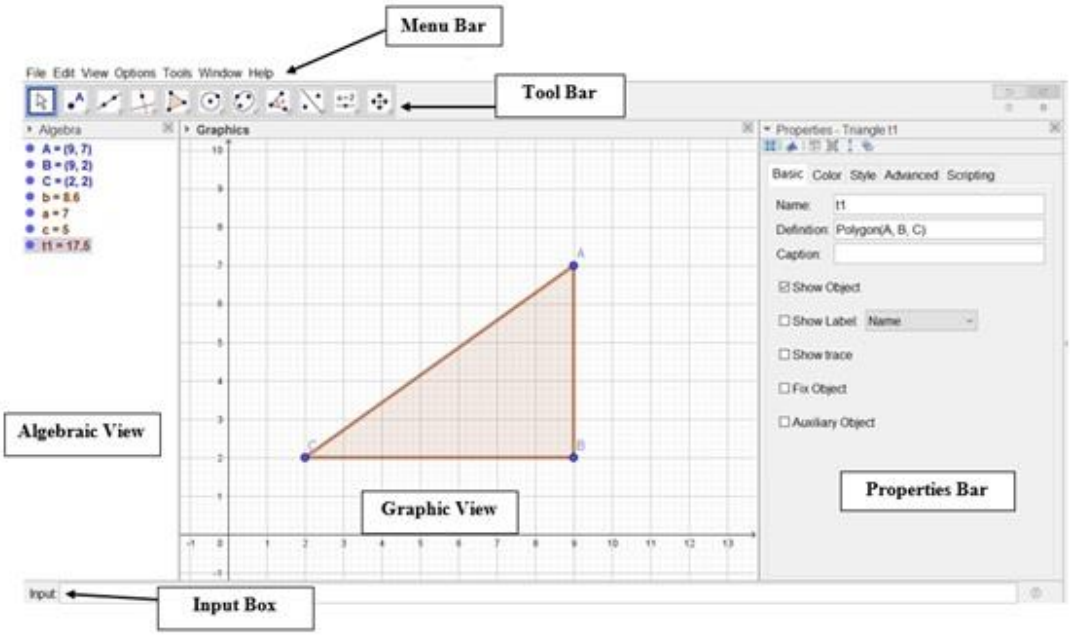
II. Required Materials:

- Computer/Laptop, projector, projection screen, white board, marker etc.
- GeoGebra 5.0 software required to be installed in computer/laptop.

III. Activities and Classroom discussion:

(Teacher introduces the students to GeoGebra software, its features and applications by demonstrating following activities using Power Point and GeoGebra software.)

- Firstly, teacher briefly explains about the development as well as application of GeoGebra via MS PowerPoint.
- Then, he opens GeoGebra software and explains about graphic view, algebraic view, spreadsheet view as well as menu bar, tool bar, input bar and so on. He also explains the uses of all these tools.
- Then, he encourages the students to draw point, line, segment, triangles etc.



A look of GeoGebra Windows

IV. Evaluation:

Draw line, line segment, angle and triangle using GeoGebra.

Teaching Episode – 2

Date: 2077-11-26

Subject: Introduction of unit circle

Duration of lesson: 45 minutes

Target group: Grade X (14-16 years old)

Teacher: Kushal Bagale

Cooperating teacher: Pradip Bhatta

I. Objectives:

- Introduction to unit circle and understand and trigonometry ratios with values.

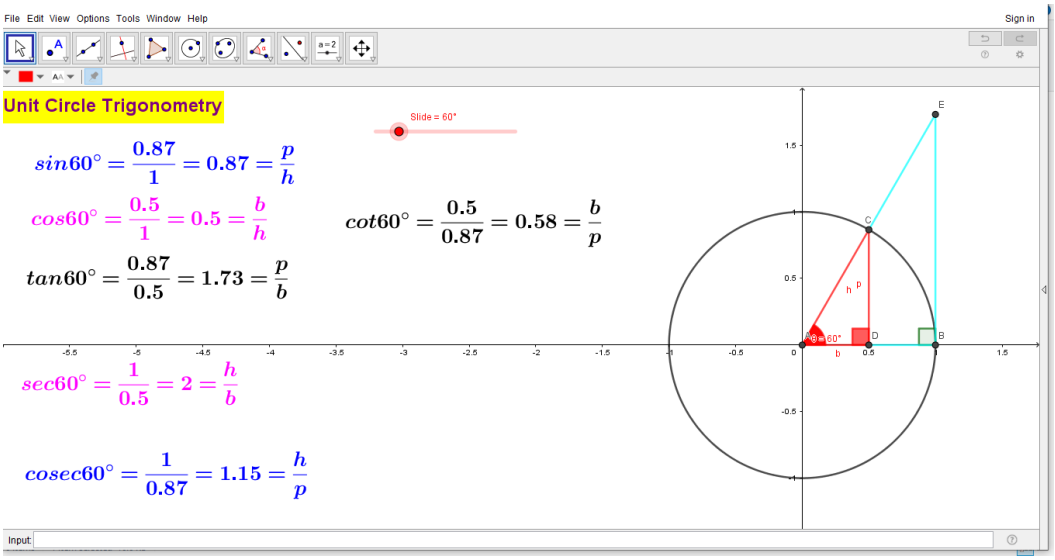
II. Required Materials:

- Computer/Laptop, projector, projection screen,white board, marker etc.
- GeoGebra 5.0 software required to be installed in computer/laptop.

III. Activities and Classroom discussion:

(Teacher introduces the students to GeoGebra software, its features and applications by demonstrating following activities using Power Point and GeoGebra software.)

- Firstly, teacher briefly explains about the trigonometry and unit circle with examples.
- Then, he opens GeoGebra software and explains about unit circle and to find the trigonometry ratio and values of trigonometry ratios.
- Then, he briefly of unit circle and trigonometry ratios and its' values.



Unit circle in GeoGebra

IV. Evaluation:

Find the values.

a) Sin 60^0

b) Cos 45^0

c) Tan 30^0

Teaching Episode – 3

Date: 2077-11-28

Subject: Angle of elevationand angle of depression

Duration of lesson: 45 minutes

Target group: Grade X (14-16 years old)

Teacher: Kushal Bagale

Cooperating teacher: Pradip Bhatta

I. Objectives:

- To recognize and define angle of elevation angle of depression.

II. Required Materials:

- Computer/Laptop, projector, projection screen, white board, marker etc.
- GeoGebra 5.0 software required to be installed in computer/laptop.

