STUDENTS' ACHIEVEMENT IN TRIGONOMETRY TEACHING THROUGH GEOGEBRA

A

THESIS

BY

RAMAN RAJ JOSHI

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

SUBMITTED

TO

DEPARTMENT OF MATHEMATICS EDUCATION

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विश्वविद्यालय क्याम्पस
कीर्तिपुर, काठमाडौं, नेपाल

UNIVERSITY CAMPUS
Kirtipur, Kathmandu, Nepal

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LETTER OF CERTIFICATE

This is to certificate that Mr. **Raman Raj Joshi**, a student of academic year 2073/2074 B.S. with thesis number 1670, Exam Roll No. **7328429**, Campus Roll No**. 50** and T.U. Regd. No. **9-2-820-47-2011** has completed his thesis under my supervision during the period prescribed by the rule and regulations of T.U. Nepal. The thesis entitled **"STUDENTS' ACHIEVEMENT IN TRIGONOMETRY TEACHING THROUGH GEOGEBRA"** embodies the result of his investigation conducted during the period of **2022** at the department of Mathematics Education, University Campus, Tribhuvan University, Kirtipur, Kathmandu. I hereby, recommended and forward that his thesis be submitted for the evaluation to award the Degree of Master of Education.

.....

Prof. Dr. Bed Raj Acharya

(Head)

Date:

Phone No.: 977-1-4331337 / 4333229, Fax No.: 4334955, E-mail : foe@tucded.edu.np, Website : tucded.edu.np

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LETTER OF APPROVAL

Thesis Submitted

By

Raman Raj Joshi

Entitled

STUDENTS' ACHIEVEMENT IN TRIGONOMETRY TEACHING THROUGH GEOGEBRA has been approved in partial fulfillment of the requirements for the Degree of Master of Education.

Committee for the viva-voce **Signature**

Prof. Dr. Bed Raj Acharya

(Chairman) .....

Assoc. Prof. Rajendra Kunwar

(External) .....

Mr. Krishna Prashad Bhatt .....

(Supervisor)

Date: 13 Feb 2022

Phone No.: 977-1-4331337 / 4333229, Fax No.: 4334955, E-mail : foe@tucded.edu.np, Website : tucded.edu.np

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RECOMMENDATION FOR ACCEPTANCE

This is to certify that Mr. **Raman Raj Joshi** has completed his M. Ed. thesis entitled **"STUDENTS' ACHIEVEMENT IN TRIGONOMETRY TEACHING THROUGH GEOGEBRA"** under my supervision during the period prescribed the rules and regulations of Tribhuvan University, Kirtipur, Kathmandu, Nepal. I recommend and forward his thesis to the Department of Mathematics Education to organize the final viva-voce.

.....

Mr. Krishna Prashad Bhatt

Date: 30 Jan. 2022

(Supervisor)

Phone No.: 977-1-4331337 / 4333229, Fax No.: 4334955, E-mail : foe@tucded.edu.np, Website : tucded.edu.np

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Defense Date: 13 Feb. 2022

Dedication

This work is affectionately dedicated to my father Mr. Gopal Datt Joshi, mother Mrs. Hira Devi Joshi and brother Kamal Raj Joshi who even in a very difficult situation gave me a great span of their life for what I am now.

DECLARATION

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

Date: 13 Feb. 2022 ……..

Raman Raj Joshi

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It is my great pleasure to express my profound gratitude to my repected supervisor Mr. Krishna Prashad Bhatta, Department of Mathematics Education, T. U., Kirtipur, who guided me throughout this study. His co- operation, valuable suggestion and keen interest in this study are ever memorable. His rigorous efforts made me easy to complete and present this research work in this form. I am really indebted to him for his incredible ideas.

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I wish to acknowledge my parents Mr. Gopal Datt Joshi and Mrs. Hira Devi Joshi. I would like to thank to my dear brother Kamal Raj Joshi for encouraging me to continue my higher education. Likewise, I would like to thank to my relatives for their unforgettable support for my educational journey.

Finally, I would like to thank all the staffs and students of Sharada Secondary School, Ramechhap, who provided me their valuable time and data for the research work.

Date: 13 Feb. 2022 …….

Raman Raj Joshi

Abstract

The topic of this study is "**Students' Achievement in Trigonometry Teaching through GeoGebra**". The purpose of this research was to find out the effect of use of Geogebra in teaching trigonometry at grade IX. In this study, pre- test post- test non- equivalent control group design of research was used which is one of the quasi-experimental research design. Connectivism has been accepted as the theoretical foundation of this research. All the students of grade IX of Ramechhap district were taken purposively as population of study. This study was conducted on two groups of students: control group and experimental group. By random sampling method the students of section 'A' who studies optional mathematics were selected for control group and the students of section 'B' who studies optional mathematics selected for experimental group. A total of 50 students were participated in the study in which control and experimental group consists 22 and 28 students respectively. Control group was facilitated by traditional method of instruction but experimental group was treated by GeoGebra software up to two weeks. Mathematics achievement test (MAT) and interview schedule were used to collect data. A pilot test was conducted in a group of students of Gokulganga Secondary School, Ramechhap for reliability coefficient, difficulty level and discrimination index of items. To ensure the validity of items, tool was developed being based on specification grid of optional mathematics of grade IX which was developed by CDC Nepal and with the help of supervisor. But for the reliability of items on interview schedule, students were asked the same questions repeatedly and for validation supervisor helped me. A pre- test was conducted on both groups before teaching. After quantitative analysis of pre- test, I taught both the groups up to two weeks. Moreover, control group was taught by traditional method of instruction while experimental group was facilitated by

GeoGebra software being based on connectivism approach. After treatment a post-test was administered on the same both groups using the same set of items used in pre- test. After quantitative analysis of the result of post- test an interview schedule was used on a group of five students of experiment group to know their perception towards the use of GeoGebra in teaching trigonometry. The collected data were analyzed by using descriptive statistics and inferential statistics both. Specially, t- test was used to test for the statistical significance difference between the control and experimental group using MS Excel 2013. The data obtained from interview schedule was analyzed by descriptive method. The result of post- test showed that the average achievement of experimental group which was facilitated through GeoGebra software was better than that of control group which was taught by traditional method of instruction. Thus, analysis of this result indicated that GeoGebra was an effective software in teaching trigonometry. Also the analysis of interview result indicated that most of the students gave the positive responses towards the use of GeoGebra software. Students of experimental group took the part in teaching learning activities actively. Also, they took GeoGebra as an essential software in learning other parts of optional mathematics.

Contents

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Acronyms

CDC	=	Curriculum Development Center
ICT	=	Information, communication and Technology
IRJMEIT	=	International Research Journal of Mathematics, Engineering and IT
MOODLE	=	Modular Object-Oriented Dynamic Learning Environment
TPACK	=	Technological Pedagogical Content Knowledge
MAT	=	Mathematical Achievement Test
N	=	Number of Students
S.D.	=	Standard Deviation
2D	=	2- Dimensional
3D	=	3- Dimensional
TPK	=	Technological Pedagogical knowledge
PCK	=	Pedagogical Content Knowledge
TCK	=	Technological Content Knowledge

Chapter I
INTRODUCTION

This research will focus on the students' achievement in trigonometry teaching through GeoGebra. This chapter includes background of the study, statement of the problem, justification of the study, objectives of the study, hypothesis of the study, delimitation of the study and operational definition of the key terms.

Background of the Study

The history of mathematics tells us that mathematics was originated along with the human civilization. The term mathematics has been defined in various ways. Advanced Learner's Dictionary (1992) defines mathematics as "Mathematics is the science of number, quantity and space of which arithmetic, algebra, trigonometry and geometry are its branches". Similarly, according to the mathematics dictionary, "The logical study of shape, arrangement, quantity and many related concepts. Mathematics often is divided into three fields; algebra, analysis and geometry" (James & James, 1986, p.239). Also, according to the Nepali Brihat Shabdakosh (2055) "Mathematics is the discipline of number and quantity." These definitions cover the large area with branches of mathematics.

Mathematics is defined by various mathematicians in various ways. Aristotle defined mathematics as the science of quantity. In Aristotle's classification of sciences, discrete quantities were studied by arithmetic, continuous quantities by geometry. Auguste Comte said that "Mathematics is the science of indirect measurement (1851). Where the "indirectness" in Comte's definition refers to determining quantities that cannot be measured directly, such as the distance to planets or the size of atoms, by means of their relations to quantities that can be measured directly.

Carl Friedrich Gauss referred mathematics as the queen of science and the theory of number is the queen of mathematics, but unfortunately students fear from this queen, although the subject is very essential to the growth of many other disciplines. The science of mathematics depends on the mental ability. It is the means to develop the thinking power and reasoning intelligence, which sharps the mind and makes it creative. The development of human beings and the culture depends on the development of mathematics. This is why, it is known as the base of human civilization. It is also the language of all materials science and the center of all engineering branches which revolve around it. Therefore, it is the past, present and future of all sciences.

Narlikar has focused on the importance of mathematics by mentioning that in 1957 when the Soviet Union launched the first satellite Sputnik, the United States realized that to match it, the teaching of mathematics had to receive boost. After that many major steps have been taken to improve the quality education of mathematics not only in USA but in world too (International Research Journal of Mathematics, Engineering and IT(IRJMEIT)). Such incidence emphasizes on the importance of mathematics in our daily life.

In our country mathematics is compulsory subject from grade I to grade XII (School level). And further, it is as an optional subject. Even mathematics is important subject for our daily life, in the sector of science and engineering but students feel it difficult to understand. While analyzing the result of mathematics, it is found that maximum number of students are poor in mathematics in the comparison of other subjects. In our education system, the evaluation system is completely based on theoretical knowledge. There is no any place of practical knowledge. So, teachers emphasize on only theoretical knowledge to show the best result. In such a situation,

students only know the theoretical knowledge, they only can solve the questions which will be asked in examination but they do not know what they are actually learning. Are the things which they are learning exist on the earth or not? That's why many students are not interested in learning mathematics. They feel mathematics is the abstract subject which is only for genius students.

I do not blame that all the teachers do not use teaching materials, some of them raise their voice for lack of teaching hours. They say that they have only 45 minutes for a single period. On which if they will apply teaching materials, it takes long time and then they have remained few times to complete the daily lesson plan. To solve this situation, National Curriculum Framework 2076 mentioned that there is provision of teaching hours generally per day per subject per hour per period. If it is implemented on education system then teachers have too much time to present teaching materials.

It shows that National Curriculum Framework 2076 emphasizes on both theoretical as well as practical knowledge. Now, according to National Curriculum Framework 2076, the evaluation system of mathematics is divided into two parts; 75% through theoretical test and 25% through practical test on grade XI and XII, which shows the good sign in evaluation system. There are different areas in mathematics, trigonometry is one of them. If teacher is not familiar with mathematical software or teacher is not able to make teaching materials while teaching trigonometry, students cannot understand what the actual things are. They think that trigonometry is all about formulae. If we succeed to parrot all formulae, it is possible to understand and do solution otherwise never.

With this concern of my own incidence, I am standing to make easy and visualize trigonometry using GeoGebra as much as possible. So, my research topic is "Students' achievement in trigonometry teaching through GeoGebra".

To solve such queries teacher needs to use teaching materials while teaching in the classroom. In this information and communication technology era many teaching materials have been developed. They are very useful to understand abstract concept of mathematics via different software like GeoGebra, Mathematica, Math lab etc. Technology is an important tool for visualizing and perception of abstract nature as well as applied part of mathematics. Thus, teaching and learning with the use of technology has many advantages for teachers to plan and prepare instruction and for students to provide greater learning opportunities, enhancing engagement in learning, encouraging in discovery learning, learning them self everywhere, visualizing mathematical terms, construction and connect them with the related facts.

Technology plays the important role in the development of the educational process (Gursul and Keser, 2009). Technology environment allows teacher to adapt their instruction and teaching methods more effectively to their students' need (NCTM,2000). Also, Campoy (1992) has remarked that technology provides a better way of teaching mathematics. Hence, by integrating educational tools into their everyday teaching practice, it can provide creative opportunities to support students' learning and expanding the sphere of acquisition process of mathematical knowledge and skills.

The use of ICT is rapidly increasing in Nepal from last decade. In education sector, as the place of mathematics, ICT plays visualization role for all levels. According to presenting situation of Nepal; Ms-word, Ms-PowerPoint, Spreadsheet,

MeDas eClass, Modular Object-Oriented Dynamic Learning Environment (MOODLE), GeoGebra, Mathematica, Math Lab etc. and different educational pages and links are popular by teachers and students. From them GeoGebra is mostly useful and effective according to present context of Nepal in different area of mathematics.

GeoGebra was created by Markus Hohenwarter in 2001/2002 as part of his master's thesis in mathematics education and computer science at the University of Salzburg in Austria. It was designed to combine features of interactive geometry software and computer algebraic system in a single integrated and easy to use for teaching and learning mathematics. Thus, GeoGebra is an open-source dynamic mathematics software that incorporates geometry, algebra and calculus.

Many literatures indicate that teaching through GeoGebra plays vital role for improving students' achievement (Hohenwarter & Jones, 2007; Alkan,2005; Gulsul and Keser,2009; Bhandari,2015). In teaching and learning trigonometry, GeoGebra can be used effectively like as other geometric lessons of mathematics. In trigonometry of nineth class GeoGebra helps to teach trigonometric function and ratio, radians and angles, unit circle, graph of trigonometric function, concept of Pythagoras theorem.

Statement of the Problem

In our context, Mathematics is compulsory subject in school level (Grade I to XII). And further in higher level it is as an optional subject. Despite this, there is low participation of students to study optional mathematics in Nepal. The teaching learning situation of mathematics is not satisfactory and higher number of students are failed in mathematics. According to NASA report 2068 BS, the average achievement of students (Grade VIII) in mathematics was 43% and that of 2070 BS shows only

35%. This shows that the achievement of mathematics is in decreasing order. Only few numbers of students want to study mathematics. So, few numbers of students only select optional mathematics as the optional subject.

There are different areas in optional mathematics, trigonometry is one of them. Students feel it very difficult to understand and trying to parrot all the formulae and question. So, it becomes as an abstract subject for them. Being the lack of teaching material, which are developed in trigonometry, teacher only give theoretical knowledge. In that situation students do not know the actual concept about content of trigonometry. So, maximum number of students do not interest to learn trigonometry. They focus on other areas of optional mathematics except trigonometry, even trigonometry is one of the important parts of mathematics for higher level. Hence, they get low marks in trigonometry in the period of evaluation.

Now adays, many teaching materials are developed in trigonometry via different software. GeoGebra is one of the teaching mathematical software, which seems very effective in the teaching learning activities. Use of ICTs brings the effectiveness in teaching and learning process. Basically, ICTs gives clear concept in any topic of mathematics rather than traditional way of teaching and learning. The improvement of teaching method, proper use of teaching materials, technology-based teaching learning activities, management of trained teacher, etc. can play the vital role to increase the average achievement of students in mathematics. So, I want to know trigonometry teaching through GeoGebra is effective or not in students' achievement. Mainly the study will focus on the following two questions:

- Is teaching trigonometry through GeoGebra is effective in grade IX?
- What students thinks about use of GeoGebra software?

Justification of the Study

The finding of this study contributes to the educational society regarding worth of application of GeoGebra in teaching trigonometry at secondary level schools of Nepal. This type of study is beneficial to the math teachers in order to familiar with pedagogical strategy for teaching trigonometry by using GeoGebra. This study helps to prepare instructional plans for large classes and where learners are of varied abilities. This study facilitates the teachers to create dynamic demonstrations by creating dynamic relationships between objects on the screen live in front of the class using projectors as well as for professional development. Furthermore, this study helps to develop positive attitude and make responsible towards teaching profession.

This study is important to know how effective is GeoGebra in teaching trigonometry. This study is focus on teaching trigonometry through a dynamic mathematical software GeoGebra. It may be helpful for those who want to use this software in teaching and learning activities. Also, this research has provided literature for further study. This study would contribute new knowledge and experience on teaching mathematics. Mathematics teachers would get brief information with the help of this research in the content of trigonometry and teaching activities using GeoGebra in trigonometry. This would be helpful for further research or study about ICT and GeoGebra regarding on trigonometry.

Objectives of the Study

The main objectives of this study will be:

1. To compare the achievement of students in trigonometry taught through GeoGebra with achievement of students taught without using GeoGebra.

2. To identify the students' perception towards the use of GeoGebra in teaching trigonometry.

Hypothesis of the Study

A research hypothesis is a specific, clear and testable proposition or predictive statement about the possible outcomes of a research study. This study is based on a quantitative research design. In quantitative research, hypothesis plays the vital role. Moreover, specifying the research hypothesis is one of the most important steps in planning a scientific quantitative research study.

Research hypothesis

Teaching trigonometry in experimental group yields greater achievement than teaching trigonometry in control group.

