Chapter-I

INTRODUCTION

Background of the Study

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

Dynamic geometry software, hereafter abbreviated as DGS, is one of the popular technologies that are used for teaching and learning mathematics. Dynamic geometry software refers to any software that allows students to create geometric diagrams, measure quantities such as distance, area, perimeter, and manipulate the elements of diagram while maintaining their original geometric relationships. GeoGebra, Geometric Sketchpad, Cinderella, and Cabri-Geometry are examples of this type of software.

One of the important advantages of public domain DGS is that students can use it even at home and explore their ideas in the absence of their teachers. This implies that even without teachers students can learn mathematics by looking, observing, manipulating things. The DGS programs promote student-directed inquiry and collaborative work by offering students opportunities to formulate theories and to draw their own conclusions (cf. Hannafin *et al*, 2001).

DGS not only helps students to learn in effective way, but also helps teachers to change their role in the classroom. With DGS teachers can prepare lesson materials in which they use it as a cooperation, communication, and representation tool for mathematics. Thus DGS is a versatile tool for mathematics education. It can be used for demonstration and visualizations of objects, as well as for discovering mathematics, even beyond geometry (Hohenwarter and Fuchs, 2004). DGS can transform the teaching of mathematical concepts into a style in which students are engaged in interactive demonstrations, constructions and explorations. Offering new tools that are unavailable in paper and pencil geometry, use of DGS widens the range of accessible geometrical constructions and solutions (Straesser, 2001).

In addition, GeoGebra is one of the DGS types of software which is an easy-to-use tool for learning and teaching mathematics that enables the teacher to export activities as interactive web pages, so-called dynamic worksheets (Hohenwarter and Preiner, 2007). Geogebra is multiplatform, free, open -source, dynamic mathematics software which combines not merely Geometry and Algebra but also Calculus, Probability, Statistics and it can be used for Kindergarten-University Level. In fact GeoGebra enhances both instructional delivery and students learning.

Statement of the Problem

In the teaching and learning of geometry, it has been often realized that students still lack the cognitive and process abilities in the total understanding of circles. Although the teacher delivers the required knowledge to assist students in understanding the concepts of circles, students seem to face a challenge in applying this knowledge to a given task. It is as though something more is required to guide students so that they are able to manipulate circle properties to truly understand and visualize the properties of circles. This perception is supported by research (Battista, 1999; Prescott, Mitchelmore & White, 2002) whereby students faced challenges in studying geometry and many struggle to grasp the concepts and required knowledge.

The factors that influence students' attitudes towards Mathematics are the teaching materials used by teachers, classroom management, teacher content knowledge and personality, relating the topics with real life situation (Yilmaz Altun & Olkun, 2010) and teaching methods (Papanastasiou, 2000). Mathematics can be regarded as a challenging subject. Learning Mathematics involves understanding the theories and formulas to describe something. In the typical classroom, the challenge for the students is to explore complex problems. With advances in multimedia technology, learning difficulties can be overcome.

The challenge is more complex in teaching and learning of Mathematics, where teachers have to balance the mental, stationery and digital tools for teaching and learning that involve abstract mathematical concepts that is difficult to be understood by students (Prieto, Sordo Juanena & Star, 2013). Technology plays an important role in the development of the educational process (Gursul and Keser, 2009). Existing technology equipment such as GeoGebra, Geometer's Sketchpad and Mathematica should be used to the maximum by the educators. The use of technology is important because it serves as an object of education, which affect the learning content and objectives, and as a medium to improve the teaching and learning process (Voogt, 2008).

Therefore, a study on the Effectiveness GeoGebra Software on Mathematics Achievement has to be conducted to see how it can be beneficial to improve the education system in Nepal. The second objective of this study was to identify students' perceptions of the use of GeoGebra in learning Mathematics. There is much controversy over the past two decades about the effects of using the tools of technology (calculators and computers) in the teaching and learning of Mathematics (Smith, 2002). Therefore, this study aimed to prove the extent to which technology tools can impact the teaching and learning of Mathematics.

Significance of the Study

Result and Discussion from the study served to inform teachers about students' learning processes, particularly those related to using the GeoGebra software in relation to mathematics. The findings reveal the processes involved as well as the challenges and issues teachers need to consider when using GeoGebra software. The results outline how the different interactions with technology, peers and teachers affect learning. Consistent with the Vygotskian perspective, the role of social interaction in the learning process (Vygotsky, 1978) may become more evident. In other words, how learners interact with their peers and knowledgeable adults to advance their mental functions serve to inform educators about the use of GeoGebra software.

In addition, the study provides information on how learners of different abilities interact to perform assigned tasks. Such information is crucial in planning lessons for large classes and where learners are of varied abilities. The study reveals how technology integration facilitates the teaching and learning of circles; in particular, the findings help to redefine the role of the teacher so that concepts such as “facilitator” and “guide at the side” may become more apparent.