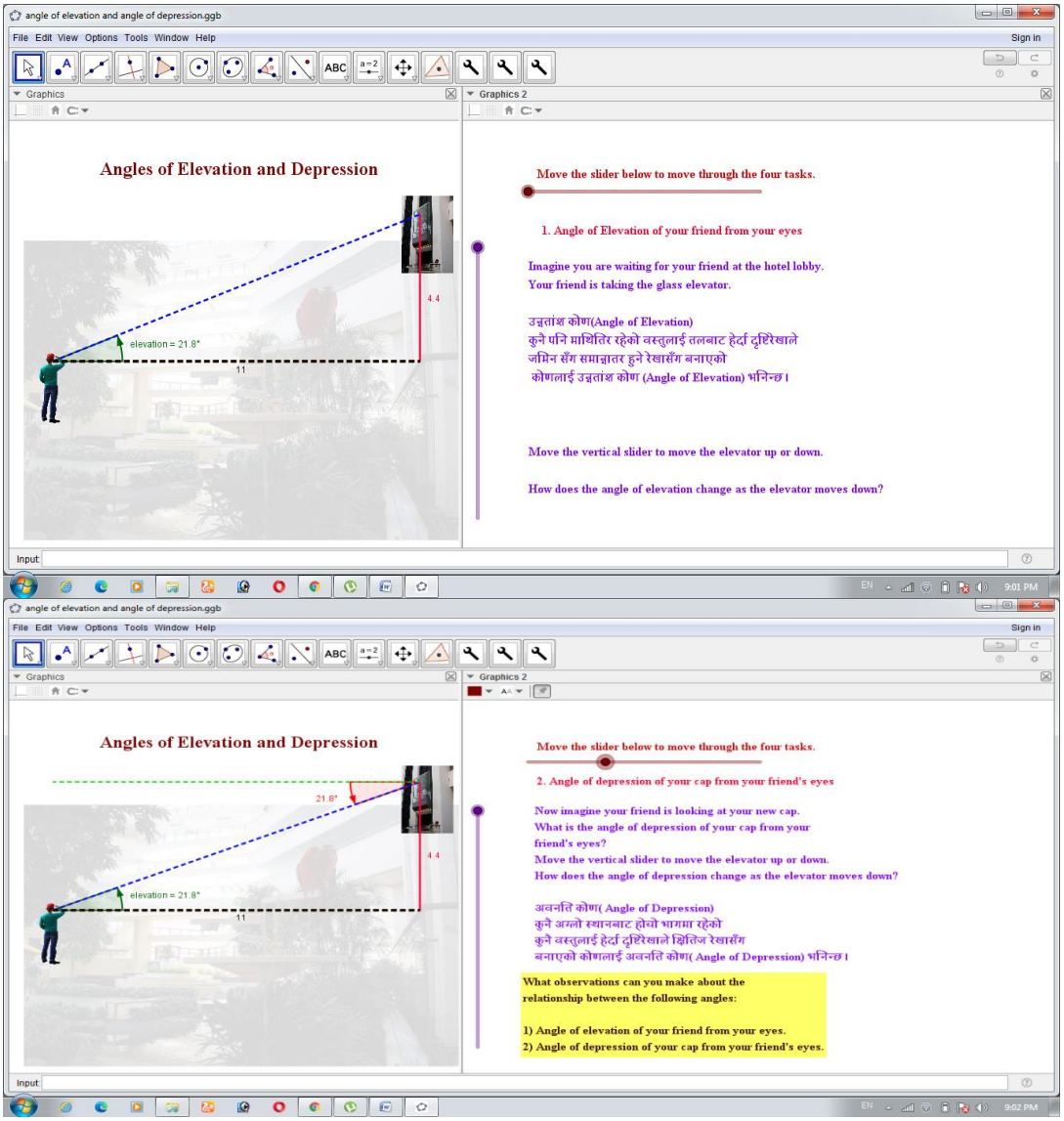
III. Activities and Classroom discussion:

For 20 minutes

- Researcher reviews about the yesterday's lesson and starts the class.
- Researcher should help the students for solving previous day's homework and ask students, what are the values of trigonometric ratios? What is the value of different ratios on different reference angles? And what is the relation between the sides and the values?
- After students answer, researcher used GeoGebra software for the different value of different reference angles and the relation between the sides and the values of the ratios in different reference angles. He demonstrates the figure of these angles in graphical view of GeoGebra window. After that researcher and students interact each other than researcher conclude the values of trigonometric ratios and the values, and what is the relationship between the sides of the right angled triangle and the values of reference angles.
- Similarly above process, researcher also discusses about how the unknown angles (except right angle) can be found when any two of the sides of right angled triangle are given.

For 25 minutes:

- Researcher describes angle of elevation and angle of depression with GeoGebra.



Screenshot of related problems

IV. Evaluation:

1. To define the angle of elevation and depression.

Teaching Episode – 4

Date: 2077-11-29

Subject: Angle of elevation

Duration of lesson: 45 minutes

Target group: Grade X (14-16 years old)

Teacher: Kushal Bagale

Cooperating teacher: Pradip Bhatta

I. Objectives:

- To recognize angle of elevation and solve the numerical problem.

II. Required Materials:

- Computer/Laptop, projector, projection screen, white board, marker etc
- GeoGebra 5.0 software required to be installed in computer/laptop.

III. Activities and Classroom discussion:

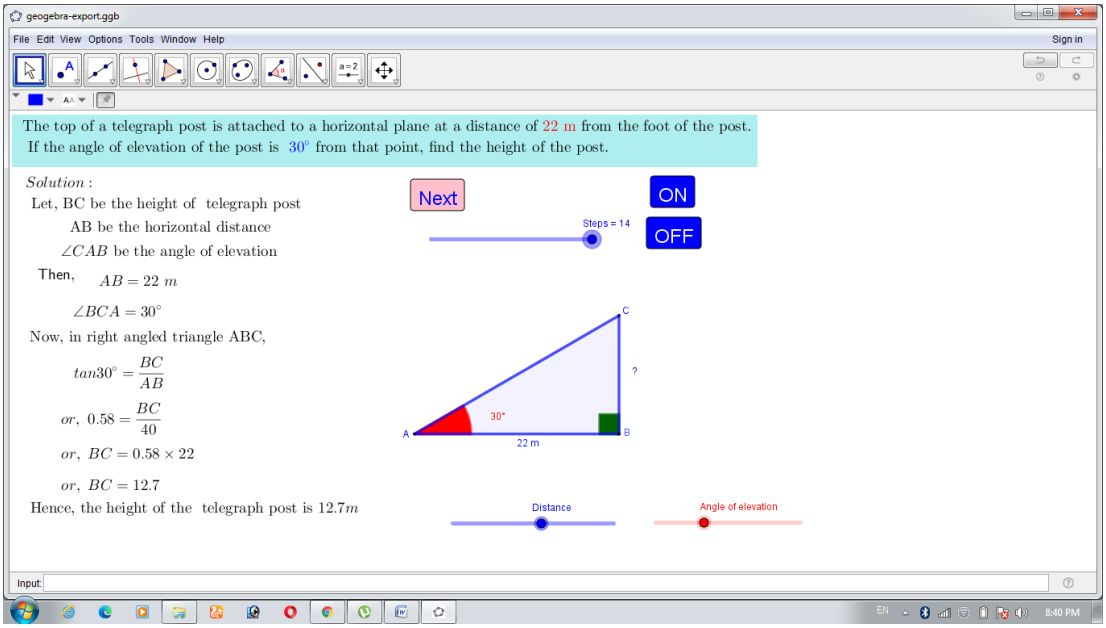
For 20 minutes

- Researcher discusses about the yesterday's lesson and starts the class.
- Researcher should help the students for solving previous day's homework and ask to students, which side is the perpendicular, hypotenuse and base? What are trigonometric ratios? What are the values of trigonometric ratios of some standard angles?
- After students answer, researcher used GeoGebra software for the height, distance and right angled triangle, reference angle, perpendicular, hypotenuse, base. He demonstrates the figure in graphical view of GeoGebra window. After that researcher and students interact each other than conclude the right angled triangles, reference angle and its different sides: base, perpendicular, hypotenuse and angle of elevation.
- Similarly above process, researcher defines the angle of elevation and how we can find it in different conditions.