Statistical hypothesis

The null and alternate hypothesis are formulated as:

H_o: The achievement of students of experimental group is same as that of control group.

i.e., $H_o: \mu_1=\mu_2$

H_1: The achievement of students of experimental group is higher than that of control group.

i.e., $H_1: \mu_1>\mu_2$

where μ_1 and μ_2 are achievement of experimental group and control group respectively.

Delimitations of the Study

This study will be limited under the following aspect:

- The study will be based on experimental research design as pre-test and post-test nonequivalent research design.
- The study will be based on trigonometry chapter of grade IX.
- As the sample; one government school will be selected from Ramechhap.
- Study will be done only in two groups of students from two sections of grade 'IX' who studies optional mathematics.
- The researcher will be used same topic for the research in both groups.
- Achievement test and interview schedule will be the tools for data collection.

Operational Definition of Key Terms

The operational definition and terminology clarify the meaning of the terms which are used in the study. Some of these terminologies related to this research study are defined as follows:

Effectiveness.

It is defined in terms of improvement in students' achievement.

Achievement

In this study, the term "achievement" is defined as the score obtained by students of experimental group and control group on test prepared by the researcher.

GeoGebra

It is freely available open-source dynamic mathematics software program that was designed to combine geometry, algebra and calculus in a single dynamic environment. It was developed in Multilanguage system and it is very useful to visualize the mathematics in 2D and 3D.

ICT

Computer and laptop, radio, television, telephone, projector, mobile phone, fax, internet, email, web, software and other computer networks are Information Communication and Technology.

Traditional method

In this study, it is a teaching method in which teacher uses chalk/marker, duster, blackboard/whiteboard, textbooks where teacher is active and students are passive.

Perception

For this study, the word "perception" means students' understanding or thought towards the use of GeoGebra software in teaching trigonometry.

Experimental group

In this study, the experimental group is the group of students were facilitated in trigonometry chapter through GeoGebra software.

Control group

The group of students which was taught by using traditional method of instructional

Chapter II

REVIEW OF LITERATURE

A literature review surveys books, scholarly articles and any other sources relevant to particular issue, area of research or theory and by so doing, provides a description, summary and critical evaluation of these works in relation to the research problem being investigated. Literature reviews are designed to provide an overview of sources we have explored while researching a particular topic and to demonstrate to our readers how our research fits within a larger field of study.

Also, review of related literature is essential part of the research because it helps to identify variables relevant to research, to avoid the repetition and synthesis of prior work. It also determines the meaning and relationship among the variables (singh, 2008). A literature review contains a critical analysis and integration of information from a number of sources as well as a consideration of any gaps in the literature and possibilities for future research. The purpose of reviewing the literature is to identify information that already exists about the topic which is going to studied. Without reviewing the previous work, it is impossible to do a new research.

Thus, we cannot avoid the previous work. These works are the road maps for new work. Review of literature helps us to identify the variables to the research, definition of problem, recognizing the significance, suggesting data gathering devices, selection for appropriate study design and source of data. This chapter includes review of the empirical literature, review of theoretical literature and conceptual framework for this study.

Review of Empirical Literature

The empirical literature which emphasized GeoGebra based instruction are reviewed below:

Zengin, Furkan & Kutluca (2011) had done a study on the topic 'The effect of dynamic mathematics software GeoGebra on students' achievement in teaching of trigonometry". The sample of study consists of 51 students. The experimental group was subjected to the lessons arranged with the GeoGebra software in computer assisted teaching method to observe the effect of dynamic mathematical software as GeoGebra, while the control group was subjected to the lessons shaped with constructivist instruction. The data collected after five weeks of application show that there is a meaningful difference between experimental and control groups' achievement in trigonometry. This difference is in favor of the experimental group which had lessons with GeoGebra.

Kepceoglu and Yuvuz (2016) conducted a study entitled " Teaching a concept with GeoGebra: Periodicity of trigonometric functions" in order to analyze and to compare the effect of the traditional teaching and the computer assisted mathematics teaching on students' conceptual learning about the periodicity of trigonometric functions. The design of the study was quasi-experimental and the participant of the study were 36 students of tenth grade from a public school in Istanbul. These participants had been chosen by using convenience sampling techniques. The students were divided into two groups (control and experimental) according to their classrooms. Fifteen days after the instruction period, participants filled in a five questions test. The answer of students was analyzed using descriptive statistics. As a conclusion, the finding of this study indicates that the aid of computer in mathematics

education is more effective on students' learning than traditional method of mathematics instruction.

Acharya (2015) had done a study on the topic "Effectiveness of GeoGebra software on Mathematics Achievement". The objectives of the study were to compare the achievement of the students in mathematics by using GeoGebra software with the achievement of students taught without using GeoGebra software and to elicit students' perception in learning circles using GeoGebra software. He has used pretest-posttest nonequivalent control group design for gathering the data. The research was done selecting two schools purposively of Kathmandu district: namely Panga Secondary School and Janasewa Secondary School taking experimental and control group respectively. The researcher has taken 28 students from class 10 as experimental group and 25 of the same grades as control group. The researcher has taken the students of secondary level of Nepal as the population in his research. He taught both the sample group for a week and then collected the data from mathematics achievement test as well as mathematics perception test. He concluded that students in experimental group have better achievement than control group. Also, students' perception is positive towards using GeoGebra in mathematics learning.

Zulnaidi and Zakaria (2012) published a research article entitled "The Effect of Using GeoGebra on Conceptual and Procedural Knowledge of High School Mathematics Students' for the purpose of determination the effect of GeoGebra on conceptual and procedural knowledge of function. The study had done on a total of 124 high school students from Ujung Batu Hulu, Riau, Indonesia. The treatment group and control contained 60 and 64 students respectively. The conceptual and procedural knowledge test of function was used to Collect the data. The result showed that the treatment group had significantly higher conceptual knowledge compared to

control group. The findings of this study had provided schools administration and teachers the opportunity to use GeoGebra software for teaching and learning mathematics.

A study carried out by Bhandari (2015) entitled "Effectives of GeoGebra Assisted Instruction in Mathematics at Secondary Level" with the aim to find the effectiveness of GeoGebra assisted instruction on students' achievement in reflection and rotation at secondary level. A total of 48 students of two schools were selected for the study. She concluded that the students in the experimental group attained significantly better achievement on the reflection and rotation tasks then the students in the control group. Also, her research has indicated that the students in the experimental group attained significantly better achievement on the reflection and rotation tasks then the students in the control group. Also, her research has indicated that the students who were taught by GeoGebra assisted instruction were motivated towards the convectional study.

In addition, Kushwaha, Chaurasia and Singhal (2014) conducted a research paper entitled "Impact of Students' Achievement in Teaching Mathematics using GeoGebra" with aiming to investigate the effects of dynamic mathematics software GeoGebra on students' achievement in teaching of geometry at secondary stage. The data were collected from 80 students which were divided equally with in experimental and control group. The control group had received teaching by traditional way i.e., without using any software while experimental group had received teaching by dynamic learning software GeoGebra. The finding of that study reveals that, there are some meaningful differences between the score of control and experimental groups. The study shows that experimental group has better achievement which had received

instruction by GeoGebra in comparison to control group in which lesson had taken without software technology.

In addition, Martinez (2017) did a research entitled " The Effects of Using GeoGebra on Students' Achievement in Secondary Mathematics". The aim of this research was to determine if integrating GeoGebra, an iPad application, would have a positive effect on students understanding of high School Geometry. It was an experimental quantitative study with a nonequivalent pre-test and post-test design using a treatment (i.e., using GeoGebra) and a control group (i.e., not using GeoGebra). During the five weeks intervention, the treatment group used GeoGebra while the control group had normal instruction. Independent and paired t-tests were conducted to determine for analyzing the data. The researcher concluded that students' scores improved when using the GeoGebra; however, not statistically higher than the control group.

Likewise, a quasi-experimental study based on constructivist approach carried out by Joshi (2017) entitled "Students' Achievement in Trigonometry Teaching Through GeoGebra" with the aim to investigate the impact on students' achievement in teaching trigonometry through GeoGebra software. Taking all the students of Kirtipur municipality as population and a total of 42 students from grade nine who were studying optional mathematics from Janasewa Secondary School, Kirtipur, Kathmandu as sample. He divided these students into two groups: experimental and control group consisting 20 and 22 students respectively. He facilitated the experimental group by GeoGebra software and control group by traditional method Achievement test and interview schedule were used to collect the data. To analyze the data t- test value and descriptive method were used. He concluded that facilitating through GeoGebra software yields better achievement than traditional method of

instruction. Also, the students' response towards the use of GeoGebra software was positive.

Moreover, Shadaan and Eu (2013) conducted a quasi-experimental design study entitled "Effectiveness of Using GeoGebra on Students' Understanding in Learning Circles" to investigate students' understanding in learning circles using GeoGebra. In this study, fifty-three students of nine years from two intact classes participated with one class assigned as the experimental group and the other as the control. Finding of this study showed a significance difference existed in the mean scores between these two groups. The results indicated that students in the experimental group outperformed those in the control group. In addition, a survey instrument was used to elicit students' perception on the use of GeoGebra. Analysis of the questionnaire responses indicated a positive overall perception of using GeoGebra in learning about circles. The results showed that students enjoyed in learning mathematics much more when using GeoGebra and were able to make better connections between previous learning and new learning.

Chalaune (2019) did a research entitled "Effectiveness of GeoGebra in Teaching Mathematics". For the objectives, to find the effectiveness of GeoGebra in teaching mathematics and to analyze the students' perception towards the use of GeoGebra in teaching mathematics. The research was based o constructivist approach. He has completed the study on a chapter: mensuration of grade nine and used pre-test and post-test non-equivalent experimental design. For data collection, he has selected two private schools purposively of Kirtipur municipality of Kathmandu district, Nepal. Study was done taking the sample of 27 and 21 number of students from experimental and control group respectively. He taught the experimental group by using GeoGebra and control by traditional method. Achievement test and

questionnaire were used as the tool of data collection. He compared mean, SD and t-test value of these two groups. He concluded that students in the experimental group outperformed those in the control group. Also, the use of GeoGebra in teaching and learning mathematics promotes the students' curiosity on subject matter, makes clear sense and encouraged to the students. He recommended that GeoGebra software should be included in school level's computer science.

From the above reviews, it was found that GeoGebra based instruction in mathematics is increasing the worldwide owing to its wider usability. GeoGebra is found to be very efficient in mathematics and can be used effectively both in teachers' training and students' learning. Also, reviewed literatures showed that GeoGebra is really necessary to enhance positive impact on students' achievement. GeoGebra software in teaching and learning mathematics promotes the students' curiosity on subject matter, makes clear sense and encourages to the students. Thus, GeoGebra is a means of improving mathematics teaching at secondary level.

In Nepalese context it is smoothly increasing its use in teaching mathematics. In the above reviews all researches have done effectiveness of GeoGebra in mathematics but I am going to do my research in optional mathematics specially in trigonometry. The purpose of my study is to find out students' achievement in trigonometry by using GeoGebra. In this study, the perception of students towards use of GeoGebra has been identified standing on different questions related with teaching learning activities.

Review of Theoretical Literature

Trigonometry is the branch of mathematics that deals with the study of relationships between sides and angles of a triangle. Trigonometry is one of the major

contents of compulsory mathematics and optional mathematics of secondary level curriculum in Nepal. In order to teach trigonometry through GeoGebra software connectivism learning theory may play vital role and so it has been chosen as theoretical ground for this study to develop students understanding.

Since 1980, technology has been radically altering daily life, communication, and education. Siemens, the developer of connectivism, labeled it as a new learning theory heavily influenced by technology. Connectivism is a theoretical framework driven by the understanding that information is a network continually being acquired and updated (Siemens, 2004). Through a network, web or internet, learners can acquire new content that is continually updated, identify credible resources, and draw distinctions between opposing facts and figures. In connectivism theory, one view of learning is knowing where to locate information may be as valuable as the information itself.

Connectivism releases the learner from the cognitive practices of acquiring knowledge through experience, study, and receiving instruction. (Abik et al., 2012). Connectivism allows students to incorporate electronic devices for the "off-site" storage of information, treating the role of memory differently than prior learning theories. With connectivism, technology is permitted to become part of the student's internal learning process. While older learning theories have their place in the communication of basic knowledge, instruction must embrace connectivism to ensure that knowledge in the 21st century will be properly conveyed (Abik et al., 2012).

In the post-technology world, Siemens proposed "connectivism as a learning theory for the digital age" (Siemens, 2004, p.1). In connectivism, knowledge is distributed across networks where connections and connectedness inform learning.

Heavily grounded in technology, connectivism is a learning theory based on the acquisition of the knowledge focused on the future, not the past (Siemens, 2012).

In the connectivism, the teachers' role is facilitator, listener, observer and organizer for the collaborative classroom. Connectives comprises all key ideas, connectives compared with existing school of thoughts includes learning and knowledge rest in diversity of opinion, learning is a process of connecting nodes of information, learning may reside in non-human appliances. Maintaining connection is needed for learning ability to see connection between ideas and concepts is a key skill currency, accurate, up-to-date knowledge. Knowledge is a vital learning.

In the process of trigonometry teaching, while one use GeoGebra software in learning facilitation process students can visualize such relations related with trigonometry like as trigonometric functions, ratios, unit circle and angle measure etc. and they may able to avoid misconceptions and connect with new knowledge. Also, GeoGebra assisted instruction helps the learners to motivate and engrossed towards learning. This type of instructions helps to explore about new knowledge. As dynamic mathematics software, use of GeoGebra is getting more common all over the world. GeoGebra is found to be very efficient in mathematics education and it is widely used dynamic mathematical software in teachers training and students' learning. Thus, GeoGebra may be an important tool in mathematics education for the betterment of students' achievement by connectivism approach.

Also, Punya Mishra and Matthew J. Koehler’s 2006 TPACK framework, which focuses on technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK), offers a productive approach to many of the dilemmas that teachers face in implementing educational technology (edtech) in their classrooms. By differentiating among these three types of knowledge, the TPACK framework

outlines how content (what is being taught) and pedagogy (how the teacher imparts that content) must form the foundation for any effective educational technology integration.

This order is important because the technology being implemented must communicate the content and support the pedagogy in order to enhance students' learning experience. According to the TPACK framework, specific technological tools (hardware, software, applications, associated information literacy practices, etc.) are best used to instruct and guide students toward a better, more robust understanding of the subject matter. The three types of knowledge technological knowledge, pedagogical knowledge and content knowledge are thus combined and recombined in various ways within the TPACK framework.

Technological pedagogical knowledge (TPK) describes relationships and interactions between technological tools and specific pedagogical practices, while pedagogical content knowledge (PCK) describes the same between pedagogical practices and specific learning objectives; finally, technological content knowledge (TCK) describes relationships and intersections among technologies and learning objectives. These triangulated areas then constitute TPACK, which considers the relationships among all three areas and acknowledges that educators are acting within this complex space.

This adaptability can be seen in the various intersections and relationships already embodied in the TPACK acronym.

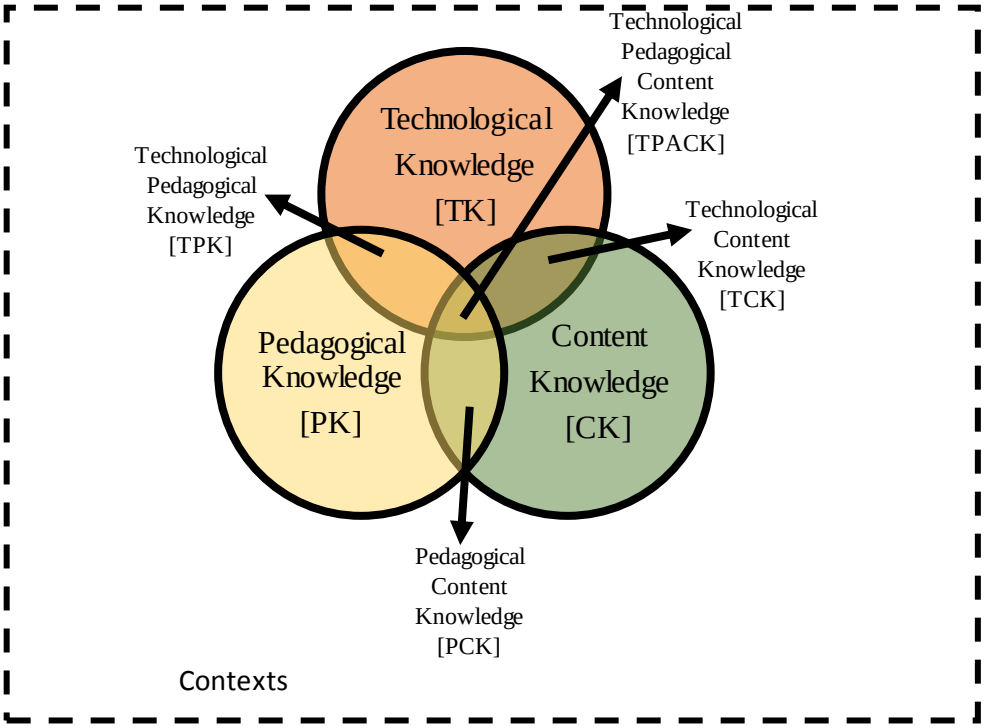

Fig.1: Technological Pedagogical Content knowledge [TPACK][Mishra at al.,2006]

Content knowledge

This describes teachers' own knowledge of the subject matter. Content knowledge may include knowledge of concepts, theories, evidence, and organizational frameworks within a particular subject matter; it may also include the field's best practices and established approaches to communicating this information to students.