GeoGebra has a very clear and intuitive interface divided into parts corresponding to the algebra and geometry. There are many views in GeoGebra window like algebraic view, spreadsheet view, CAS (Computer Algebra System) view, protocol design view and command line. All these views are linked with each other, that is, if we introduce an object in one of the views, it appears in others in an appropriate form. So for example, if we put a function in a command line, its graph appears in geometric view. All the changes of the parameters of the function are immediately shown on graph. Beside the basic capabilities of GeoGebra like drawing figures, lines and function graphs we can also calculate or measure angles, points of interceptions, lengths, fields, circumferences, maximum and minimum of a function, derivatives and integrals. Obviously, GeoGebra can be used as an advanced calculator but not only. It can operate on vectors, matrices and even solve a system of linear equations

The main idea of using GeoGebra into everyday teaching and learning is to provide opportunities for students of different mathematical skills and levels for better understanding concepts and fostering them to doing mathematics in new attractive way. The main features of GeoGebra are free for noncommercial use, multiplatform, clear and easy understanding graphical user interface, rich database of ready-made example, technical documentation in many languages, marking objects follow the mathematical syntax, ability to save a project in multiple formats, works with LaTeX, all objects in GeoGebra are dynamic, possibility to publish the work on the website through JavaScript and program is translated into many foreign languages.

Therefore, Geogebra software is very useful tool of teaching materials because a teacher can build dynamic demonstrations creating dynamic relationships between objects on the screen live in front of a class this seems preferable to using projectors. Students can build their own dynamic GeoGebra files, being able to efficiently explore key mathematical ideas i.e. they could create figure for themselves. GeoGebra is conducive to experimental learning where students can take ownership in and personalize their work. GeoGebra supports multiple representations, that it combines many of the features of a computer algebra system and dynamic geometry program, it also has a built in spreadsheet. It seems to be a number of the commercial packages in one for free! Students can solve problems by exploring mathematics dynamically. I believe using GeoGebra encourages you to think like a mathematician especially in defining relationships between objects. GeoGebra is widely available in that it can be loaded directly from the internet for free.

Objectives and Research Questions

The main objective of this study was to investigate the effectiveness of using GeoGebra on Mathematics achievement. Further, the study also aimed at investigating if this learning method surpassed the traditional method and was to elicit students' perception in learning circles using GeoGebra.

More precisely the objectives of this study were:

1. To compare the achievement of the student in mathematics by using GeoGebra software with the achievement of students taught without using GeoGebra software.
2. To elicit students' perception in learning circles using GeoGebra software.

Hypothesis of the study

Research Hypothesis

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

Statistical Hypothesis

Formulation of null and alternative hypothesis was:

a) H_o: The average achievement of the students at mathematics of experimental group does not differ to the average achievement of the students at mathematics of control group on post test. i.e. $\mu_1 = \mu_2$

   H_1: The average achievement of the students at mathematics of experimental group is higher than the average achievement of the students at mathematics of control groups on post-test i.e. $\mu_1 > \mu_2$

Delimitation of the Study

This study has based on:

1) The subject of mathematics only.
2) Ten grade students only.
3) The chapter of circles only.
4) Two public schools of Kathmandu district were selected for the study.
5) In experimental group 28 students were trained by researcher in Panga secondary school about how to use GeoGebra software in Circles. Researcher taught using Multimedia Projector for one week. Researcher regularly gave and checked homework. In this study the researcher has Dynamic Geometric Software GeoGebra.
6) In control group 25 students were selected for the study. Researcher, himself taught as usual tradition method (without using GeoGebra Software).

Operational Definition of the Key Terms

GeoGebra: It is free, multi-platform, open source dynamic mathematics software suitable for learning and teaching of mathematics. It combines geometry, algebra and calculus into a single easy-to-use package that are dynamically linked.

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

Traditional instruction (conventional method): Instruction in which course content is delivered by lecture in a face-to-face classroom setting in which students listen passively and take notes.

Effectiveness: The measure of effectiveness for this study includes the followings:

A. Increase in the average achievement of the students' in mathematics.
B. Elicit the students' perception towards GeoGebra in circles.

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

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

Education technology: The hardware, software and other digital technologies to advance learning, teaching and interaction in educational settings. The following is a partial list of the types of technologies found in educational settings.

Experimental Group: A group of students which had exposed and use of GeoGebra (Treatment) regularly, while teaching circle at grade X.

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

Chapter-II

REVIEW OF RELATED LITERATURE

Literature Review

"A literature review is a description of the literature relevant to a particular field or topic. It gives an overview of what has been said, who the key writers are, what are the prevailing theories and hypotheses, what questions are being asked and what methods and methodologies are appropriate and useful. As such, it is not in itself primary research, but rather it reports on other findings" (Cooper, 2002).

Capitalizing on the reviews of expert researchers can be fruitful in providing helpful ideas and suggestions. The search for related literature is one of the first steps in the research process. It is a valuable guide to defining the problem, recognizing its significance, suggesting promising data gathering devices, appropriate study design and sources of data (Best and Kahn, 2006).