For 25 minutes:

- Researcher shows some conditions in daily life situation where the angle of elevation can be constructed, and how the right triangles can be formed, and how we can solve such problems, how we can use the angle of elevation in daily life.

For this researcher uses GeoGebra and PowerPoint presentation for figure. He demonstrates the problems from the exercise book in graphical view of GeoGebra window after that, researcher and students conclude about angle of elevation based problem.



Screenshot of the presentation

IV. Evaluation:

- The top of a telegraph post is attached to a horizontal plane at a distance of 20m from the foot of the post. If the angle of elevation of the post is $45^0$from that point, find the height of the post.

Teaching Episode – 5

Date: 2077-11-30

Subject: Angle of depression

Duration of lesson: 45 minutes

Target group: Grade X (14-16 years old)

Teacher: Kushal Bagale

Cooperating teacher: Pradip Bhatta

I. Objectives:

- To solve recognize angle of depression and define the angle of depression.

II. Required Materials:

- Computer/Laptop, projector, projection screen, white board, marker etc
- GeoGebra 5.0 software required to be installed in computer/laptop.

III. Activities and Classroom discussion:

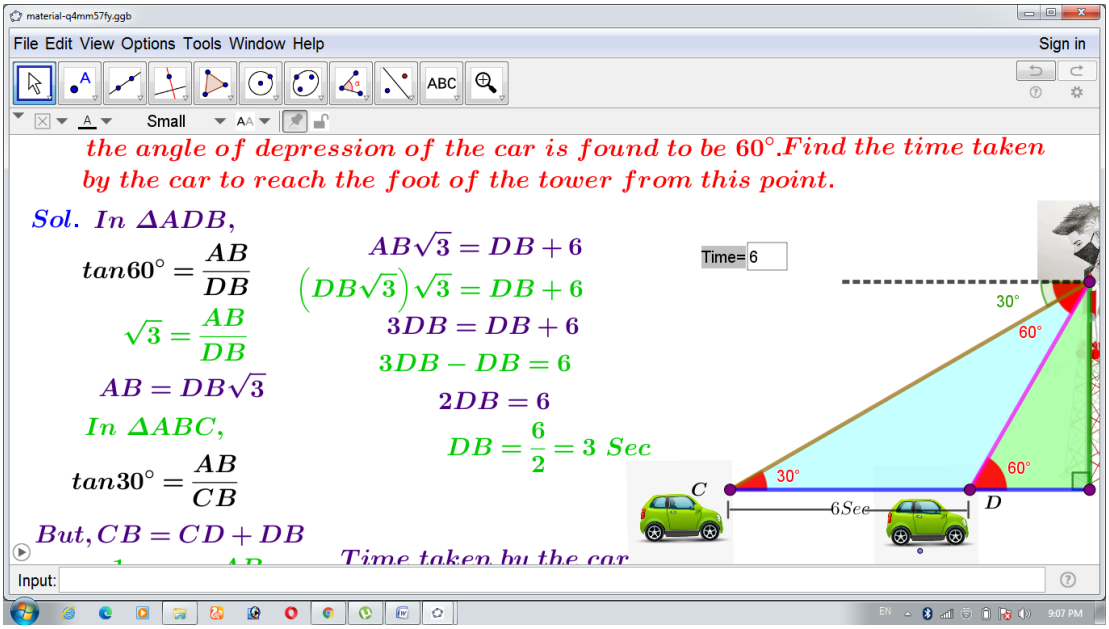
For 20 minutes:

- Researcher discusses about the yesterday's lesson and starts the class.
- Researcher should help the students for solving previous day's homework and ask to students, which side is the perpendicular, hypotenuse and base? What are trigonometric ratios? What are the values of trigonometric ratios of some standard angles? What is angle of elevation? What is the angle of depression?
- After students answer, researcher used to GeoGebra software for the height, distance and right angled triangle, reference angle, perpendicular, hypotenuse, base, angle of elevation and angle of depression. He demonstrates the figure in graphical view of GeoGebra window. After that researcher and students both interaction each other than conclude the right angled triangles, reference angle and its different sides: base, perpendicular, hypotenuse, angle of elevation and angle of depression.
- Similarly above process, researcher defines the angle of depression and how we can be constructed in different conditions.

For 25 minutes:

- Researcher shows some conditions in daily life situation where the angle of depression can be constructed, and how the right angled triangles can be formed,

and how we can solve such problems, how we can use the angle of depression in daily life. For this researcher uses different figures in the board through the help of projector and encourages the students for recognize the angle of depression and helps them to find out. Researcher used to GeoGebra software for figure. He demonstrates the problems from the exercise book in graphical view of GeoGebra window after that, researcher and students concludes about angle of depression based example.



Screenshot of the presentation

IV. Evaluation:

- Define angle of elevation with figure.
- Solve the problem

  Two vertical poles are fixed 60m apart. The angle of depression of the top of the first pole having height 115.36m as seen from the top of the second which is 150m high is 0^0 find the value of θ.

Teaching Episode – 6

Date: 2077-12-01

Subject: Height and distance

Duration of lesson: 45 minutes

Target group: Grade X (14-16 years old)

Teacher: Kushal Bagale

Cooperating teacher: Pradip Bhatta

I. Objectives:

- To draw the figure according the word problem given in the question.
- To find out the unknown side of the right angle triangle when angle of elevation and any one of the side of triangle is given.

II. Required Materials:

- Computer/Laptop, projector, projection screen, white board, marker etc.
- GeoGebra 5.0 software required to be installed in computer/laptop.