Pedagogical knowledge

This describes teachers' knowledge of the practices, processes, and methods regarding teaching and learning. As a generic form of knowledge, pedagogical knowledge encompasses the purposes, values, and aims of education, and may apply to more specific areas including the understanding of student learning styles, classroom management skills, lesson planning, and assessments

Technological knowledge

This describes teachers' knowledge of, and ability to use, various technologies, technological tools, and associated resources. Technological knowledge concerns understanding educational technology, considering its possibilities for a specific subject area or classroom, learning to recognize when it will assist or impede learning, and continually learning and adapting to new technology offerings.

Pedagogical content knowledge

This describes teachers' knowledge regarding foundational areas of teaching and learning, including curricula development, student assessment, and reporting results. Pedagogical content knowledge focuses on promoting learning and on tracing the links among pedagogy and its supportive practices (curriculum, assessment, etc.), and much like content knowledge (CK), will also differ according to grade level and subject matter. In all cases, though, pedagogical content knowledge (PCK) seeks to improve teaching practices by creating stronger connections between the content and the pedagogy used to communicate it.

Technological content knowledge

This describes teachers' understanding of how technology and content can both influence and push against each other. Technological content knowledge (TCK) involves understanding how the subject matter can be communicated via different educational technology offerings, and considering which specific educational technology tools might be best suited for specific subject matters or classrooms.

Technological pedagogical knowledge

This describes teachers' understanding of how particular technologies can change both the teaching and learning experiences by introducing new pedagogical affordances and constraints.

Finally, TPACK is the end result of these various combinations and interests. TPACK framework is useful for the ways in which it explicates the types of knowledge most needed in order to make technology integration successful in the classroom. Teachers need not even be familiar with the entire TPACK framework as such in order to benefit from it: they simply need to understand that instructional practices are best shaped by content-driven, pedagogically-sound, and technologically-forward thinking knowledge.

In the trigonometry teaching through GeoGebra, TPACK framework is very useful. Researcher use GeoGebra as technology, connectivism as pedagogy and subject matter (trigonometry) as content in the teaching learning process. While students' use GeoGebra, they can visualize the actual thing about trigonometry. So, they can get new ideas about trigonometry and try to connect it to what they already know. Which helps to makes the teaching learning process effective. In this process, teacher will be a facilitator who encourage and motivate students for learning and students will connect their knowledge themselves. Classes will be student centered by which interaction with others will possible.

Conceptual Framework

The conceptual framework of learning facilitation process in experimental group is as follows:

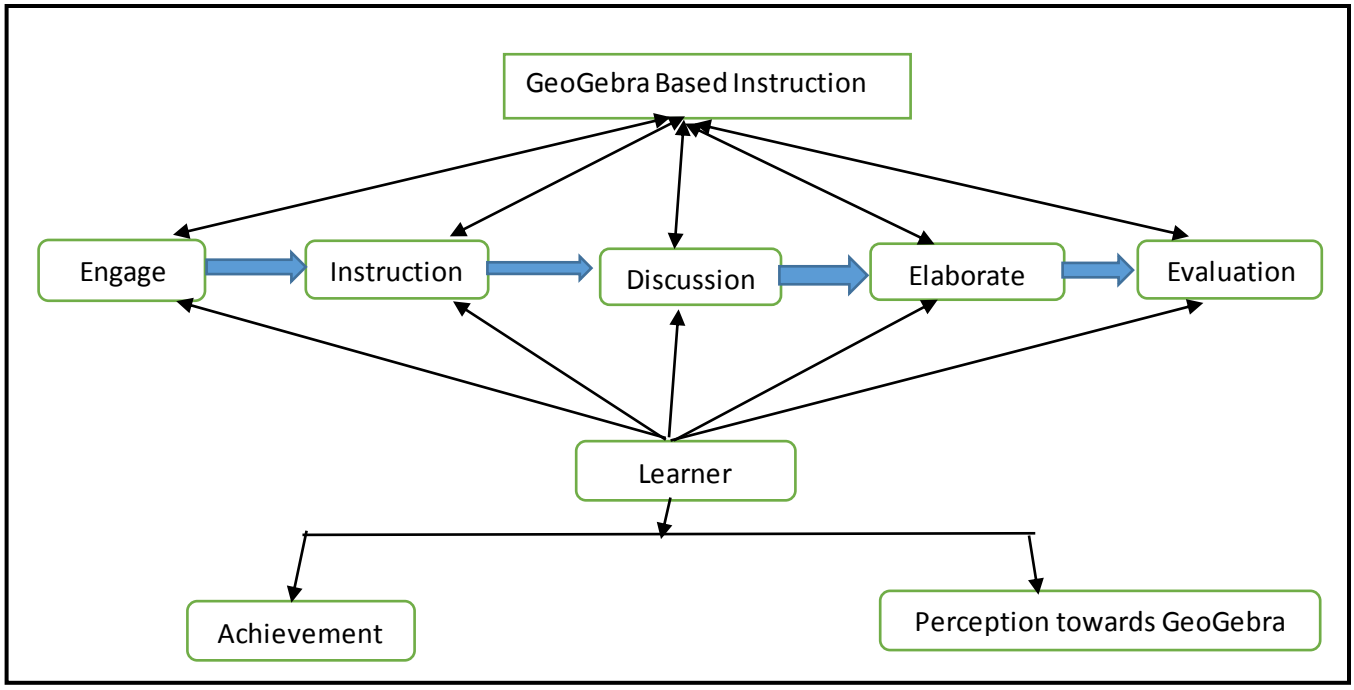

Fig.2: Learning Facilitation Process

The above diagram is based on the *'5E instructional model for constructivism'* which was developed by Roger Bybee (as cited in NASA eClips^{TM},2015). The 5Es represent five stages of a sequence for teaching and learning: Engage, Explore, Explain, Extend and Evaluation. Researcher took the help of such stages to construct the appropriate conceptual framework of this study.

Above diagram shows that how researcher conducted GeoGebra based instruction for analyze impact on students' achievement in teaching trigonometry through GeoGebra software.

In the process of GeoGebra based instruction, students engaged all over the period of teaching and learning process. There are five steps for teaching

trigonometry with GeoGebra viz. Engage, Instruction, Discussion, Elaborate and Evaluation.

Engage

This stage assesses the previous knowledge of the learners and helps them to engage in a new concept through the use of short activities along with proper use of GeoGebra software. Such activities promote curiosity on students and fulfill the gaps between students' prior knowledge and new knowledge in related contents.

Instruction

In this stage students are facilitated by the GeoGebra software to learn trigonometrical concepts of optional mathematics of ninth standard.

Discussion

In this stage students are provided some problems and promote them to describe concepts or skills in their own words. For this, they try to solve themselves, interact with other and reach at a conclusion. Moreover, one can use GeoGebra to clarify conclusion of discussion.

Elaborate

This phase challenges the students to extend their understandings or skills. Through new experiences at this time, students develop deeper understanding and improved skills. At this stage researcher can use GeoGebra software to justify their understanding or skills.

Evaluation

The final phase encourages students to assess their understanding and abilities and provide opportunity for the teacher to evaluate students' progress toward achieving the learning objectives for the activity.

Chapter III

METHODS AND PROCEDURES

Methods are tools or techniques applied in the research process and procedures are a way to put tools and techniques together in combinations to achieve objectives. So, the appropriate methods and procedures need to be carefully selected to achieve the objectives and produce reliable knowledge. Here, this chapter will focus on research methodology. Specially, it describes; research design, population, sample and sampling strategies, data collection tools and techniques, data collection procedure and data analysis and interpretation procedures.

Design and Method of the Study

Research design is the plan, structure, and strategy of investigation designed to obtained answers to research questions and to control variance. The plan is an overall scheme or program of research. It includes an outline of the hypothesis, operational implications, and analysis of data (Bhatt, 2020).

According to Singh (2008), the research design is the detailed plan of the whole study. In fact, it is the blue-print of the detailed procedures of performing the experiment, testing the hypothesis, analyzing the obtained data and summarizing the findings. Thus, the research design is the overall plan for the research.

In this research quantitative research design will be followed. But some qualitative data will be taken. I will select the pre-test post-test nonequivalent control group design. In this study, there will be two group of students of grade IX. Moreover, one group will be experimental group and another will control group. The experimental group will be treated by a mathematical dynamic software GeoGebra and control group of students by traditional method of instruction. I will teach these

two groups the same content of grade IX under the topic 'trigonometry'. The quasi-experimental research design can be diagramed as below (Best & Kahn, 2009):

Table 1: ***Design for the study***

Groups	Pre-test	Treatment	Post-test
Experimental	O_1	T_1	O_3
Control	O_2	T_2	O_4

Here, O_1 and O_2 represents the pre-test for experimental and control group respectively while O_3 is the post-test for experimental group and O_4 is the post-test for control group. Similarly, T_1 and T_2 denote the teaching method of instruction for these two groups. More precisely, T_1 represents the teaching method for experimental group (i.e., new innovation teaching method using a dynamic mathematical software GeoGebra) and T_2 indicates the teaching method for control group (traditional method of instruction).

The marks obtained by students in pre-test will be their achievement before treatment and used to measure the similarities between the experimental and control group. After the treatment, a post-test will be conducted for both the groups using the same test as used in pre-test. Also, to measure the perception of students towards the use of GeoGebra in teaching trigonometry, an interview will be conducted for a sample of students from the experimental group only.

Population, Sample and Sampling Strategies

Population

Population is a group of items, units, or subjects which are under the reference of study, Population may consist of a finite or infinite member of units (Agrawal, 2003, p.184). It is better to study each and every unit of the population for the real condition of the learning achievements subject wise however it is generally

impossible to study each individual that is whole units of the group under consideration (Bhatt, 2020). In this study, all students of secondary level of grade IX of Ramechhap district will be taken as the population.

Sample

Sampling is the process of measuring the characteristics of the population by studying only a part or portion of the population chosen (Chaudhary & Sharma, 2060, p.173). In a sample, part of observation is selected from which observations are made or data are collected, and then inferences are made to the whole population (Bhatt, 2020). In this study, it will not be possible to study on whole such population due to lack of many resources. So, I will select one government school from Ramechhap district purposively for the sample.

Sampling strategies

A combination of sampling design and estimator is called a sampling strategy. An estimator is a function of sample information, which gives an estimate for population parameters (Bhatt, 2020). In this study, all students of secondary level of grade 'IX' of Ramechhap district were taken as population. But it is not possible to study on whole such population due to lack of many resources. Being the teacher of Sharada secondary school (Model) Ramechhap, I had selected this school purposively for the sample. So, to accomplish the motto of this study researcher selected only two groups of students who were studying optional mathematics at grade 'IX' from section 'A' and section 'B'.

Using random sampling method (tossing a coin), students of one group will be taken as experimental group and that of another group as control group. Also, a group of five students of experimental group will be participated to express their

views towards the use of GeoGebra. This group of students will consist the students with poor, average and good scores on achievement test.

Table 2: ***Composition of Sample***

Groups	Number of students
Experimental	28
Control	22
Total	50

Variables

Independent variables

The independent variable is the variable the experimenter manipulates or changes, and is assumed to have a direct effect on the dependent variable (Saul, 2019). In this study, the independent variable will be teaching method using a dynamic mathematical software GeoGebra.

Dependent variables

The dependent variable is the variable being tested and measured in an experiment, and is 'dependent' on the independent variable (Saul, 2019). In this study, students' score on mathematics achievement test (post-test) as well as students' perception towards the use of GeoGebra software in teaching trigonometry will be dependent variables.

Extraneous variables

Extraneous variables are undesirable variables that influence the relationship between the variables that the experimenter is observing (Megan, 2019). In this study, Selection of school, selection of teacher/instructor in both groups, teaching content,

time duration, school environment, students' labor, home environment, time duration between pre-test and post-test, evaluation system, experiment time, tuition classes of students outside of school will be extraneous variables to this study.

Control Mechanism for Extraneous Variables

In this study, except experimental variable (independent variable) which may have significance influence on students' achievement (dependent variable) will be controlled as soon as possible. To control such extraneous variables, only one school will be selected, the same instructor/teacher (researcher himself) will teach the same content up to two weeks in both groups, the time duration between pre-test and post-test will be fifteen days and the same items for achievement test will be used in both groups. In this way, these conditions will be kept in mind. But some other extraneous variables like home environment, school environment, interaction among students, students' labor, students' tuition classes etc. will not be controlled.

Data Collection Tools

In this study, to collect the data two instruments will be used: achievement test and interview schedule.

Mathematical achievement test (MAT)

Achievement test is an important tool to collect the data for the study. I will develop the achievement test with the help of pilot test and specification grid of class IX developed by CDC Nepal 2075 BS. There will be 24 objective questions of weight one marks, eight subjective questions in which four questions each of four marks and remaining four questions each of five marks. In this way there will be 32 questions on pilot test and the full marks will 60. But MAT will consist only seven objective questions, four subjective questions in which two questions each of four marks and

remaining two questions each of five marks. Thus, there will be only eleven questions on MAT and the full marks will be 25. And the other questions submitted on pilot test will be rejected.

Interview schedule

To identify the perception of the students towards the use of GeoGebra in teaching trigonometry, an interview schedule will be used. Open ended questions for analyzing students' opinion towards the use of GeoGebra in teaching trigonometry will be used. Interview will be conducted taking a sample from experimental group after treatment by GeoGebra software. With the help of supervisor only five open ended questions will be made.

Reliability and Validity of the Tool

Reliability refers to whether or not we get the same answer by using an instrument to measure something more than once. In simple terms, research reliability is a degree to which research method produces stable and consistent results. Similarly, a test is said to valid if it measures what is supposed to measure.

A pilot test will be conducted to measure the quality of questions. For standardization the questions, difficulty index (p-value) and discrimination index (D-value) will be calculated. After analyzing the items, I will prepare MAT for pre-test and post-test.

For the reliability of interview, respondents will be asked the same question repeatedly. Also, questions for the interview schedule will be constructed by the judgement of supervisor.

Threats to Validity

An experiment is valid if the results obtained are due to only the manipulated independent variable and if they are generalizable to individuals or contexts beyond the experimental setting (Gay et al., 2012). These two criteria are referred respectively, as the internal and external validity of an experiment which are mentioned below:

Threats to internal validity

Internal validity is the degree to which observed differences on the dependent variables are a direct result of manipulation of the independent variable, not some other variables (Gay et al., 2012). In this study, the control mechanism of threats to internal validity is as follows:

Maturation. This study will be done in short period of time. So, no more changes occur in participants due to growing older, more experienced etc. which will be only possible due to independent variable.

Testing. The time duration between pre-test and post-test will be fifteen days. So, the results of pre-test may not affect the results of post-test.

Instrumentation. The item analysis and estimation of reliability of test items will be determined through pilot test. Also, MAT will test in both the groups at the period of pre-test and post-test which are same. So, the results will not be affected by instrumentation.

Differential selection of participants. Two groups of students will be selected from one school and pre-test will be used to check the initial equivalence of the groups.

Morality. In this study, those students participating only one test either pre-test or post-test will not include for the result of the study.

Threats to external validity

It is the degree to which study results are generalizable or applicable, to groups and environments outside of the experimental setting (Gay, at al., 2012). The possible treats that affect the external validity and their control mechanism are mentioned as below:

Experimenter effects. I will try for my best to control all the extraneous variables. So, there will not produce any experimental change. Also, I will teach/facilitate both the groups for the same duration time and analyze the data without any bias. So, there is possibilities of generalizations of the study.

Multiple treatment interference. In this study, the experimental group will be facilitated the course under the topic 'trigonometry' by using a mathematical dynamic software GeoGebra and control group of students will be taught by traditional method of instructional only. The participants in both the groups will not get more than one treatment.

Data Collection Procedures

This study will mainly have based on quantitative data from achievement test and qualitative information from interview schedule.

To collect the data for the study, I will visit one school of Ramechhap district. I will take permission from the principal for the study. After taking permission I will visit towards students and give general information about research and purpose of the study and keep privacy of them who are going to involve in that event. Then, a pre-test will be conducted on both the groups using MAT with the help of subject teacher.

After the treatment up to two weeks, there will be post-test for both groups using the same MAT. After that, quantitative analysis of the result of post-test will be calculated. At last, interview will be conducted taking a sample of five students from experimental group. For this, five open-ended questions will be asked and responses will be recorded.

Data Analysis and Interpretation Procedures

In this study, collected data from mathematics achievement test will be analyzed by descriptive and inferential statistical method. In descriptive method, mean, standard deviation and variance will be calculated with the help of Microsoft office excel 2019 of the score of both groups in pre-test and post-test. To compare the achievement of students in pre-test and post-test, t-test will be used. Also, the data collected from interview schedule will be analyzed by thematic approach which is helpful to know the perception of students towards the use of GeoGebra in teaching 'trigonometry'.

Ethical Consideration

To accomplish this research, some of the important ethical issues will be considered. I will take permission from institutions prior to planning or conducting experiment providing accurate information about research proposal. I will keep the responses of respondents' confidential. The institutions' name will not be mentioned without permission of school administration. Also, before collecting data, I will give the clear information of my study to the cooperative institutions and participants. I will use appropriate language in my research all over the time.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

This chapter deals with the presentation and interpretation of the collected data with result of the data analysis. In this study data were collected from achievement tests (pre-test and post-test) and interview schedule. In this study, achievement test was conducted in both groups (experimental and control group) but interview was administered taking a sample from experimental group only. The collected data were analyzed by descriptive statistic and inferential statistics. Specially, t-test was used to test for the statistical significance difference between the experiment and control group while descriptive method was used to analyze the data obtained from interview. The analysis and interpretation of the data achieved from tools was analyzed as follows:

Comparison of Achievement of Students on Pre-test

After dividing the groups as control and experimental group, pre-test was conducted with in both groups; control and experimental groups. The aim of this test was to find out whether both groups were homogenous in cognitive level or not. The scores obtained by students of both groups in pre-test is presented in 'Appendix-E'. But the statistical result of both groups in pre-test is presented in the following table:

Table 3: *Result of Pre-test*

Group	N	Mean	SD	Variance	Calculated t-value	Level of significance	Tabulated t-value
Control	22	9.77	4.64	21.54	0.45	0.05	1.96
Experimental	28	10.46	5.43	29.48			

Table no. 3 shows that the number of students, mean, standard deviation and variance of the Control and experimental group on pre-test. The total number of students on both the groups were 50, where control group consists 22 students and experimental group consists 28 students. The mean score of control and experimental groups were 9.77 and 10.46 respectively which are very close. Similarly, the standard deviation of control group was 4.64 while that of experimental group 5.43. Also, the variance of control group was calculated as 21.54 and that quantity of experimental group was 29.48 only. Again, calculated t-value was 0.45 while its tabulated value was 1.96 on two tailed at 0.05 level of significance. This shows that there was not significant difference between mean achievement of students in control group and experimental group on pre-test. Thus, both group of students were homogeneous in terms of their achievement. The result (mean and standard deviation) of pre-test of control and experimental group is presented in the following figure:

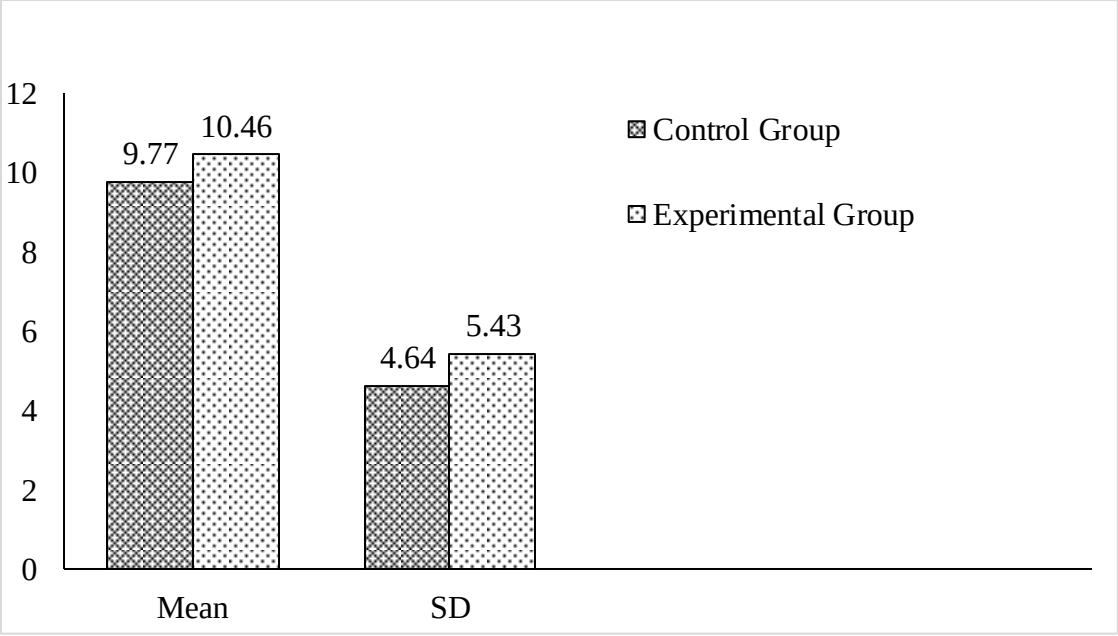

***Figure 3*: Result of Control Group and Experimental Group on Pre- test**

Comparison of Achievement of Students on Post-test

After pre-test, some treatment was provided to both the groups. Specially, control group was treated by traditional teaching method while experimental group was treated by using GeoGebra up to two weeks. After two weeks one more test (using the same items as in pre-test) was conducted on both the groups namely post-test. The marks obtained by individual students in post-test was presented in 'Appendix- F'. But the statistical result of post-test presented in the following table.

Table 4: ***Result of Post-test***

Group	N	Mean	SD	Variance	Calculated t- value	Level of significance	Tabulated t-value
Control	22	14.41	5.59	31.25	4.93	0.05	1.645
Experimental	28	20.43	2.29	5.24			

Above table- 4 shows that the number of students participated in the study, mean, standard deviation and variance of control group and experimental group on post-test. The mean score of control group in post-test was 14.41 where it was of experimental group 20.43. The standard deviation of control and experimental group in post-test were 5.59 and 2.29 respectively. Similarly, the variance of control group was 31.25 and that of experimental group was 5.24. The tabulated and calculated t-value at 0.05 level of significance for one tailed test are 1.645 and 4.93 respectively. This yields that calculated t-value is greater than tabulated t-value. Thus, the null hypothesis (The achievement of students of experimental group is same as that of control group) stated in chapter I is rejected. Consequently, alternative hypothesis

(The achievement of students of experimental group is higher than that of control group) is accepted.

This implies that there is significant difference between the mean achievement of control group and experimental group on post-test. Also, the higher mean score of experimental group indicated that experimental group had greater achievement than control group. This means students who had facilitated using GeoGebra software in teaching 'Trigonometry' had significantly better achievement than the students who had taught by traditional method of instruction. The result (mean and standard deviation) of post- test of control group and experimental group is presented in the following figure:

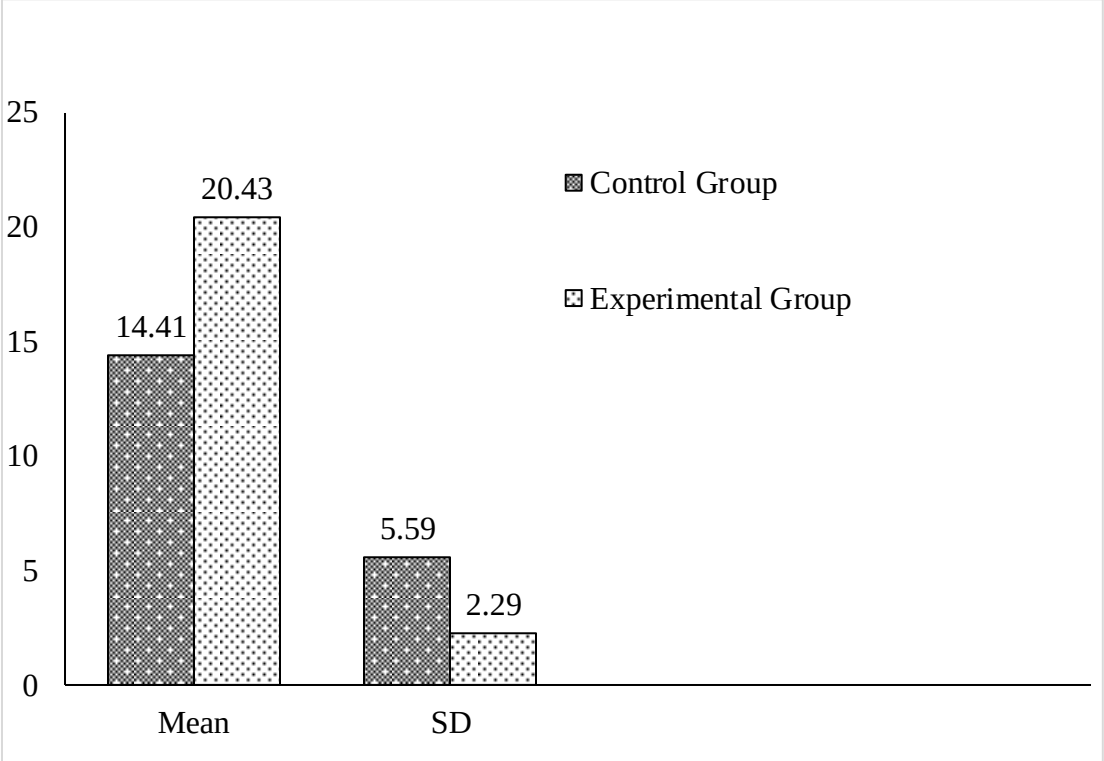

***Figure 4*: Result of Control Group and Experimental Group on Post- test**

Comparison of Achievement Score of Experimental Group on Pre-test and Post-test

This section will compare the result of pre-test and post -test of experimental group only. The statistical result is presented in the following table:

Table 5: ***Result of Pre-test and Post-test of Experimental Group***

Test	Mean	S D	Variance
Post-test	20.43	2.29	5.24
Pre-test	10.46	5.43	29.48

Above table no. 5 shows that mean scores, standard deviation and variance of experimental group on pre-test and post-test. The mean score of experimental group on post-test were 20.43 while it was on pre-test 10.46 only. Here, the mean score of experimental group on pre-test is differ by 9.97 than that on post-test. Similarly, the standard deviation of experimental group on post-test and pre-test were 2.29 and 5.43 respectively. Finally, the variance of the same group on post-test and pre-test were 5.24 and 29.48 respectively. Thus, analyzing the above result presented in table no.-5, it is clear that the average achievement of experimental group on post-test is greater than that on pre-test. Since the post-test was conducted after the treatment i.e., using GeoGebra software. Hence, GeoGebra looks like an effective software in teaching learning of 'Trigonometry' for grade IX. The result (mean and standard deviation) of post- test of control group and experimental group is presented in the following figure:

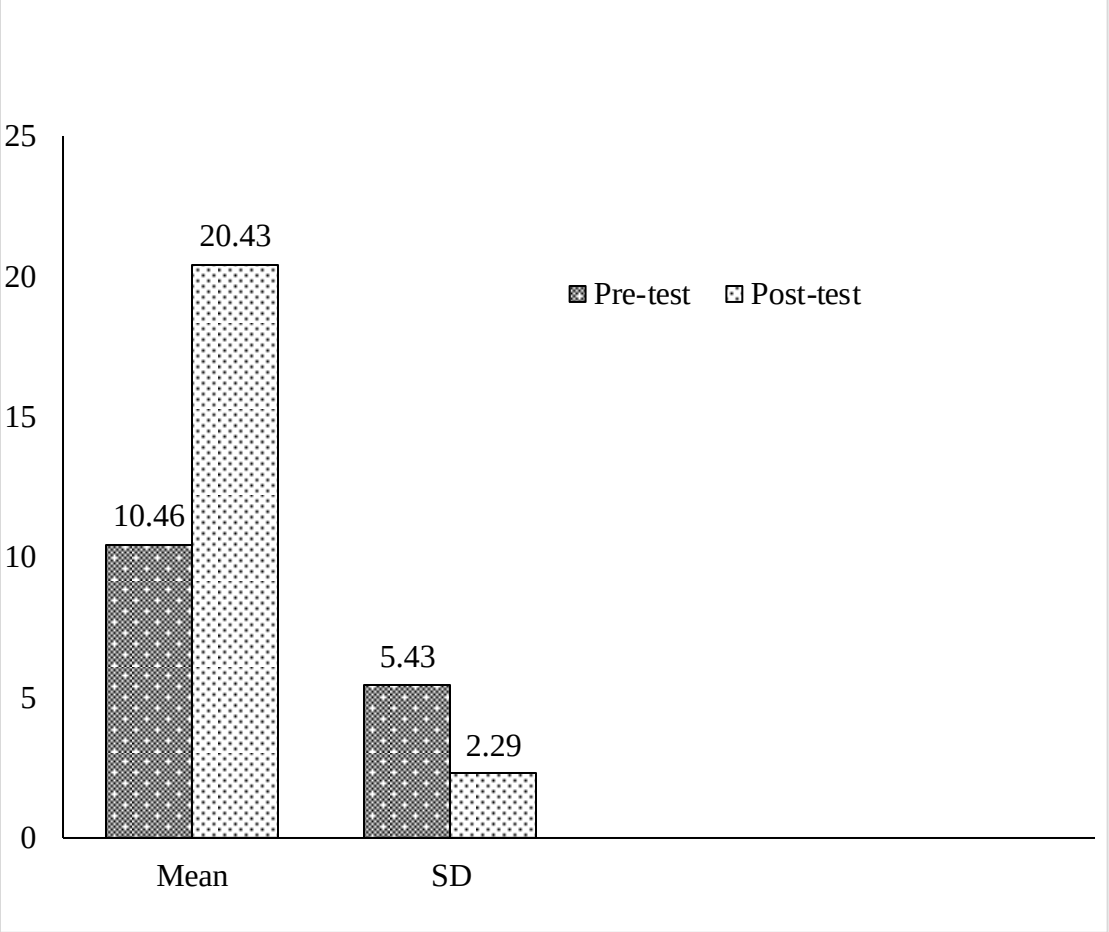

***Figure 5*: Result of Experimental Group on pre-test and Post- test**

Students' Perception towards Learning Trigonometry Using GeoGebra Software

The perception of students' toward learning trigonometry using GeoGebra software was identified through an interview schedule. Five open- ended questions (which are presented in Appendix-G) were included in interview schedule and it was conducted among five students of experimental group. To analyze the data collected from in interview schedule thematic approach was used. Being based on students' views on all five open ended questions, following three themes were conducted:

Visualization and understanding. Visualization and understanding mean to develop the power to make experience from the formation of mental visual image. In teaching learning activities understanding depends on visualization. Taking more precisely,

good visualization for mathematical problem shows better understanding for mathematics solution. It means visualization is very important to understand any mathematical concept.

In the process of data collection, I asked the question 'What did you feel about GeoGebra while using in teaching trigonometry?' to the respondent. Then, they reply as follow:

One of the students replied me that *"Sir, I have never seen this type of software to teach mathematics before. While you used GeoGebra to provides concept about Pythagoras theorem step by step, it makes me so easy to understand what the actual meaning of* $h^2 = p^2 + b^2$ *(Pythagorean identities), before this class we only learnt formulae and getting to solve problems. So, I felt GeoGebra is very interesting software in mathematics"*.

Similarly, another one replied that *"Sir, now I feel very easy to learn trigonometry. Before we rote all the formulae which are given in trigonometry, now you make clear them by using unit circle in GeoGebra. When you moved object in GeoGebra it was really very interesting. This process helps me to understand the figure and I know having good concept about figure helps us to know geometrical meaning about formulae"*.

Another one replied *"Sir, I think GeoGebra is very effective in learning mathematics. While you use GeoGebra to provide the concepts of graph of trigonometric function, it's really amazing to know how the domain of sine and cosine function is from* $-\infty$ *to* $+\infty$ *by moving the graph to the left or right side then we didn't get the end point of graph, and we also observe that the graph of sine and cosines*

function lies between -1 to 1. So, we know the range of sine function and cosine function lies between -1 and 1. So, I can say that it is the easy way of learning".

Another one replied that *"Sir, GeoGebra software made me more clearly about the graph that you visualize in trigonometry. I think we can learn many mathematical concepts visually through GeoGebra. It's easy to understand trigonometrical concepts".*

And last one replied that "*Sir, the use of GeoGebra software in trigonometry ensures long time memorization of what the teacher taught. Learning through visualization impact in our mind for a long time. So, GeoGebra is very essential tool in learning trigonometry".*

From the above students' view we can conclude that students' feel easy to learn and understand trigonometrical concepts visually through GeoGebra software. They took interest in learning trigonometry through GeoGebra software.