III. Activities and Classroom discussion:

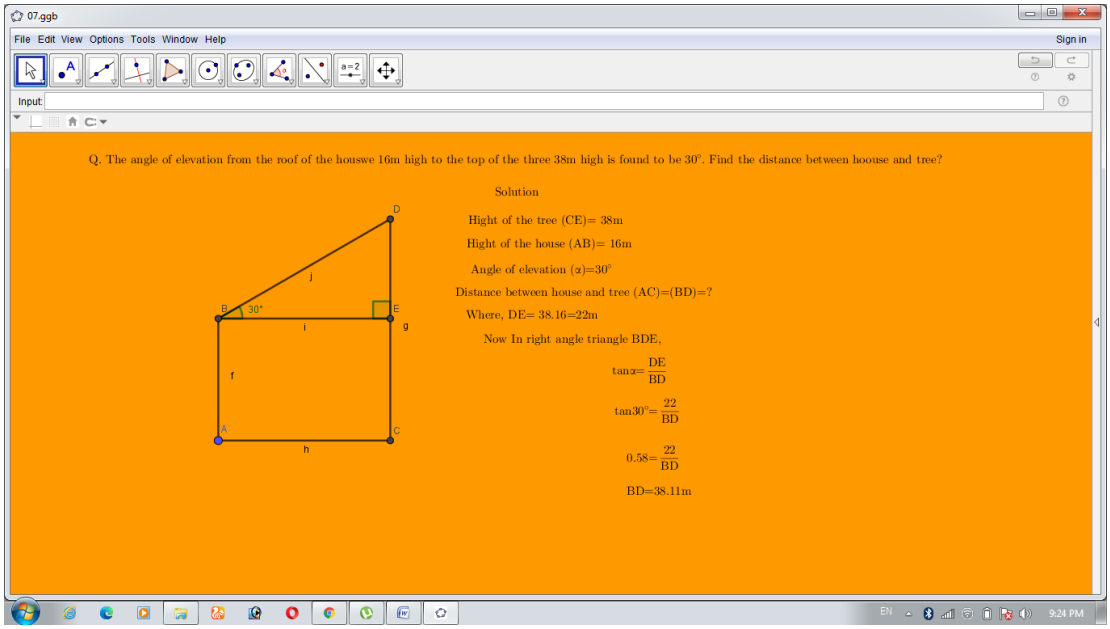
For 20 minutes:

- Researcher discusses about the yesterday's lesson and starts the class.
- Researcher should help the students for solving previous day's homework and ask to students, Researcher should ask to students, what is right angled triangle? What are the characteristics of right angled triangle? What are the values of trigonometric ratios of some standard angles? What is the angle of elevation?
- After students answer, researcher used GeoGebra software for right angled triangle, reference angle and angle of elevation. He demonstrates the figure in graphical view of GeoGebra window. After that researcher and students both interaction each other than conclude the right angled triangles, reference angle, angle of elevation and how we can draw them.

For 25 minutes:

- Researcher takes a word problem from the book and doing discuss with students and draws the figure according to the question step by step and after drawing the

figure teacher finds the answer of the question by the help of the students. For this researcher uses the board through the help of projector and encourages the students for finding the solutions themselves and helps them to find out the solutions of other questions. He demonstrates the problems from the exercise book in graphical view of GeoGebra window.



Screenshot of the presentation

IV. Evaluation:

- The angle of elevation of the top of a tree observed from a point 60m, away from its foot is 45°; find the height of the tree.

Teaching Episode – 7

Date: 2077-12-03

Subject: Height and distance

Duration of lesson: 45 minutes

Target group: Grade X (14-16 years old)

Teacher: Kushal Bagale

Cooperating teacher: Pradip Bhatta

I. Objectives:

- To draw the figure according the word problem given in the question.
- To find out the unknown side of the right angle triangle when angle of depression and any one of the side is given

II. Required Materials:

- Computer/Laptop, projector, projection screen, white board, marker etc.
- GeoGebra 5.0 software required to be installed in computer/laptop.

III. Activities and Classroom discussion:

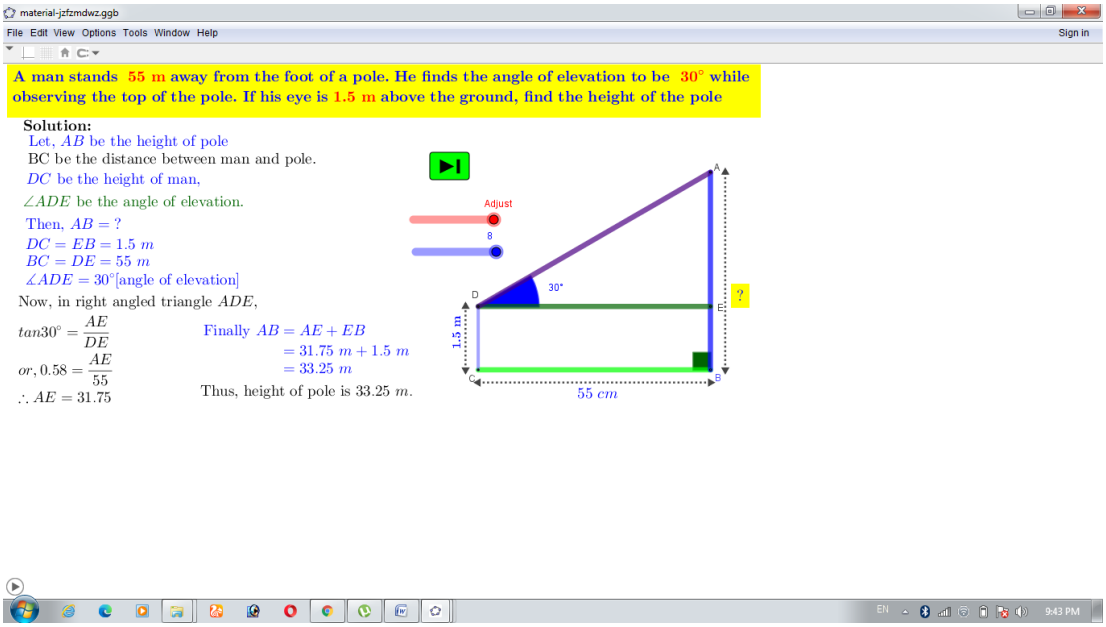
For 20 minutes:

- Researcher discusses about the yesterday's lesson and starts the class.
- Researcher should help the students for solving previous day's homework and Researcher asks to students, what is right angled triangle? What are the characteristics of right angled triangle? What are the values of trigonometric ratios of some standard angles? What is the angle of elevation? What is the angle of depression?
- After students answer, researcher used GeoGebra software for right angled triangle, reference angle and angle of elevation. He demonstrates the figure in graphical view of GeoGebra window. After that researcher and students both interaction each other than conclude the right angled triangles, reference angle, angle of elevation, angle of depression and how we can draw them.

For 20 minutes:

- Researcher takes a word problem from the book and doing discuss with students and draws the figure according to the question step by step and after drawing the

figure teacher finds the answer of the question by the help of the students. For this researcher uses the board through the help of projector and encourages the students for finding the solutions and helps them to find out the solutions of other questions. He demonstrates the problems from the exercise book in graphical view of GeoGebra window.



Screenshot of the Solved problem

IV. Evaluation:

From the top of a tower, the angle of depression to the roof of a house 10m high and 40m away from the tower was observed and found to be 30°. Find the height of the tower.

Teaching Episode – 8

Date: 2077-12-03

Subject: Height and distance

Duration of lesson: 45 minutes

Target group: Grade X (14-16 years old)

Teacher: Kushal Bagale

Cooperating teacher: Pradip Bhatta

I. Objectives:

- To draw the figure according the word problem given in the question.
- To find out the unknown side of the right angle triangle when angle of depression and any one of the side is given

II. Required Materials:

- Computer/Laptop, projector, projection screen, white board, marker etc.
- GeoGebra 5.0 software required to be installed in computer/laptop.