Similarly, students' views on the next statement ' Did you have any differences in learning trigonometrical concepts with or without using GeoGebra software? Is presented as below:

One of the students replied that *"Yes, I got differences in learning trigonometrical concepts by using GeoGebra and without using GeoGebra. Before earlier classes we just rote all the things about Pythagorean identities. And now, after using GeoGebra we can visualize that how in the right-angled triangle, the sum of squares on the two sides of the triangle is equally fit on the square formed on the hypotenuse. So, learning visually through GeoGebra is very effective in trigonometry".*

Another one replied *"I also found differences in learning trigonometry before and now after using GeoGebra. Before while we draw the graph of trigonometric function y= sin x, we take particular points $0^0, 30^0, 45^0, 60^0, 90^0$ and so on. And we got the output in those particular points. After that we make the graph of sin x in increasing order from 0^0 to 90^0. Then I had gotten so many queries in my mind. Is really the graph of sin x from 0^0 to 30^0 in increasing order, similarly increasing between 30^0 to45^0, and so on, such queries are always coming in my mind? Now, after using GeoGebra we can saw the graph of sin x, at each and every point that lies in domain of sin x. How the graph of sin x moves from $-\infty$ to $+\infty$. It is very easy to understand the domain and range of trigonometric function via GeoGebra software"*.

Another one replied *"Sir, before I'm very straggling to understand the concept of unit circle but I didn't to understand it but now after using GeoGebra it is very easy to understand visually in GeoGebra software"*.

Next one replied *"After using GeoGebra, it is very easy to understand the formulae that are used in trigonometry. There is no need to root the formulae. Now we can memories the formulae for a long time"*.

Last one replied *"Sometimes earlier classes were more boring especially while learning trigonometry but now after using GeoGebra it was more interesting and encouraging"*.

Collecting the students' views on the above statement, it was found that they got the differences in learning trigonometry. They feel easy to understand the trigonometrical concept. They can easily take the feel about trigonometry via GeoGebra. GeoGebra software provides opportunity to learn visually which is not

possible through traditional way of learning. They found that GeoGebra based instruction is much clear, interesting and encouraging rather than earlier method.

Use of technology in learning. As mentioned, before it is the age of science and technology. Every step of human being is affected by the modern technology. Knowingly or unknowingly our live is driven by the technology. Obviously teaching learning activities may not live far from this technology. Since I have used GeoGebra software in teaching trigonometry and GeoGebra is the gift of Modern technology. Here, I had tried to understand the students' perception towards GeoGebra being based on the following two questions:

When I asked the question ' Do you think that GeoGebra should be used to teach other concept of mathematics? Why?' one of the students replied me as: "*yes, it should be used in coordinate geometry also. It may helpful to understand internal section division, external section division, mid-point of a line, centroid of a triangle, orthocenter of a triangle, slope of a line, locus of a circle etc. in coordinate geometry"*.

Another one replied *"yes, it should be used in teaching learning activities of other concept of mathematics because it helps the students to understand the subject matter in different ways. Mainly, it should be used in teaching theorems, experimental verifications. These geometrical concepts are very difficult as we all know"*.

Next one replied *"yes, it should be used in mathematics also. Especially in mensuration, GeoGebra may play the vital role to make clear concept about combined figures"*.

Another one replied "*Yes, it will be better for students' and teacher if GeoGebra is used in other geometrical parts of mathematics. In short period of time, we can understand the solution if GeoGebra is used in teaching*".

Also, next one replied "*yes, it should be used in vector geometry also which is one of the major parts of optional mathematics. It may helpful to give concept about displacement, different types of vectors (Unit vector, Position vector, like vectors, Unlike vectors, Equal vectors, parallel vectors), direction of a vector, triangle law of vector addition, parallelogram law of vector addition, Polygon law of vector addition etc. Mainly GeoGebra software helps us to understand the geometrical figures. If we have the knowledge of figure, then there is maximum chance of solving problems"*.

The students' views on the above question indicate that GeoGebra is useful for students to understand the things in the easiest manner. They had focused the use of GeoGebra on Geometrical part to understand the figure easily. They said that they can develop more concept of subject matter in the short period of time with the help of GeoGebra. GeoGebra is important for durable learning. Thus, we can conclude that GeoGebra should be used in to teach other concept of mathematics.

Again, I asked 'Do you think GeoGebra can be used to learn every problem of mathematics'? Why? Then they replied as:

First one "*It may not beneficial in all mathematical problems and exercises but it helps us to understand abstract and basic mathematical concepts diagrammatically"*.

Second one *"I think GeoGebra is useful for Geometrical parts rather than theoretical parts"*.

Third one *"I think we can learn maximum mathematical concepts and also solve maximum mathematical problems through GeoGebra. But I don't think it can be useful for all mathematical problems"*.

Fourth one replied as: *"I think no it is not so effective for numerical parts"*

And last one replied as *"sir, I'm not sure that it can be used to learn every mathematical problem because it is especially developed for geometry, algebra, graphing, statistics etc."*

Above views indicated that GeoGebra software is effective in abstract, diagrammatic and basic mathematical concepts rather than all mathematics problems and exercises. This showed the appropriateness of GeoGebra software in teaching trigonometrical concepts.

Learning environment. Technology can help students by making learning more engaging and collaborative. Rather than memorizing facts, students learn by doing and through critical thinking. This could be as simple as taking an interactive quiz in class or participating in tech-enabled group discussions or it could be as involved as playing educational games, practicing in science experiments in a virtual lab or taking a virtual field trip. Doing math on a computer is not any different than doing math with a pencil and pad of paper. Ultimately, interactivity and technology enhance learning. Here, I had tried to understand the students' perception towards GeoGebra based instruction by asking the question 'Do you think teaching through GeoGebra change the classroom learning environment? How?' Then the students view on this question is presented as:

One of the students replied that *"yes, GeoGebra helps us to understand abstract concept of mathematics through visually in the easiest way. So, I feel easy nowadays than before to solve trigonometrical problems. Also, I'm excited in learning while you are using GeoGebra. So, I can say GeoGebra change the learning environment of classroom"*.

Second one replied as "*Sir, while you are using GeoGebra almost students are taking interest on learning. We all are curious about the final results. While you elaborate the concepts on different topic via GeoGebra it helps us for the long-time learning. Besides this some students get the chance to talk with each other. Students who take mathematics as a hard subject also take interest on learning and try to do their best for learning. So, I can say that use of technology changes the class room learning environment"*.

Another one replied as "*Technology in the classroom obviously enhance the engagement of students and also enhance students learning. Which may helpful to change the traditional way of learning. So, it plays the role to change the classroom learning environment"*.

Next one replied as "*yes, sir technology takes the teaching learning activities on the next level. Especially in the mathematics, GeoGebra plays the vital role in learning. We all can take basic concepts on different topic of mathematics through GeoGebra classroom. Many readymade files are presenting there for learning by many tutors. Nowadays, only we need to interest to learn something, we can get easily so many materials in google, YouTube, GeoGebra classroom etc. we can learn many things over there. While we use these platforms of learning on the classroom it is able*

to success to attract the students' attention, they are also excited to learn in the new learning environment".

And the last one replied as *"Obviously yes, we all are excited to learn mathematics in the new way and GeoGebra becomes the best application for mathematics learning, which took the mathematics classroom environment in the next level"*.

Above results shows that, most of the students gave positive responses towards the use of GeoGebra while teaching trigonometry. They took lots of benefits through classroom discussion while using GeoGebra. Also, they were excited and motivated as well as engaged in the overall learning process. They also found that, GeoGebra based instruction helped them to think creatively and critically in the process of discussion and they were able to visualize abstract concepts related with trigonometry. Also, the differences on students' achievement in trigonometry are a direct result of manipulation of GeoGebra software. It shows that students are interested in technology for learning. When they had any quires about any topic of mathematics then they did online group discussion, watched related videos on YouTube which helped them to increase their learning understanding capacity. Thus, GeoGebra is useful application for students to connect their pre-knowledge with new knowledge.

Chapter V

FINDING, CONCLUSION AND RECOMMENDATION

This chapter deals with the findings, conclusion and recommendation of the study.

Findings of the Study

On the basis of data obtained from achievement test and interview schedule, it was found that:

- The average achievement of control group and experimental group in pre-test was 9.77 and 10.46 respectively. This implies that the average achievement of experimental group was more than that of control group by 0.69.
- The result of pre-test showed that the calculated t-value was 0.45 while tabulated t-value (two tailed) at 0.05 level of significance was 1.96. This implies that there was no significance difference between control group and experimental group on mathematical average achievement. Hence, both group were assumed homogeneous for the further study.
- The average achievement of control group and experimental group in post-test was 14.41 and 20.43 respectively. This implies that the average achievement of experimental group was more than that of control group by 6.02.
- The result of post-test showed that the calculated t-value was 4.93 while tabulated t-value (one tailed) at 0.05 level of significance was 1.645. Clearly, calculated t-value is greater than tabulated t-value i.e., 4.93>1.645. Thus, the null hypothesis is rejected and then alternative hypothesis is accepted. This implies that experimental group of students has greater achievement than that of control group.

- The result of experimental group on pre-test and post-test showed that their average achievement was 10.46 and 20.43 respectively. This implies that there was improvement in post-test than in pre-test.
- Technology based teaching learning activities motivate the students to participate in learning actively.
- It is seen that most of the students liked the trigonometry when GeoGebra software was used in teaching learning activities.
- Interview with students showed that GeoGebra create the situation to interact in group.
- Furthermore, the data collected from interview schedule showed that student's perception towards GeoGebra in teaching trigonometry was positive.

Conclusion

The purpose of this study was to examine the achievement of students in trigonometry teaching through GeoGebra at secondary level. The result of post-test of this study showed that average achievement of students of experimental group was far better than that of control group. Since, experimental group was treated by a dynamic mathematical software GeoGebra but control group was taught by traditional method of instruction. It was found students of experimental group were active and the whole class was silent while using GeoGebra in classroom to teach trigonometry and they took the part in teaching learning activities actively than those of control group. Also, students' views towards use of GeoGebra was positive. Students were in the favor of GeoGebra and they felt the use of GeoGebra in geometrical part of mathematics would be fruitful. Also, students of experimental group claimed that it is very important to develop the concept about figure and for long term learning. Based on the results and views about GeoGebra it is concluded that GeoGebra is an effective

mathematical software in teaching trigonometry to increase the students' achievements.

Furthermore, for self-study and long-term learning technology-based activities are necessary in classroom of every student. To adjust in modern society, we need to increase the use of technological activities in school and home also. In teaching mathematics, we can use many ICT based software such as GeoGebra, Mathematica, Math lab, etc. The use of these software is necessary to make mathematics as easy subject by teaching it meaningfully. This work is helpful to develop the positive attitude towards the whole mathematics.

Recommendations

As we all know that we are in 21st century which is the era of post modernism. It is also said that it is the age of modern technology. All our activities are affected by technology. There is no any field where technology is not used. We can save our time, money energy etc. by using modern technology in our work site. Also, for correct and fine result we use it.

Education sector is also affected by modern technology. In teaching learning activities, we are using so many software, applications, etc. In teaching mathematics also, we can use so many innovations of science and technology. Here, this study carried out to examine the effect of use of GeoGebra software in teaching. Since the result of any research paper is useful for other areas also. The data and results of this study can be used in teaching learning mathematics and in other related areas. The conclusion of this research paper is that GeoGebra is an effective mathematical software in teaching learning trigonometry for secondary level. It increases the students learning capacity which helps them to improve their achievement. Hence, we

can say that, the GeoGebra assist instruction yields better achievement and encourage the students in learning trigonometry than traditional method of instruction. Thus, technology-based instruction is essential for aur context to improve the current achievement of students.

Recommendation for implication**.** Here, some recommendations for the educational implications are mentioned as follows:

- Our classroom should be developed physically by which we can use technology for teaching learning activities.
- Mathematics teachers should be given training, organize seminars, workshop etc. about the proper use of mathematical software like GeoGebra, Mathematica, Math lab etc.
- 'Computer' should be a core subject to make the mathematical software like GeoGebra as learning part of secondary level students.
- Mathematics laboratory should be established in each school including ICT tools like GeoGebra.

Recommendation for the further research. Since this study was conducted in only one school taking two different sections of grade IX in a short period of time due to insufficient resources and lack of time. Other research can conduct taking more sample and for a long time by which the research will give more accurate result about effectiveness of GeoGebra software. Also, this study has taken the sample from grade IX only but new researcher can use it on other grades as well as other levels. Being based on this study, I have made the following recommendations for the further study:

- Further study can be carried out by taking large samples from private and public schools of Nepal and up to long time
- It is recommended to find out and compare the average achievement of boys and girls
- Further study can be carried out on other topics of mathematics
- It is recommended that other grades and levels can be used to examine the effect of GeoGebra in teaching learning

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Appendices

Appendix -A
Item Analysis of Objective Questions

Stu. Items	Upper 27% students who have given correct answer									Lower 27% students who have given Correct answer									C	P%	D	Re.
	1	2	3	4	5	6	7	8	T	1	2	3	4	5	6	7	8	T				
1	1	1	1	1	1	1	1	1	**8**	1	0	0	0	0	0	0	0	**1**	**18**	**64.29**	**0.88**	**Accepted**
2	1	1	1	1	1	1	1	1	**8**	0	1	1	1	1	0	1	0	**5**	**22**	**78.57**	**0.36**	**Rejected**
3	1	1	1	1	1	1	1	1	**8**	0	1	1	1	1	1	1	1	**7**	**26**	**92.86**	**0.13**	**Rejected**
4	1	1	1	1	0	1	1	1	**7**	0	1	0	1	0	0	0	0	**2**	**19**	**67.86**	**0.63**	**Accepted**
5	0	1	0	1	1	1	1	1	**6**	1	0	0	0	0	0	0	0	**1**	**9**	**32.14**	**0.63**	**Rejected**
6	1	1	1	1	1	1	0	1	**7**	1	0	1	1	0	1	1	0	**5**	**22**	**78.57**	**0.25**	**Rejected**
7	1	1	1	1	1	1	1	1	**8**	1	1	1	1	1	1	0	1	**7**	**23**	**82.14**	**0.13**	**Rejected**
8	1	1	1	1	1	0	0	0	**5**	1	0	0	0	0	0	0	0	**1**	**20**	**71.43**	**0.5**	**Accepted**
9	1	1	1	1	1	1	1	1	**8**	1	1	1	1	1	1	1	0	**7**	**27**	**96.43**	**0.13**	**Rejected**
10	1	1	1	1	1	1	1	1	**8**	1	1	1	1	1	0	1	1	**7**	**27**	**96.43**	**0.13**	**Rejected**
11	1	0	0	0	0	0	0	0	**1**	0	0	0	1	0	0	0	0	**1**	**3**	**10.71**	**0**	**Rejected**
12	1	1	1	1	1	1	1	1	**8**	0	0	0	0	0	0	0	0	**0**	**14**	**50**	**1**	**Accepted**
13	1	1	1	0	1	1	1	0	**6**	1	1	1	0	0	1	0	0	**4**	**23**	**82.14**	**0.25**	**Rejected**
14	1	1	1	0	1	1	1	0	**6**	1	1	0	0	1	0	0	0	**3**	**16**	**57.14**	**0.38**	**Accepted**
15	1	1	1	1	1	1	1	1	**8**	1	1	1	1	1	1	0	0	**6**	**26**	**92.86**	**0.25**	**Rejected**
16	1	1	1	1	1	1	1	0	**7**	0	1	1	1	1	1	1	1	**7**	**26**	**92.86**	**0**	**Rejected**
17	0	1	0	1	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**	**2**	**7.14**	**0.25**	**Rejected**
18	1	1	1	1	1	1	1	1	**8**	1	1	1	1	1	1	1	0	**7**	**27**	**96.43**	**0.13**	**Rejected**
19	1	1	1	1	0	0	1	1	**6**	1	1	1	0	0	0	0	0	**3**	**17**	**60.71**	**0.38**	**Accepted**
20	1	0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0	0	**1**	**3**	**10.41**	**0**	**Rejected**
21	1	0	1	1	1	1	1	1	**7**	1	0	0	0	0	0	0	1	**2**	**18**	**64.29**	**0.63**	**Accepted**
22	1	1	1	1	1	1	1	1	**8**	0	1	1	1	1	0	1	1	**6**	**24**	**85.71**	**0.25**	**Rejected**
23	0	0	1	0	1	0	0	1	**3**	0	0	0	0	0	0	0	0	**0**	**10**	**35.71**	**0.36**	**Rejected**
24	1	1	0	1	1	1	0	1	**6**	1	1	1	0	0	1	1	0	**5**	**23**	**82.14**	**0.13**	**Rejected**
T	21	20	19	19	19	18	18	17		14	14	13	12	10	9	9	6					

Interpretation of difficulty level of the items

Indicator (%)	Meaning
0 – 39	Very difficult
40 – 60	General
61 – 75	Substantial
76 – 90	Easy
91 - 100	Very easy

Interpretation of discrimination index

Degree of D value	Meaning
-1 – 0.19	Negligible
0.20 – 0.29	General
0.30 – 0.39	Good
0.40 – 1.00	Very good

Source: Ebel and Frisbie, 1991, p. 132 (as cited in Khanal et al., 2071, p. 266-268)

Note: - P = Difficulty index of the item

R = Number of examinees who gave correct answer

T = Total number of examinees

D = Discrimination index

C= correct answer

Re. = Remarks

Appendix – B

Item Analysis of subjective Questions

Stu. Item	Upper 27% students									Lower 27% students									C	P%	D	Re.
	1	2	3	4	5	6	7	8	T	1	2	3	4	5	6	7	8	T				
1	1	1	1	1	1	1	1	1	**8**	1	1	1	1	0	0	0	0	**4**	**21**	**75**	**0.5**	
	1	1	1	1	1	1	1	1	**8**	1	1	1	1	0	0	0	0	**4**	**21**	**75**	**0.5**	
	1	1	1	1	1	1	1	1	**8**	1	1	0	1	0	0	0	0	**3**	**19**	**67.86**	**0.63**	
Total	1	1	1	1	1	0	0	0	**5**	0	0	0	0	0	0	0	0	**0**	**10**	**35.71**	**0.63**	**Accepted**
	4	**4**	**4**	**4**	**4**	**3**	**3**	**3**	**29**	**3**	**3**	**2**	**3**	**0**	**0**	**0**	**0**	**11**	**71**	**63.39**	**0.57**	
2	1	0	0	1	0	1	1	1	**5**	1	0	0	0	0	0	0	0	**1**	**15**	**53.57**	**0.5**	
	1	0	0	1	0	1	1	1	**5**	0	0	0	0	0	0	0	0	**0**	**13**	**46.43**	**0.63**	
Total	0	0	0	1	0	0	0	0	**1**	0	0	0	0	0	0	0	0	**0**	**4**	**14.29**	**0.13**	
	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	**2**	**7.14**	**0**	**Rejected**
	2	**0**	**0**	**3**	**0**	**2**	**2**	**2**	**11**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**34**	**30.36**	**0.32**	
3	1	1	1	1	1	1	1	1	**8**	1	1	1	1	0	1	0	0	**5**	**22**	**78.57**	**0.38**	
	1	1	1	1	1	1	1	1	**8**	0	1	1	0	0	1	0	0	**3**	**20**	**71.42**	**0.63**	
Total	1	1	1	1	1	1	1	1	**8**	0	1	1	0	0	1	0	0	**3**	**17**	**60.71**	**0.63**	
	1	1	1	1	0	1	1	1	**7**	0	1	0	0	0	0	0	0	**1**	**12**	**42.88**	**0.75**	**Accepted**
	4	**4**	**4**	**4**	**3**	**4**	**4**	**4**	**31**	**1**	**4**	**3**	**1**	**0**	**3**	**0**	**0**	**12**	**71**	**63.40**	**0.60**	
4	1	1	1	1	1	1	1	1	**8**	1	0	1	0	0	0	0	0	**2**	**15**	**53.5**	**0.7**	**R**

																			7	5	
	1	1	1	1	1	1	1	1	**8**	1	0	0	0	0	0	0	0	**1**	**12**	**42.86**	**0.88**	
Total	1	1	0	0	0	1	0	0	**3**	1	0	0	0	0	0	0	0	**1**	**10**	**35.71**	**0.25**	
	0	1	0	0	0	1	0	0	**2**	0	0	0	0	0	0	0	0	**0**	**7**	**25**	**0.25**	
	3	**4**	**2**	**2**	**2**	**4**	**2**	**2**	**21**	**3**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**4**	**44**	**39.29**	**0.53**	
5	1	1	1	1	1	1	1	1	**8**	1	1	1	0	0	0	0	0	**3**	**20**	**71.43**	**0.63**	
	1	1	1	1	1	1	1	1	**8**	1	1	1	0	0	0	0	0	**3**	**20**	**71.43**	**0.63**	
Total	1	1	1	1	1	1	1	1	**8**	1	1	0	0	0	0	0	0	**2**	**19**	**67.86**	**0.75**	
	1	1	1	1	1	1	1	1	**8**	1	0	0	0	0	0	0	0	**1**	**18**	**64.29**	**0.88**	
	1	1	1	1	1	1	1	1	**8**	1	0	0	0	0	0	0	0	**1**	**18**	**64.29**	**0.88**	**Accepted**
	5	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**40**	**5**	**3**	**2**	**0**	**0**	**0**	**0**	**0**	**10**	**115**	**67.86**	**0.75**	
6	1	1	1	1	1	1	1	1	**8**	1	1	1	1	1	1	1	1	**8**	**26**	**92.86**	**0**	
	1	1	1	1	1	1	1	1	**8**	1	1	1	1	1	1	1	1	**8**	**26**	**92.86**	**0**	
Total	1	1	1	1	1	1	1	1	**8**	1	0	1	1	1	0	0	0	**4**	**23**	**82.14**	**0.5**	
	1	1	1	1	1	1	1	0	**7**	1	0	1	1	1	0	0	0	**4**	**22**	**78.57**	**0.38**	
	1	1	1	1	1	1	1	0	**7**	1	0	1	1	1	0	0	0	**4**	**22**	**78.57**	**0.38**	
	5	**5**	**5**	**5**	**5**	**5**	**5**	**3**	**38**	**0**	**0**	**5**	**5**	**5**	**2**	**2**	**2**	**21**	**115**	**85**	**0.25**	**Rejected**
7	1	1	1	0	1	0	1	1	**6**	1	1	0	0	1	1	1	0	**5**	**21**	**75**	**0.13**	
	1	1	1	0	1	0	1	1	**6**	1	1	0	0	1	1	1	0	**5**	**21**	**75**	**0.13**	**Rejected**

Total	1	1	1	0	1	0	1	1	**6**	1	1	0	0	1	1	1	0	**5**	**20**	**71.43**	**0.13**	
	1	1	1	0	1	0	0	1	**5**	1	1	0	0	0	0	0	0	**2**	**10**	**35.71**	**0.38**	
	1	0	1	0	1	0	0	0	**3**	1	1	0	0	0	0	0	0	**2**	**10**	**35.71**	**0.13**	
	5	**4**	**5**	**0**	**5**	**0**	**3**	**4**	**26**	**5**	**5**	**0**	**0**	**3**	**3**	**3**	**0**	**19**	**82**	**58.57**	**0.18**	
8	1	1	1	1	1	1	1	1	**8**	0	1	1	0	0	0	0	0	**2**	**20**	**71.42**	**0.75**	
	1	1	1	1	1	1	1	1	**8**	0	1	1	0	0	0	0	0	**2**	**20**	**71.42**	**0.75**	
Total	1	1	1	1	1	1	1	1	**8**	0	1	0	0	0	0	0	0	**1**	**18**	**64.29**	**0.88**	
	1	1	1	1	1	1	0	0	**6**	0	0	0	0	0	0	0	0	**0**	**16**	**57.14**	**0.75**	
	1	1	1	1	0	1	0	0	**5**	0	0	0	0	0	0	0	0	**0**	**16**	**57.14**	**0.63**	**Accepted**
	5	**5**	**5**	**5**	**4**	**5**	**3**	**3**	**35**	**0**	**3**	**2**	**0**	**0**	**0**	**0**	**0**	5	**90**	**64.28**	**0.75**	
Grand Total	**33**	**31**	**30**	**28**	**28**	**28**	**27**	**26**		**18**	**18**	**15**	**13**	**8**	**8**	**5**	**2**					

Note: - The word meaning and interpretation for P as well as interpretation criteria for D in subjective items are same as that of objective items mentioned in Appendix- A.

Appendix- C

Computations of Reliability Coefficient

S. N.	Scores on Odd items (X)	Scores on even items (Y)	X^2	Y^2	X Y
1	18	22	324	484	396
2	26	19	676	361	494
3	9	22	81	484	198
4	23	20	529	400	460
5	27	27	729	729	729
6	3	14	9	196	42
7	23	16	529	256	368
8	26	26	676	676	676
9	2	27	4	729	54
10	17	3	289	9	51
11	18	24	324	576	432
12	10	23	100	529	230
13	71	34	5041	1156	2414
14	71	44	5041	1936	3124
15	115	115	13225	13225	13225
16	82	90	6724	8100	7380
	$\Sigma X = 541$	$\Sigma Y = 526$	$\Sigma X^2 = 34301$	$\Sigma Y^2 = 29846$	$\Sigma XY = 30273$

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

$$= \frac{16 \times 30273 - 541 \times 526}{\sqrt{16 \times 34301 - (541)^2}\sqrt{16 \times 29846 - (526)^2}}$$

`

$$= \frac{484368 - 284566}{226818.84}$$

$= 0.88$

Now, reliability coefficient (r) $= \frac{2r_{xy}}{1+r_{xy}}$

$= \frac{2 \times 0.88}{1+0.88}$

$= 0.93$

 Reliability coefficient (r) = 0.93

Appendix – D

Test Items for Pre-test and Post-test

Objective Questions

School: - ……

Subject: Optional Maths Full Marks:25

Class: IX Time: 45 mins

Date: - …… Roll no.: …….

Student's Name: ……

Group A [7×1=7]

Read the questions carefully then tick (√) the correct answer.

1. **Convert 10^0 into sexagesimal seconds.**

a) 35000 b) 36000 c) 37000 d)38000

2. **One angle of a right-angled triangle is 60^g. Then the other two angles in degree are:**

a) 90^0 & 16^0 b) 90^0 & 26^0 c) 90^0 & 36^0 d) 90^0 & 46^0

3. **What is the angle in radian subtended by an arc length of 28 cm at the centre of the circle of radius 7 cm?**

a) 4^c b) 6^c c) 8^c d) 10^c

4. **Which one is correct for hypotenuse in right angled triangle?**

a) $h^2 = p^2 + b^2$ b) $p^2 = h^2 + b^2$ c) $b^2 = h^2 + p^2$ d) $h^2 = p^2 - b^2$

5. **If $\sqrt{3}\tan\theta = 1$ and θ is acute, then which one is correct for θ?**

a) 0^0 b) 30^0 c) 45^0 d) 60^0

6. Which one is correct for cos $(270^0 - \theta)$?

a) Sin θ b) - sin θ c) cos θ d) - cos θ

7. Which one is the correct formula of cos (A - B)?

a) sinA.cosB + cosA.sinB b) sinA.cosB – cosA.sinB

c)cosA.cosB – sinA.sinB d) cosA.cosB + sinA.sinB

Subjective Questions

Group B [2×4= 8]

8. The difference between two acute angles of a right-angled triangle is $\frac{3\pi}{10}$ radian. Find the angles in degree.
9. Draw the graph of cos θ in the domain of 0^0 to 36^0.

Group C [2×5 =10]

10. The angles of a quadrilateral are in the ratio 3:4:5:6. Find the angles in grade as well as in degree.
11. Prove trigonometrically that cos (A + B) = cosA.cosB – sinA.sinB

Good Luck

Appendix – E

Score on pre-Test

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

27		3
28		2

Appendix- F

Score on Post-Test

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

27		18
28		16

Appendix – G

Interview schedule

1. What did you feel about GeoGebra while using in teaching trigonometry?
2. Did you got any differences in learning trigonometrical concepts with or without using GeoGebra software?
3. Do you think that GeoGebra should be used to teach other concept of mathematics? Why?
4. Do you think GeoGebra can be used to learn every problem of mathematics? Why?
5. Do you think teaching through GeoGebra change the classroom learning environment? How?

Appendix – H

Some statistical formulae

1. Mean $(\bar{X}) = \frac{\Sigma X}{N}$
2. Variance $(s^2) = \frac{\Sigma f(X-\bar{X})^2}{N} - \left(\frac{\Sigma f(X-\bar{X})}{N}\right)^2$
3. Standard Deviation $(\sigma) = \sqrt{\frac{\Sigma f(X-\bar{X})^2}{N} - \left(\frac{\Sigma f(X-\bar{X})}{N}\right)^2}$
4. T-distribution $(T) = \frac{(\bar{X}_1 - \bar{X}_2)-(\mu_1-\mu_2)}{S_p\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}$
5. Pearson's correlation coefficient $(r_{xy}) = \frac{N\Sigma XY - \Sigma X\Sigma Y}{\sqrt{N\Sigma X^2-(\Sigma X)^2}\sqrt{N\Sigma Y^2-(\Sigma Y)^2}}$
6. Reliability coefficient $(r) = \frac{2r_{xy}}{1+r_{xy}}$
7. Difficulty level of item $(P\%) = \left(\frac{R}{T}\times 100\right)\%$, where P= Difficulty index of the item, R= Number of examinees who gave correct answer, T= Total number of examinees
8. Discrimination index of item $(D) = \frac{R_u - R_l}{\frac{N}{2}}$, where R_u and R_l are the number of correct responses given by upper 27% and lower 27% students respectively, N is the total number of students on upper and lower 27% of students.

Appendix-I

Pilot Test

Objective Questions

School: -……

Subject: - Optional Math Full Marks: 60

Class: - IX Time: 2hrs.

Date: -…… Roll no.: …….

Student's Name: …….

Group A [24×1=24]

Read the questions carefully then tick (√) the correct answer.

1. **Convert 10^0 into sexagesimal seconds.**

a) 35000 b) 36000 c) 37000 d) 38000

2. **Convert $25^g 15'$ into centesimal seconds.**

a) 251500" b) 250500" c) 250050" d) 250005"

3. **Which one is the correct grades of 45^0**

a) 45^g b) 48^g c)50^g d) 60^g

4. **One angle of a right-angled triangle is 60^g. Then the other two angles in degrees are:**

a) 90^0 & 16^0 b) 90^0 & 26^0 c) 90^0 & 36^0 d) 90^0 & 46^0

5. **One angle of a right-angled triangle is 63^0. Then the other two angles in grades are:**

a) 10^g & 100^g b) 15^g & 100^g c)20^g &100^g d) 30^g &100^g

6) which one is the correct radian of 70^0

a) $\frac{7\pi^c}{15}$ b) $\frac{7\pi^c}{16}$ c) $\frac{7\pi^c}{17}$ d) $\frac{7\pi^c}{18}$

7) which one is the correct degree measure of $\frac{\pi^c}{3}$.

a) 50^0 b) 60^0 c) 70^0 d) 80^0

8) what is the angle in radian subtended by an arc length of 28cm at the centre of the circle of radius 7cm?

a) 4^c b) 6^c c) 8^c d) 10^c

9) which one is the correct for cos θ?

a) $\frac{p}{h}$ b) $\frac{h}{p}$ c) $\frac{b}{h}$ d) $\frac{p}{b}$

10) which one is correct for tan θ?

a) $\frac{1}{\sin\theta}$ b) $\frac{1}{\cos\theta}$ c) $\frac{\cos\theta}{\sin\theta}$ d) $\frac{\sin\theta}{\cos\theta}$

11) which one is the value of $\sin^4 A - \cos^4 A - 2\sin^2 A$.

a) $\frac{1}{2}$ b) $\frac{-1}{2}$ c) 1 d) -1

12) Which one is correct for hypotenuse in right angled triangle?

a) $h^2 = p^2+b^2$ b) $p^2 = h^2 + b^2$ c) $b^2 = h^2 + p^2$ d) $h^2 = p^2-b^2$

13) If $\cos\theta = \frac{4}{5}$, then which one is the value of sin θ?

a) $\frac{2}{5}$ b) $\frac{3}{5}$ c) $\frac{4}{5}$ d) $\frac{2}{3}$

14) If $\sqrt{3}$ tan θ = 1 and θ is acute, then which one is correct for θ?

a) 0^0 b) 30^0 c) 45^0 d) 60^0

15) If θ = 30^0 then, which one is the value of cos 3 θ?

a) 1 b) $\frac{\sqrt{3}}{2}$ c) $\frac{1}{\sqrt{2}}$ d) 0

16) Which one is correct for tan (90^0 - θ)?

a) cosec θ b) sec θ c) cot θ d) -cot θ

17) If cos 35^0. sec (90^0- θ) = 1, which one is the measure of θ?

a) 55^0 b) 65^0 c)75^0 d) 45^0

18) Which one of the following trigonometric ratios is positive in third quadrant?

a) sine b) cosine c) tangent d) cosecant

19) Which one is correct for cos (27^0- θ)?

a) sin θ b) -sin θ c) cos θ d) -cos θ

20) Which one is the correct value of tan 240^0 ?

a) -1 b) $\frac{-1}{\sqrt{3}}$ c) $\sqrt{2}$ d) $\sqrt{3}$

21) Which one is the correct formula of cos (A - B)?

a) sinA.cosB + cosA.sinB b) sinA.cosB - cosA.sinB

c) cosA.cosB - sinA.sinB d) cosA.cosB + sinA.sinB

22) Which one is the correct formula of tan (A + B)?

a) $\frac{tanA+tanB}{1-tanA.tanB}$ b) $\frac{tanA-tanB}{1+tanA.tanB}$

c) $\frac{catA.cotB-1}{cotB+cotA}$ d) $\frac{cotA.cotB+1}{cotB-cotA}$

23) which one is the value of $sin54^0.cos36^0 + cos54^0.sin36^0$?

a) 1 b) -1 c) $\frac{1}{2}$ d) 0

24) Which one is correct for one right angle in centesimal system?

a) 90^g b) 100^g c) 180^g d) 200^g

Subjective Questions

Group B [4×4=16]

25) The difference between two acute angles of a right-angled triangle is $\frac{3\pi}{10}$ radian. Find the angles in degree.