III. Activities and Classroom discussion:

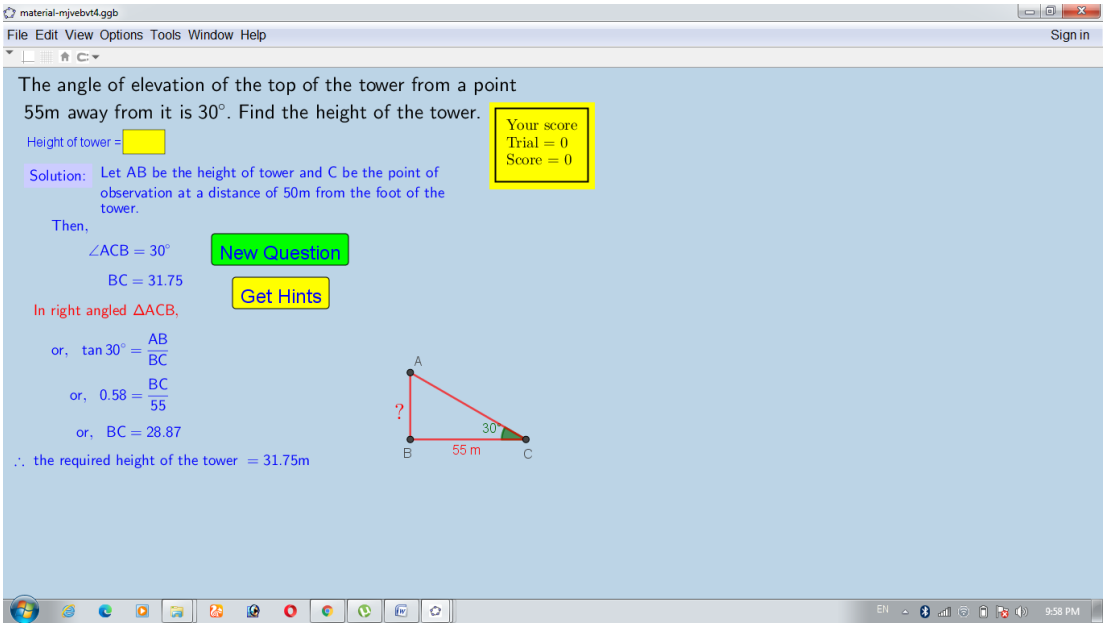
For 20 minutes:

- Researcher discusses about the yesterday's lesson and starts the class.
- Researcher should help the students for solving previous day's homework and Researcher asks to students, what is right angled triangle? What are the characteristics of right angled triangle? What are the values of trigonometric ratios of some standard angles? What is the angle of elevation? What is the angle of depression?
- After students answer, researcher used GeoGebra software for right angled triangle, reference angle and angle of elevation. He demonstrates the figure in graphical view of GeoGebra window. After that researcher and students both interaction each other than conclude the right angled triangles, reference angle, angle of elevation, angle of depression and how we can draw them.

For 20 minutes:

IV. Researcher takes a word problem from the book and doing discuss with students and draws the figure according to the question step by step and after

drawing the figure teacher finds the answer of the question by the help of the students. For this researcher uses the board through the help of projector and encourages the students for finding the solutions and helps them to find out the solutions of other questions. He demonstrates the problems from the exercise book in graphical view of GeoGebra window.



Screenshot of the Solved problem

V. Evaluation:

A tower on the bank of a river is of 20m high and the angle of elevation of the top of the tower from the opposite bank is 30^0. Find the breath of their river.

Appendix-2

Teaching episodes for control group

Teaching Episode – 1

Date: 2077-11-27

Subject: Right angled triangle

Duration of lesson: 45 minutes

Target group: Grade X (14-16 years old)

Teacher: Kushal Bagale

Cooperating teacher: Man Raj Bagale

I. Objectives:

- To find out the size of unknown side of a right angled triangle when, any one side and reference angle are given.

II. Required Materials:

- White board, marker, text book etc.

III. Activities and Classroom discussion:

For 20 minutes

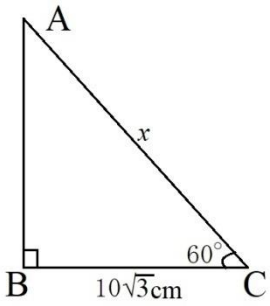
- Researcher should ask the students some questions, what are the values of different ratios on different reference angles? And what is the relation between the sides and the ratios?
- After students answer, researcher tells the value of different reference angles and the relation between the sides and the values of the ratios in different reference angles. He demonstrates the figure of such triangles in white board. After that researcher and students both interaction each other than conclude the values of trigonometric ratios in different conditions and what is the relationship between the sides of the right angled triangle and the values of reference angles.
- Similarly above process, researcher also discusses about how the unknown size of sides can be found when we know the value of any reference angle and any one of the size of the side.

For 25 minutes

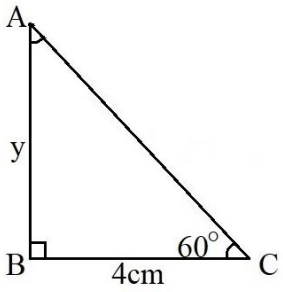
- Researcher writes some problems for unknown side on white board and discusses how it can be solved. For this researcher uses different figures in the board and encourages the students for finding the solutions and helps them to find out. He demonstrates the problems from the exercise book in white board after that, researcher and students interact to each other about figure and different condition then solve problems.

IV. Evaluation:

- Find the value of x.



- Find the value of y.



Teaching Episode – 2

Date: 2077-11-28

Subject: Introduction of unit circle

Duration of lesson: 45 minutes

Target group: Grade X (14-16 years old)

Teacher: Kushal Bagale

Cooperating teacher: Man Raj Bagale

I. Objectives:

- Introduction to unit circle and understand and trigonometry ratios with values.

II. Required Materials:

- White board, marker, text book etc.

III. Activities and Classroom discussion:

For 20 minutes

- Researcher should ask the students some questions, what are the values of different ratios on different reference angles? And what is the relation between the sides and the ratios?
- After students answer, researcher tells the value of different reference angles and the relation between the sides and the values of the ratios in different reference angles. He demonstrates the figure of such triangles in white board. After that researcher and students both interaction each other than conclude the values of trigonometric ratios in different conditions and what is the relationship between the sides of the right angled triangle and the values of reference angles.
- Similarly above process, researcher also discusses about how the unknown size of sides can be found when we know the value of any reference angle and any one of the size of the side.

For 25 minutes:

- Researcher drawn the unit circle and describes the unit circle and it's important and use in trigonometry ratios. For this researcher uses figures through the help white board and marker than encourages the students for finding the solutions and helps them to find out. He demonstrates the problems from the

exercise book in white board after that, researcher and students interact each other about figure and different condition then solve problems.

IV. Evaluation:

Find the values.

a) $Sin30^0$

b) $Cos60^0$

c) $Tan45^0$

Teaching Episode – 4

Date: 2077-11-28

Subject: Right angled triangle

Duration of lesson: 45 minutes

Target group: Grade X (14-16 years old)

Teacher: Kushal Bagale

Cooperating teacher: Man Raj Bagale

I. Objectives:

- To find out the size of unknown reference angle when any two of the sides of right angled triangles are given.

II. Required Materials:

- White board, marker, text book etc.