26) Find the degree measure of the angle subtended at the centre of a circle of radius 100 cm by arc of length 22cm.

27) Draw the graph of cos θ in the domain of 0^0 to 360^0.

28) Show that in quadrilateral ABCD [if $\angle A + \angle C = 180^0$ and $\angle B + \angle D = 180^0$]

(i) tanA + tanB + tanC +tan D = 0

(ii) cos $(180^0$ - A) + cos $(180^0$+B) +cos$(180^0$+C) – sin $(90^0$+D) =0

Group C [4×5=20]

29) The angles of a quadrilateral are in the ratio 3:4:5:6. Find the angles in grade as well as in degree.

30) Express all trigonometric ratios of θ in terms of tan θ.

31) Find the all values of trigonometric ratios of 45^0.

32) Prove trigonometrically that cos (A+ B) = cosA.cosB - sinA.sinB

Appendix 'J'

Sample of Teaching Episodes

Teaching Episode: 01

Subject: Optional Mathematics — Time: 40 mins

Unit: Trigonometry — Period: 8th

Topic: Pythagoras theorem — No. of students….

Grade: 9 — Date….

School…….

1. Specific Objectives:

At the end of the class, students will able to

a) Write the statement of Pythagorus.

b) Write the relation between sides of right-angled triangle.

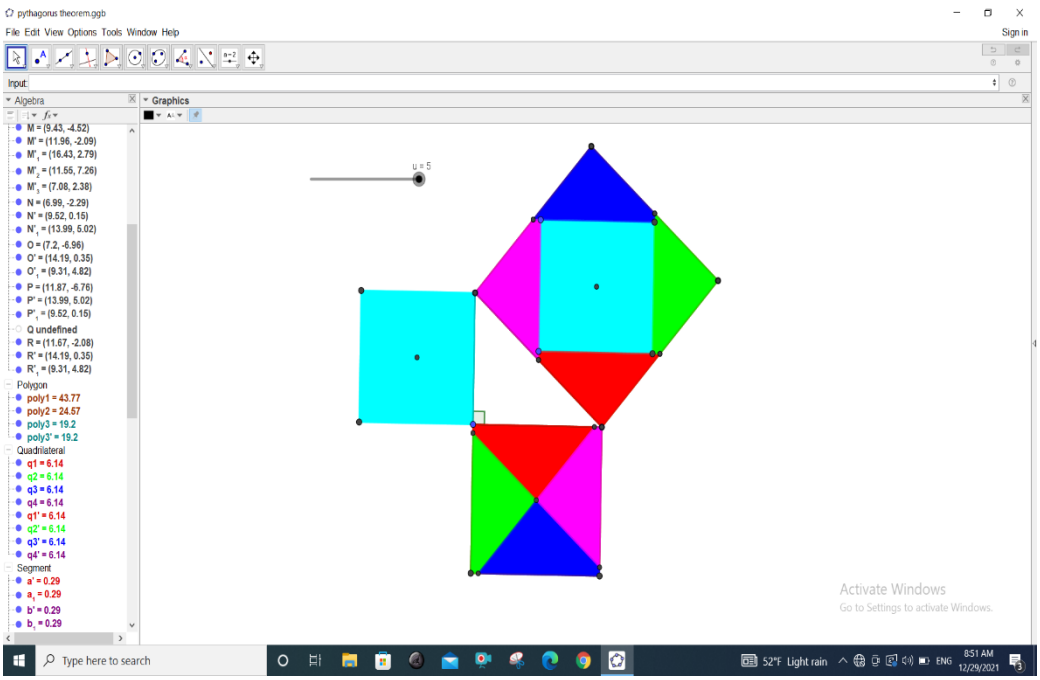
2. Teaching Materials:

a) Offline sources: GeoGebra applet of Pythagorus theorem.

b) Online sources: Different applet from www.GeoGebra.org, You tube etc.

3. Teaching learning activities:

- Before discuss on the topic of Pythagorus theorem, we will discuss on right-angled triangle.
- Ask to the students "what is right-angled triangle?" and take their responses and then we will discuss on its longest side, reference angle, adjacent side and opposite side.
- Now, tell them the statement of Pythagorus theorem and for the visual proof show them GeoGebra applet of Pythagorus theorem.



- And then, discuss on how we can find side of right-angled triangle while only two sides are given.
- Practice some problem to find any remaining sides while any ywo sides are only given.

4. Evaluation:

a) What is the statement of Pythagorus theorem?

b) Which side represent perpendicular, base and hypotenuse in right-angled triangle?

5. Homework:

Draw a right-angled triangle of any size. Also, draw squares on each sides. Calculate the area of each square and write the result which you find.

6. Appendix: Construction protocol of 'Pythagorus theorem' in GeoGebra.

- Take any two points parallel to x-axis and join the points by the segment 'AB'.
- Draw a perpendicular line at A and take a point 'C' on it. Join 'AC' segment.

- Take another point 'D' on 'AC' segment and hide the point 'C' also segment 'AC'. Draw new segments 'AD' and 'BD'.
- Click on angle and then click on perpendicular and base segment.
- Click on regular polygon and then click on vertices 'B' and 'D' and then take number of vertices 4, then press 'ok'. If our polygon form in opposite side then we can redefine its vertices.
- Similarly, we can make squares on each sides.
- By taking mid-point tool tool fin the mid-point of diagonal of each square.
- Draw a line parallel to hypotenuse and passes through mid-point 'M' of second large square.
- Draw a perpendicular line at 'M'.
- Then find the intersecting points of base square and the line which we draw at 'M'.
- By taking polygon tool make four quadrilaterals in base square. Also give them different colour.
- Click on slide and take interval 0 to 5 and increment is 0.01.
- Then make the translation vector. For this, go to input and type

```
Translate(q1,vector(M,if(u<0,M,if(0<=u<=1,M+u(B-M),B))))
Translate(q2,vector(M,if(u<1,M,if(1<=u<=2,M+(u-1)(E-M),E))))
Translate(q3,vector(M,if(u<2,M,if(2<=u<=3,M+(u-2)(F-M),F))))
Translate(q4,vector(M,if(u<3,M,if(3<=u<=4,M+(u-3)(D-M),D))))
Translate(poly3,vector(L,if(u<4,L,if(4<=u<=5,L+(u-4)(K-L),K))))
```

Teaching Episode:02

Subject: Optional Mathematics | Time: 40 mins

Unit: Trigonometry | Period: 8th

Topic: Unit Circle | No.of students….

Grade: 9 | Date……

School……

1. **Specific Objectives:**

   At the end of this class, students will able to

   a) Define unit circle.

   b) Write the importance of unit circle in trigonometry.

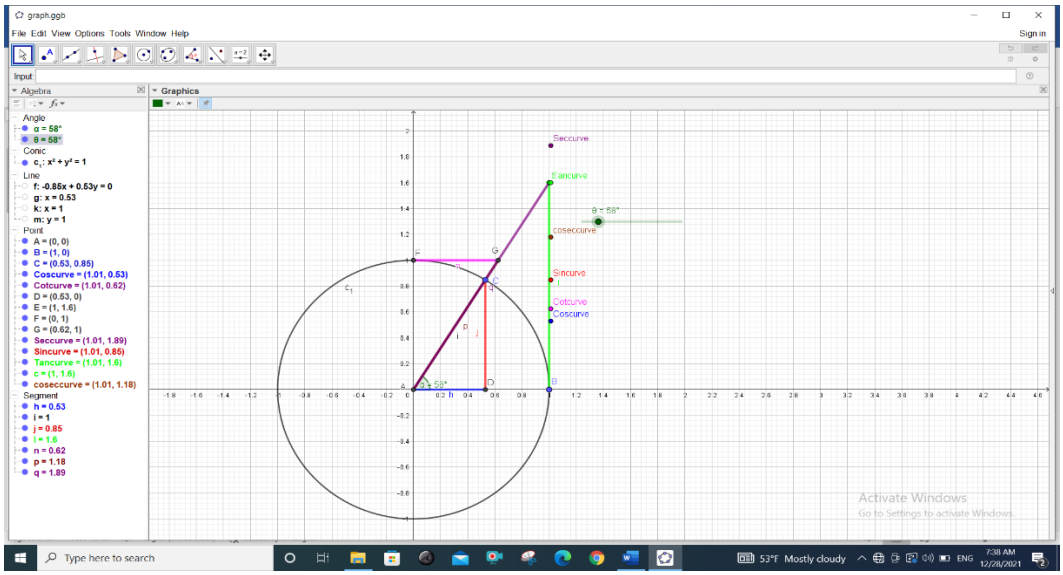
2. **Teaching Materials:**

   a) Offline source: GeoGebra applet of 'unit circle'

   b) Online sources

3. **Teaching Learning Activities:**

   - At first check students' pre-knowledge about unit circle.
   - Then ask to the students', is it can be use in trigonometry and take their responses.
   - Then show the applet of unit circle that researcher make in GeoGebra.



- And make a discussion about each segment that we construct in GeoGebra. Also, discussion on how each segment work in unit circle.
- Finally, discuss on the importance of unit circle in trigonometry.

4. Evaluation:

a) What is unit circle?

b) Which segment represents sin curve in unit circle?

5. Homework:

List the importance of unit circle in trigonometry.

6. Appendix: Construction protocol of unit circle in GeoGebra.

1. Open GeoGebra classic 5.0
2. Click on navigation key and select graphing.
3. Draw a circle by click on 'circle with center through point' and draw a circle having radius 1 unit.
4. Click on slider then select angle and rename angle α by θ. By default, interval is minimum 0^0, maximum 360^0 and increment 1^0. But we can take the length of interval as our need.
5. Then click on angle and select angle with given size.
6. Click on point 'B' and origin 'O' take angle θ to connect with slider. We get a new point B' and rename it by point 'C'.
7. Take a line and then join origin 'O' to the point 'C'.
8. Select perpendicular line and click on point 'C' and X-axis.
9. Take a intersection point of perpendicular line and X-axis.
10. Take segments and join 'OC', 'OD' and 'CD'.
11. Take a tangent line and click on point 'B' and circle then we get a tangent at point 'B'.

12. Take intersection point of tangent and line 'f'.
13. Take a segment and join 'B' to 'E'. Then we have three segments 'CD', 'OD' and 'BE'.
14. Then hide the line f, g and k
15. Change the segments colour and give red colour to perpendicular 'CD', blue to base 'OD' and green to tangent 'BE'. We can give any colour to any segment according to own choice.
16. Take a point (θ,sin(θ)) for a curve. Change colour of new point 'F' by red colour.
17. Rename point 'F' by sin curve
18. Right click on new point 'F' and click on 'Trace on'. Also right click on slider and click on 'Animation on'.
19. Hide the blue and green segments to show only the graph of sine curve.
20. Take a point (θ,cos(θ)) for cosine curve. And hide red and green segments to show the graph of cosine curve.
21. Right click on blue segment and click on 'Trace on' and right click on slider and click on 'Animation on'.
22. Take a point (θ,tan(θ)) for tangent curve and follow the same process as above that we did for sine and cosine curve.
23. Hide sine and cosine curve while showing tangent curve.
24. Take a point 'F' on y-axis and draw tangent at 'F' and take an intersection point of tangent and line 'f'.
25. Change the segment colour.
26. Take a point (θ,sec(θ)) and rename it to sec curve.
27. Take a point (θ,cot(θ)) and rename it to cot curve.

28. Give the same colour to the points which we give to segments.
29. Now we can show the required graph of each trigonometric function by hiding others. Where segment 'CD' (red) represents sine curve, blue 'AD' represents cosine, green (BE) represents tangent curve, segment 'AG' represents cosec curve, segment A, tangent curve (purple) represents sec curve and segment (FG) pink represents cot curve.

Teaching Episode:03

Subject: Optional Mathematics | Time: 40 mins

Unit: Trigonometry | Period: 8th

Topic: Trigonometric ratios of some special angles | No.of students….

Grade: 9 | Date……

School……

1. **Specific Objectives:**

At the end of this class, students will able to

a) Write the values of special angles of sine.

b) Write the values of special angles pf cosine.

c) Write the values of special angles of tangent.

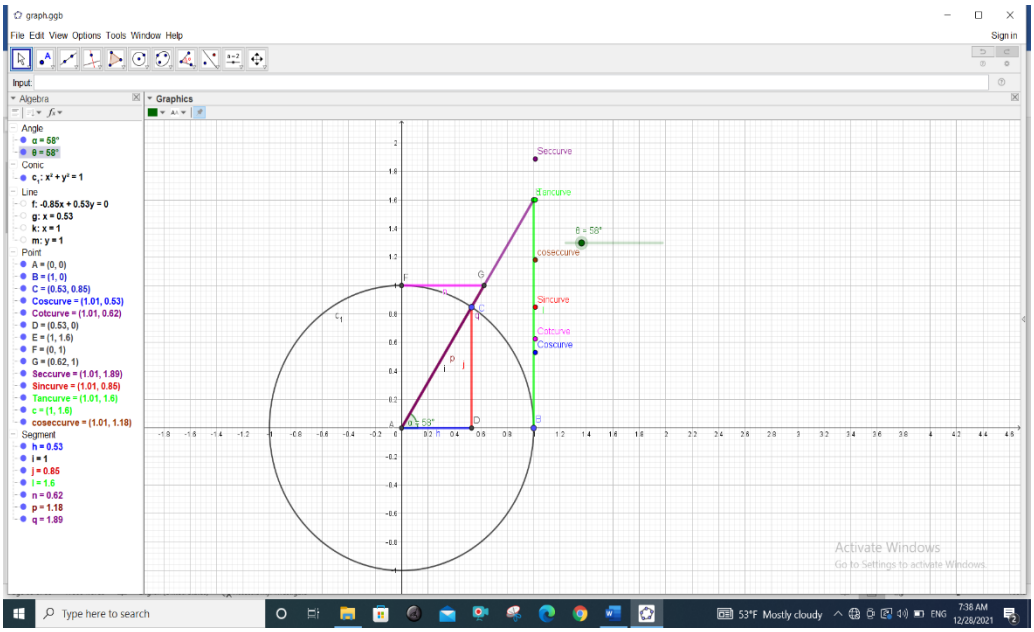
2. **Teaching Materials:**

a) Offline source: GeoGebra applet of 'Unit circle'

b) Online sources: materials from www.GeoGebra.org

3. **Teaching Learning Activities:**

- At first open the applet of unit circle which we construct on GeoGebra.



- Then start the discussion with students on how we can find values of different angles of sine.
- For this, give the suggestion to the students to draw a unit circle. And tell them to draw an angle of any measurement. Where the point meets the circle, from that intersection point, draw perpendicular to x-axis.
- Ask students to measure the length of perpendicular with the help of scale which gives us the value of that particular angle of sine.
- Tell them, similarly we can find value of other angles of sine. Also, make discussion how we can find angles while values of trigonometric ratios are given.
- By showing Unit circle which, we construct on GeoGebra, tell them if me measure the base (The length from origin to perpendicular line) with the help of scale which gives us the value of different angles of cosine.
- If we measure the length of tangent that gives us the values of different angle of tan.
- Also, discuss on how we can find angles, while values of trigonometric ratios are given by using unit circle.

4. Evaluation:

a) What is the value of sin 30^0?

b) What is the value of cos 60^0?

5. Homework:

Write all the values of sin, cosine and tangent at special angle $0^0, 30^0, 45^0, 60^0$ and 90^0.

Teaching Episode:04

Subject: Optional Mathematics | Time: 40 mins

Unit: Trigonometry | Period: 8th

Topic: Trigonometric ratios of some special angles | No.of students….

Grade: 9 | Date……

School……

1. **Specific Objectives:**

At the end of this class, students will able to

a) Write the values of special angles of cosecant.

b) Write the values of special angles pf secant.

c) Write the values of special angles of cotangent.