III. Activities and Classroom discussion:

For 20 minutes

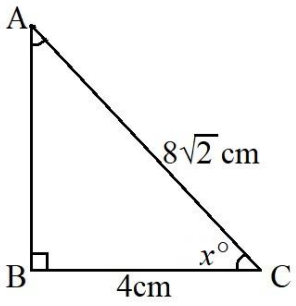
- Researcher reviews about the yesterday's lesson and starts the class.
- Researcher should help the students for solving previous day's homework and ask students, what are the values of trigonometric ratios? What is the value of different ratios on different reference angles? And what is the relation between the sides and the values?
- After students answer, researcher tells the value of different reference angles and the relation between the sides and the values of the ratios in different reference angles. He demonstrates the figure of these angles in white board by drawing using marker. After that researcher and students interact each other than researcher conclude the values of trigonometric ratios and the values, and what is the relationship between the sides of the right angled triangle and the values of reference angles.
- Similarly above process, researcher also discusses about how the unknown angles (except right angle) can be found when any two of the sides of right angled triangle are given.

For 25 minutes:

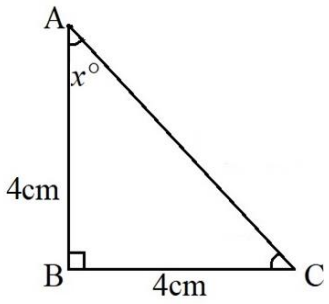
- Researcher writes some problems for unknown size of angle on white board and discusses how it can be solved. For this researcher uses different figures through the help white board and marker than encourages the students for finding the solutions and helps them to find out. He demonstrates the problems from the exercise book in white board after that, researcher and students interact each other about figure and different condition then solve problems.

IV. Evaluation:

- Find the value of x.



- Find the value of x.



Teaching Episode – 3

Date: 2077-11-29

Subject: Angle of elevation

Duration of lesson: 45 minutes

Target group: Grade X (14-16 years old)

Teacher: Kushal Bagale

Cooperating teacher: Man Raj Bagale

I. Objectives:

- To recognize angle of elevation and define the angle of elevation.

II. Required Materials:

- White board, marker, text book etc.

III. Activities and Classroom discussion:

For 20 minutes

- Researcher discusses about the yesterday's lesson and starts the class.
- Researcher should help the students for solving previous day's homework and ask to students, which side is the perpendicular, hypotenuse and base? What are trigonometric ratios? What are the values of trigonometric ratios of some standard angles?
- After students answer, researcher makes the figure in the white board for the height, distance and right angled triangle, reference angle, perpendicular, hypotenuse, base. He makes the figure in white board. After that researcher and students interact each other than conclude the right angled triangles, reference angle and its different sides: base, perpendicular, hypotenuse and angle of elevation.
- Similarly above process, researcher defines the angle of elevation and how we can find it in different conditions.

For 25 minutes:

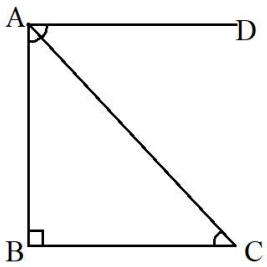
- Researcher shows some conditions in daily life situation where the angle of elevation can be constructed, and how the right triangles can be formed, and how we can solve such problems, how we can use the angle of elevation in daily life. For this researcher draws different figures in the white board and

encourages the students for finding the solutions and helps them to find out if they cannot. Researcher shows the problems from the exercise book in white board after that, researcher and students conclude about angle of elevation.

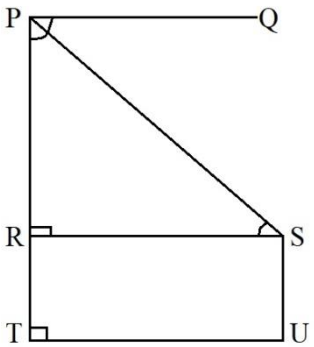
IV. Evaluation:

- Define angle of elevation with figure.
- Write the name of angle of elevation in the given figure.

(a)



(b)



Teaching Episode – 4

Date: 2077-11-30

Subject: Angle of depression

Duration of lesson: 45 minutes

Target group: Grade X (14-16 years old)

Teacher: Kushal Bagale

Cooperating teacher: Man Raj Bagale

I. Objectives:

- To recognize angle of depression and define the angle of depression.

II. Required Materials:

- White board, marker, text book etc.

III. Activities and Classroom discussion:

For 20 minutes:

- Researcher discusses about the yesterday's lesson and starts the class.
- Researcher should help the students for solving previous day's homework and ask to students, which side is the perpendicular, hypotenuse and base? What are trigonometric ratios? What are the values of trigonometric ratios of some standard angles? What is angle of elevation? What is the angle of depression?
- After students answer, researcher used draws the figure in the white board for the height, distance and right angled triangle, reference angle, perpendicular, hypotenuse, base, angle of elevation and angle of depression. After that researcher and students both interaction each other than conclude the right angled triangles, reference angle and its different sides: base, perpendicular, hypotenuse, angle of elevation and angle of depression.
- Similarly above process, researcher defines the angle of depression and how we can be constructed in different conditions.

For 25 minutes:

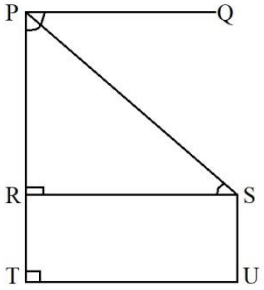
- Researcher shows some conditions in daily life situation where the angle of depression can be constructed, and how the right angled triangles can be formed, and how we can solve such problems, how we can use the angle of depression in daily life. Researcher encourages the students for recognize the angle of

depression and helps them to find out. He demonstrates the problems from the exercise book in white board after that, researcher and students concludes about angle of depression.

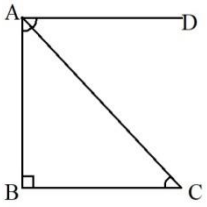
IV. Evaluation:

- Define angle of elevation with figure.
- Write the name of angle of elevation in the adjoining figure.

(a)



(b)



Appendix - 3

Mathematics Achievement Test for Pre-Test and post-test of objective questions

I would like to thank you for taking part in my research program. This test is only for my thesis program, you will not get any mark to be added in your formal exam. I want to make sure that your information will be secure and used only for my thesis program.

Class: - X **Full mark: 10**

Sub: - C. Math **Time: 10min.**

Objective Questions

Group 'A' **[5x1=5]**

1. The opposite side of the right angle of a right angled triangle is called.

   a. Base b. Perpendicular c. Hypotenous d. Perpendicular

2. In a ΔABC, ∠B is right angle and ∠C = 30° what is the value of the side AC when AB = 6cm

   a. 6cm b. 9cm c. 12cm d. $4\sqrt{3}$ cm

3. The angle made by upward line of sight with horizontal line is known as.....

   a. Angle of elevation b. Angle of depression c. Right angle d. Straight angle

4. InΔPQR, ∠R is a right angle and PQ = 10cm and PR= 5cm what is the measurement of ∠P.

   a. 0° b. 30° c. 45° d. 60°

5. Value of tan 45° is equal to the value of

   a. tan 90° b. sin 90° c. cos 90° d. cot 90°

6. The value of tan can be determined by the …… of the values of sin and cos.

a. Addition b. Subtraction c. Multiplication d. Ratio

7. The area of any triangle is calculated as half of the product of any two sides of the triangle and the ..... of the angle between them

a. sine b. cosine c. tangent d. cotangent

8. InΔABC, $AC=4\sqrt{2}$cm, BC=7cm and $\angle C = 45°$ then what is the area of the triangle?

a. 7sq cm b. 8sq cm c. 14sq cm d. 16 sq cm

9. The sides of any triangle are proportion to the sines of the ..... angle

a. base b. reference c. acute d. opposite

10. In a parallelogram ABCD, find the area of ΔABC, where $\angle B = 30°$, BC = 6cm and DC = 5cm.

a. 5sq cm b. 7.5sq cm c. 15sq cm d. 16sq cm

Appendix - 4

Mathematics Achievement Test for Pre-Test and post-test of subjective questions

I would like to thank you for taking part in my research program. This test is only for my thesis program, you will not get any mark to be added in your formal exam. I want to make sure that your information will be secure and used only for my thesis program.

Class: - X **Full mark: 20**

Sub: - C. Math **Time: 40min.**

Attempt all question

Group 'A" **[2×2=4]**

1. Define the angle of elevation and angle of depression.
2. The angle of elevation of the top of a tower is $19\sqrt{3}$m away from the point of observation is 30^0. Find the height of the tower.

Group ''A" **[4× 4=16]**

3. A tower on the bank of a river is of 20m height and the angle of elevation of the tower from the opposite bank 30^0. Find the breadth of the river.
4. From the roof of a house 6m high, the angle of elevation of the top of a temple 66m high is observed to be 60^0. Find the distance between the house and the temple.
5. From the top of a tower, the angle of depression to the roof of a house 10m high and 40m away from the tower was observed and found to be 30^0. Find the height of the tower.
6. A pillar is fixed in the center of a circular meadow with diameter of 60m. The angle of elevation of its top was found to be 60^0, when observed from a point of the circumference of circular meadow. Find the height of the pillar from the ground.

Appendix-5

Item analysis of objectives questions of the test

S.N. Q. N.	Upper 27%								Lower27%								P % Value	D Value	Remarks
	1	2	3	4	5	6	7	Total	1	2	3	4	5	6	7	Total			
1	1	1	1	1	1	1	0	6	1	1	1	0	0	1	0	4	71.43%	0.29	**Accept**
2	1	1	1	1	0	1	1	6	1	1	1	0	1	0	1	5	78.57%	0.14	**Reject**
3	1	0	1	1	1	1	1	6	1	1	1	1	0	1	1	6	85.71%	0	**Reject**
4	1	1	1	1	1	1	1	7	1	1	0	0	1	1	0	4	78.57%	0.43	**Reject**
5	1	1	1	1	1	1	1	7	0	0	0	0	0	0	0	0	50%	1	**Accept**
6	1	1	1	0	1	1	0	5	1	1	1	1	0	1	0	5	78.57%	0.14	**Reject**
7	1	1	1	1	1	1	1	7	0	1	1	0	1	0	0	3	64.29%	0.43	**Accept**
8	1	1	0	1	1	0	1	5	0	0	0	1	1	1	1	4	64.29%	0.14	**Reject**
9	1	1	1	1	1	1	1	7	1	0	0	0	1	0	0	2	64.29%	0.71	**Accept**

10	1	1	1	1	1	1	1	7	0	1	1	0	0	1	0	3	71.43%	0.57	**Accept**
11	1	1	1	1	1	1	1	7	1	0	0	0	0	0	0	1	57.14%	0.86	**Accept**
12	1	1	1	1	1	1	1	7	1	1	0	1	1	0	1	5	85.71%	0.29	**Reject**
13	1	1	1	1	0	1	1	6	0	0	1	0	0	0	0	1	57.14%	0.86	**Accept**
14	1	1	1	1	1	0	1	6	1	1	1	1	0	0	0	4	64.29%	0.14	**Reject**
15	1	1	1	1	1	1	1	7	0	0	0	1	0	1	1	3	64.29%	0.57	**Accept**
16	1	1	1	1	1	1	1	7	0	0	0	0	1	0	0	1	57.14%	0.86	**Accept**
17	1	1	1	1	1	1	0	6	0	0	1	0	0	0	1	2	57.14%	0.57	**Accept**
18	1	1	1	1	1	1	1	7	0	0	0	1	0	0	0	1	57.14%	0.86	**Accept**
19	1	1	1	1	1	1	1	7	1	0	0	1	1	1	0	4	78.57%	0.42	**Reject**
20	1	1	1	1	1	1	1	7	1	1	1	1	1	1	0	6	92.86%	0.14	**Reject**
Total	20	19	19	19	18	18	17		11	10	10	9	9	9	6				

Appendix –6

Item analysis of subjective questions of the test

S.N. Q.N.	Upper27%								Lower 27%								P Value	D Value	Remark
	1	2	3	4	5	6	7	Total	1	2	3	4	5	6	7	Total			
1	1	1	1	1	1	1	1	7	1	1	1	0	0	1	1	5	85.71 %	0.29	
	1	1	1	1	1	1	1	7	1	1	1	0	0	1	1	5	85.71 %	0.29	
																	85.71 %	0.29	Rejected
2	1	1	1	1	1	1	0	6	1	0	0	0	0	1	0	2	57.14 %	0.57	
	1	1	1	1	1	1	0	6	1	0	0	0	0	1	0	2	57.14 %	0.57	
																	57.14 %	0.57	Accepted
3	1	1	1	1	1	1	0	6	1	1	0	0	1	1	0	4	71.43 %	0.29	
	1	1	1	1	1	1	0	6	1	1	0	0	1	1	0	4	71.43 %	0.29	

																	71.43 %	0.29	Accepted
4	1	1	1	1	0	0	0	4	0	0	1	0	0	0	1	4	50%	0.14	
	1	1	1	1	0	0	0	4	0	0	1	0	0	0	1	4	50%	0.14	
																	50%	0.14	Rejected
5	0	1	1	1	1	1	1	6	1	0	0	0	1	0	0	2	57.14 %	0.57	
	0	1	1	1	1	1	1	6	1	0	0	0	1	0	0	0	57.14 %	0.57	
	0	1	1	1	1	0	1	5	0	0	0	1	0	0	0	1	42.86 %	0.57	
	0	1	1	1	1	0	1	5	0	0	0	0	1	0	0	1	42.86 %	0.57	
																	50%	0.57	Accepted
6	1	1	0	1	1	0	1	5	0	1	1	0	0	0	0	2	50%	0.43	
	1	1	0	1	1	0	1	5	0	1	1	0	0	0	0	2	50%	0.43	
	1	1	0	1	1	0	1	5	0	1	1	0	0	0	0	2	50%	0.43	