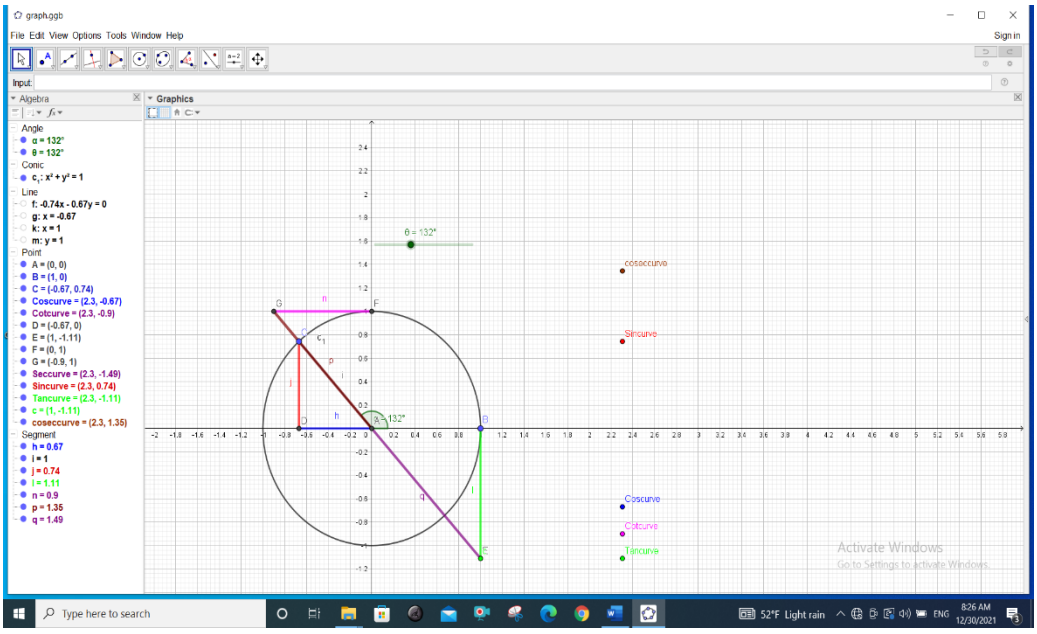
2. **Teaching Materials:**

a) Offline source: GeoGebra applet of 'Unit circle'

b) Online sources: materials from www.GeoGebra.org

3. **Teaching Learning Activities:**

- At first open the applet of unit circle which we construct on GeoGebra.



- Then start the discussion with students on how we can find values of different angles of cosecant.
- For this, give the suggestion to the students to draw a unit circle. And tell them to draw an angle of any measurement. Where the point meets the circle, from that intersection point, draw perpendicular to x-axis.
- For the values of cosecant draw a tangent which is parallel to x-axis. Where the tangent meets the line 'f', the length from that intersection point to origin (AG) is the values of cosecant at that particular angle.
- Tell them the measure of hypotenuse 'At to tangent curve' is the value of secant.
- And the length of tangent 'FG' is the value of cotangent.

4. Evaluation:

a) What is the value of cosec 45^0?

b) What is the value of Cot 45^0?

c) Which segments represents cot.

5. Home work:

Write all value of cosecant, secant and cotangent at special angles $0^0, 30^0, 45^0, 60^0$ and 90^0.

Teaching Episode:05

Subject: Optional Mathematics | Time: 40 mins

Unit: Trigonometry | Period: 8th

Topic: Graph of different trigonometric ratios | No. of students….

Grade: 9 | Date….

School……

1.Specific Objectives:

At the end of this class, students will able to

(a) Draw the graph of sine, cosines and tangent function

(b) Write the range and period of sine cosine and tangent function

2.Teaching Materials:

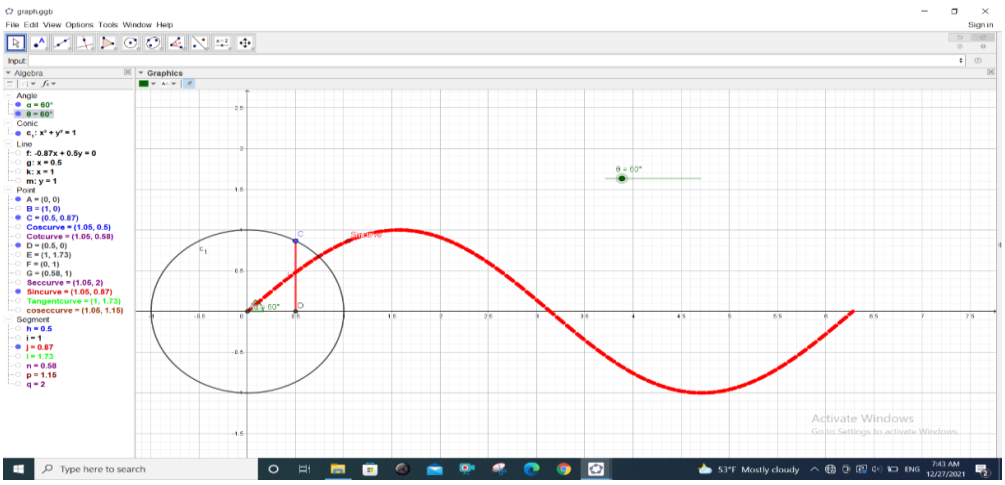
(a) offline sources: GeoGebra applet on 'Graph of sine, cosines and tangen

(b) Online sources:

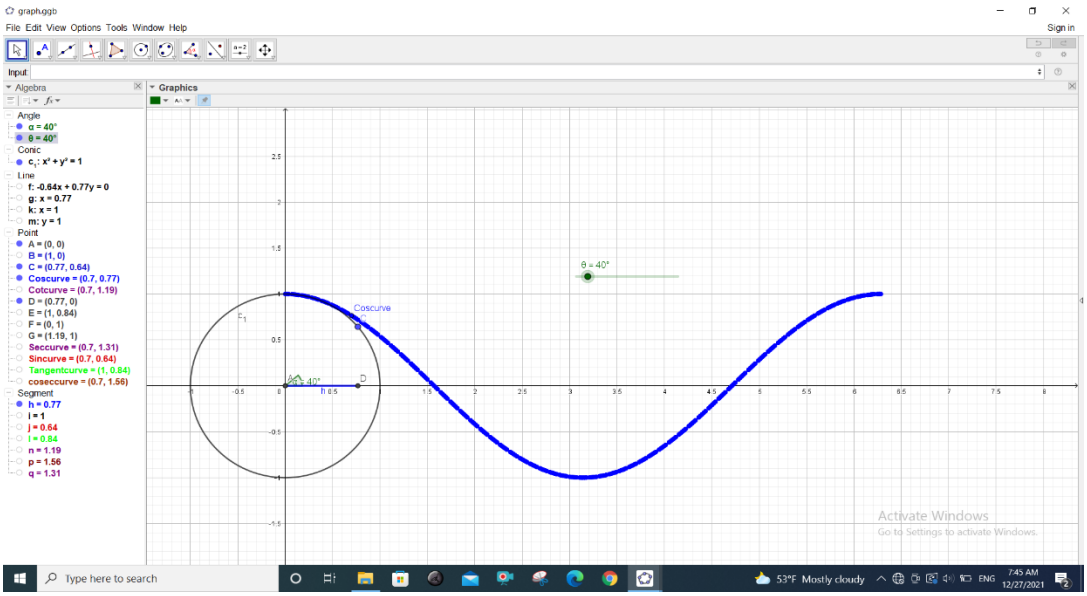
3. Teaching Learning Activities:

Following activities will be done during the class period:

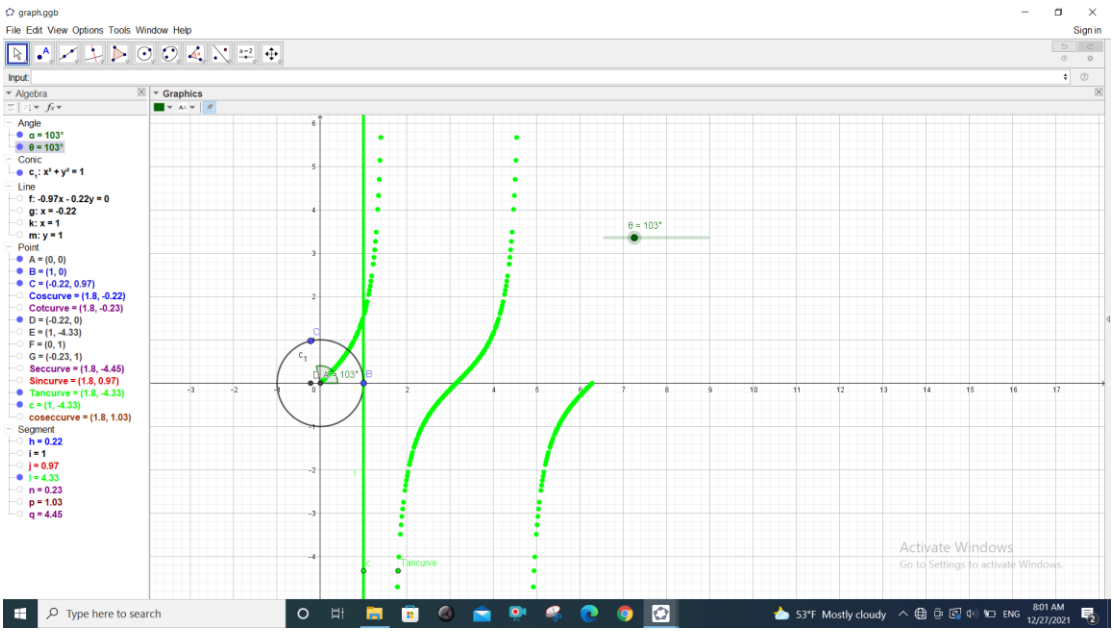
- Trigonometry is completely new chapter for class 9. So, by using GeoGebra software researcher will show the graph of sine function



- After that researcher will ask the question to the students 'Do you ever seen such type of graph in our daily life
- After the students' response we will discuss about the application of sine function in our daily life
- Then, we will discuss about the range and period of sine function
- After the completion of discussion on sine function sine function, researcher will show the graph of cosines functions. And, discuss about the range and period of cosine function



- Also, we will discuss about the application of cosine function in our daily life
- Finally, researcher will show the graph of tangent function and discuss about the range and period of tangent function



4.Evaluation:

(a) What is the range of sine function?

(b) What is the period of cosine function?

(c) Where is the use of sine function in our daily life?

5. Homework:

Draw the graph of sine function and mention the range and period of it.

Teaching Episode:06

Subject: Optional Mathematics | Time: 40 mins

Unit: Trigonometry | Period: 8th

Topic: Graph of different trigonometric ratios | No.of students….

Grade: 9 | Date……

School……

1. **Specific Objectives:**

   At the end of this class, students will be able to

   (a) Draw the graph of cosecant, secant and cotangent function

   (b) Write the range and period of cosecant, secant and cotangent function

2. **Teaching Materials:**

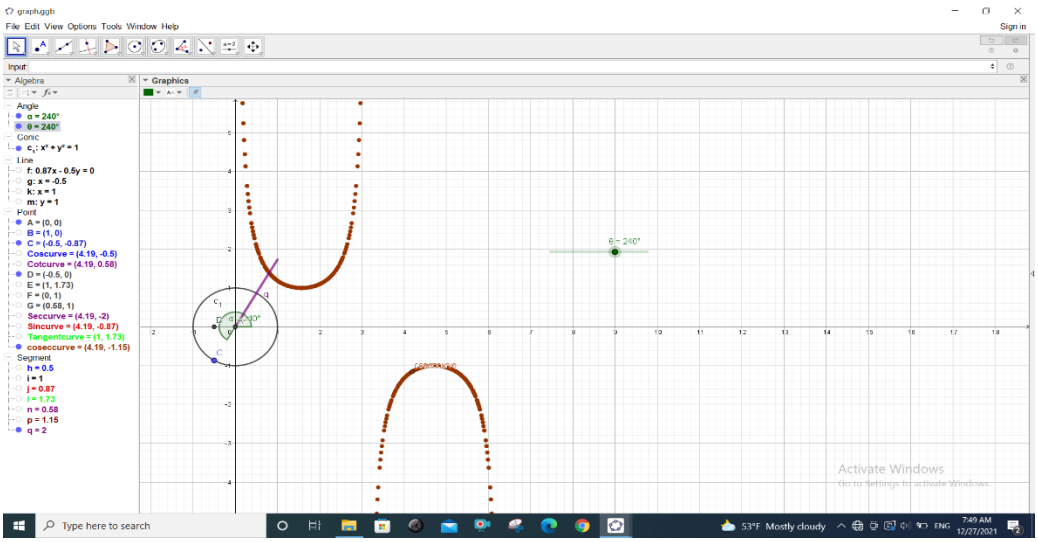
   (a) Offline sources: GeoGebra applet on 'Graph of cosecant, secant and cotangent function

   (b) Online sources:

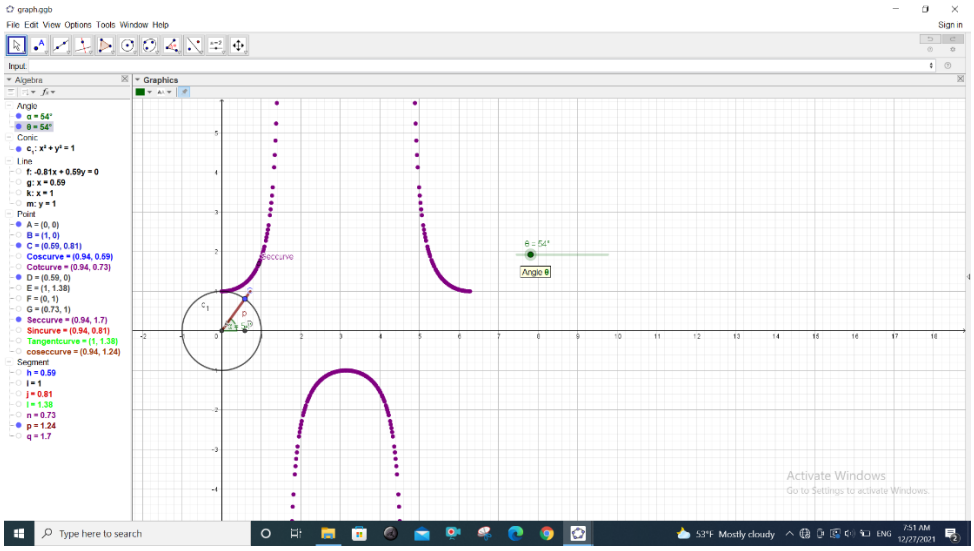
3. **Teaching Learning activities:**

   Following activities will be done during the class period

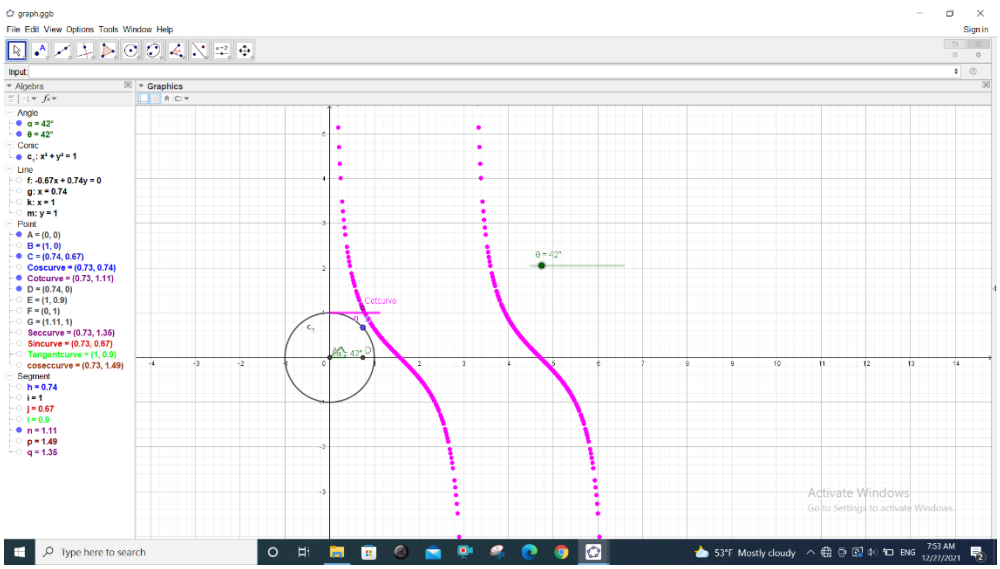
   - Trigonometry is completely new chapter for class 9. So, by using GeoGebra software researcher will show the graph of cosecant function



- After that we will discuss about the range and period of cosecant function
- After that researcher will show the graph of secant function



- And we will discuss about the range and period of secant function
- Finally, researcher will show the graph of cotangent function and discuss about the range and period of cotangent function



4. Evaluation:

(a) What is the range of cosecant function?

(b) What is the period of secant function?

(c) What is the range and period of cotangent function?

5. Home work:

Draw the graph of cosecant function and mention the range and period.