	1	1	0	1	1	0	1	5	0	1	1	0	0	0	0	2	50%	0.43	
																	50%	0.43	Accepted
7	1	1	1	0	0	0	1	4	1	1	1	1	1	0	0	5	64.29%	-0.14	
	1	1	1	0	0	0	1	4	1	1	1	1	1	0	0	5	64.29%	-0.14	
	1	1	1	0	0	0	1	4	1	1	1	1	1	0	0	5	64.29%	-0.14	
	1	1	1	0	0	0	1	4	1	1	1	1	1	0	0	5	64.29%	-0.14	
																	64.29%	-0.14	Rejected
8	0	1	1	1	1	1	1	6	0	0	0	1	0	0	1	2	57.14%	0.57	
	0	1	1	0	1	1	1	5	0	0	0	1	0	0	1	2	50%	0.57	
	0	1	1	0	1	1	0	4	0	0	0	0	0	0	1	1	71.43%	0.57	
	0	1	1	0	1	0	0	3	0	0	0	0	0	0	1	1	28.57%	0.57	

																	51.79%	0.57	Accepted
9	1	0	1	1	1	1	0	5	0	0	0	0	0	1	0	1	42.86%	0.57	
	1	0	1	1	1	1	0	5	0	0	0	0	0	1	0	1	42.86%	0.57	
	1	0	1	1	1	1	0	5	0	0	0	0	0	1	0	1	42.86%	0.57	
	1	0	1	1	1	1	0	5	0	0	0	0	0	1	0	1	42.86%	0.57	
																	42.86%	0.57	Accepted
10	1	0	0	1	0	1	0	3	0	0	0	1	0	0	0	1	28.57%	0.29	
	1	0	0	1	0	1	0	3	0	0	0	1	0	0	0	1	28.57%	0.29	
	1	0	0	1	0	1	0	3	0	0	0	1	0	0	0	1	28.57%	0.29	
	1	0	0	1	0	1	0	3	0	0	0	1	0	0	0	1	28.57%	0.29	
																	28.57%	0.29	Accepted
Total	24	2	24	23	22	19	18		12	12	12	11	11	10	8				

Appendix-7

Reliability of the test

S.N.	Scores on Odd items	Scores on even items	X^2	Y^2	XY
1	10	11	100	121	110
2	12	11	144	121	132
3	7	11	49	121	77
4	9	9	81	81	81
5	9	10	81	100	90
6	8	12	64	144	96
7	8	9	64	81	72
8	10	8	100	64	80
9	8	8	64	64	64
10	11	13	121	169	143
11	24	16	576	256	384
12	20	14	400	196	280
13	28	28	784	784	784
14	36	24	1296	576	864
15	24	16	576	256	384
N=15	**$\sum X$=224**	**$\sum Y$=200**	**$\sum X^2$=4500**	**$\sum Y^2$=3134**	**$\sum XY$=3641**

Correlation Coefficient (r_{xy}) $= \frac{N(\Sigma XY)-(\Sigma X)(\Sigma Y)}{\sqrt{[N(\Sigma X^2)-(\Sigma X)^2][N(\Sigma X^2)-(\Sigma Y)^2]}}$

$= \frac{15\times3641-224\times200}{\sqrt{[15\times4500-(224)^2][15\times3134-(200)^2]}}$

$= 0.89$

Reliability Coefficient (r) $= \frac{2r_{xy}}{1+r_{xy}} = \frac{2\times0.89}{1+0.89} = 0.94$

Appendix – 8

Score of pre-test

S.N.	Experimental Group	Control Group
1	24	19
2	11	17
3	17	9
4	12	10
5	10	18
6	6	8
7	6	10
8	13	7
9	10	8
10	8	3
11	7	5
12	7	5
13	8	4
14	9	8
15	5	3
16	3	4
17	3	5
18	5	5
19	3	3
20	5	7
21	3	2
22	3	4
23	3	3
24	4	5
25	3	4
26	3	2
27	7	8
28	6	4
29	5	2

30	6	4
31	3	2
32	6	3
33	6	2
34	7	3
35	9	4
36	4	4
37		3
38		6
39		7
	$N_1 = 36$, $\overline{x_1} = 6.94$, $s_1^2 = 19.37$, $s_1 = 4.40$	$N_2 = 39$, $\overline{x_2} = 5.9$, $s_2^2 = 17.4$, $s_2 = 4.17$

Appendix – 9

Score of post-test

S.N.	Experimental Group	Control Group
1	28	24
2	26	22
3	28	20
4	25	15
5	18	21
6	21	16
7	26	13
8	18	17
9	22	20
10	24	14
11	26	16
12	15	17
13	23	13
14	12	10
15	15	17
16	15	10
17	10	13
18	12	12
19	19	13
20	11	15
21	11	3
22	15	9
23	17	7
24	16	15
25	17	12
26	15	16
27	21	10
28	15	10
29	20	10

30	23	14
31	10	9
32	20	9
33	22	9
34	22	9
35	18	10
36	13	11
37		6
38		10
39		13
	$N_1 = 36$, $\overline{x_1}=18.58$, $s_1^2 = 27.79$, $s_1 = 5.27$	$N_2 = 39$, $\overline{x_2} = 13.05$, $s_2^2 = 20.89$, $s_2 = 4.57$

Appendix-10

Scale of students view on GeoGebra software

Name: ……. Class: X

Roll No: ……. Subject: C. Mathematics

School: …….

S.N.	Items	Strongly agree	Agree	undecided	Disagree	Strongly disagree
1	At the beginning, I did not like GeoGebra software					
2	I liked studying geometry lessons with using GeoGebra software					
3	GeoGebra helped me a lot to learn the trigonometry Concept					
4	GeoGebra is essential and important for the teaching Trigonometry					
5	GeoGebra software helps easy to understand Trigonometry problems					
6	GeoGebra software helps visualizing the problems of Trigonometry concept					
7	GeoGebra software enhance my learning in trigonometry Lessons					
8	GeoGebra software help to make the learning more enjoyable					
9	GeoGebra makes trigonometry class boring					
10	Using GeoGebra makes trigonometry more difficult for me					

Appendix - 11

Statistical formula used in data collection and analysis procedure

S.N.	Subject	Notation	Formula
1	Pooled Variance	S_p^2	$\frac{(n_1-1)S_1^2+(n_2-1)S_2^2}{n_1+n_2-2}$
2	t - distribution	t	$\frac{(\overline{X_1}-\overline{X}_2)-(\mu_1-\mu_2)}{S_p\sqrt{\frac{1}{n_1}-\frac{1}{n_2}}}$
3	F-distribution	F	$\frac{S_1^2}{S_2^2}$
4	Degree of freedom	d.f.	$n_{1+}n_2-2$
5	Pearsons's Correlation Coefficient	r_{xy}	$\frac{N(\Sigma XY)-(\Sigma X)(\Sigma Y)}{\sqrt{[N(\Sigma X^2)-(\Sigma X)^2][N(\Sigma X^2)-(\Sigma Y)^2]}}$
6	Reliability Coefficient	r	$\frac{2\,r_{xy}}{1+r_{xy}}$
7	Difficulty Level of Item	P%	$(\frac{R_u+R_l}{N}\times 100)\%$
	Discrimination Index of Item	D	$\frac{R_u-R_l}{\frac{N}{2}}$
			Where R_u and R_1 are the number of correct response given by upper 27% And lower 27% students respectively. N is the total number of lower 27% students plus total number of upper 27% students.