Technology integration in the teaching and learning process in the classroom has attracted a lot of attention in recent years. Providing a rich learning environment to promote social interaction, critical thinking skills and a holistic understanding of their learning experiences has brought about the urgency to incorporate technology in the classroom. Classroom teaching should be engaging and intellectually stimulating to inspire students in learning Mathematics. Therefore, the learning process designed using technology will be able to cater for such an environment. Similarly, the National Council of Teachers of Mathematics **(NCTM, 2000)** in the document *"Principles and Standards for School Mathematics"* listed technology as one of the key principles to enhance the quality of mathematics, suggesting that, "Teachers should use technology to enhance their students' learning opportunities by selecting or creating mathematical tasks that take advantage of what technology can do efficiently and well – graphing, visualizing and computing". In the fast moving era of technology, it is essential to keep up with the current interventions and innovations in relation to technology to meet its relevance for the present and future (NCTM 2000, p. 10).

GeoGebra might play the role in filling up the gap by assisting students to visualize and understand circles through exploration. A review of literature also shows that using GeoGebra has an impact on students' understanding of geometry. Dogan (2010) revealed that GeoGebra had positively affected students' learning and achievement and improved their motivation. Another study by Erhan and Andreasen (2013) also suggested that students improved their mathematics understanding after using the dynamic geometry software. Students will be able to explore and form conjectures and therefore had better scores as well. In particular the statement that the measure of an inscribed angle is half the measure of the central angle with the same intercepted arc is a conjecture in circle geometry. The view of the GeoGebra file, which has been prepared to dynamically see this conjecture given the relationship between a central angle and an angle inscribed in the same arc, is shown in Figure 1. In the GeoGebra material, inscribed and central angle can be changed optionally by means of β-slider.

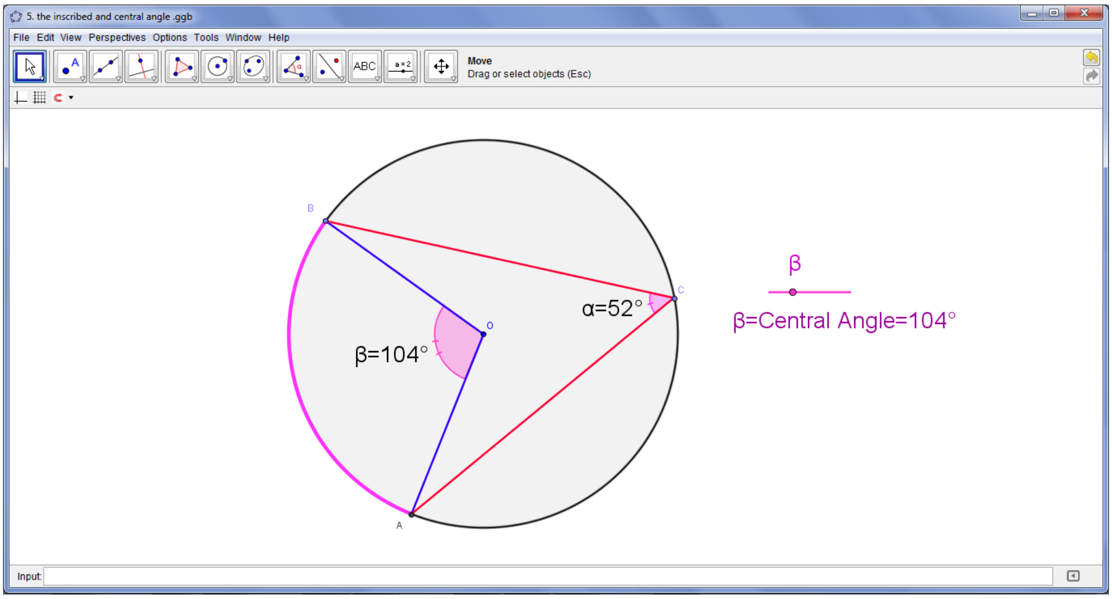


Figure 1: A view of the material for the inscribed and central angle

According to Hohenwarter (2008), GeoGebra is a computer program (software) for Mathematics, especially for learning geometry, algebra, calculus, statistical, etc. Abramovich (2013) defines GeoGebra as a free online software application for the study of geometry, algebra, and calculus at grade level and different teaching. Studies on students' perception on applying technology in Mathematics classes were given less attention (Li, 2007).

Empirical literature

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

Dogan (2010) conducted an experimental design study using a pre-post test to evaluate the success of students learning using the GeoGebra software. It was a twelve hour course held for a period of two weeks involving two eighth grade classes. It was observed that computer based activities can efficiently be used in the learning process and the GeoGebra software encouraged higher order thinking skills. The software was also observed as having a positive effect in motivating students toward learning and retaining their knowledge for a longer period. This was proven based on a recall test conducted a month later. In another study, Kemp (2006) found that high ability Grade 9 boys felt the lesson was interesting. Students explored their learning beyond what was assigned by the teacher and were happy and engaged in the lesson using GeoGebra software. The teacher was able to identify students who faced challenges in such a setting and did not engage in the lesson; therefore it was suggested that further strategies need to be incorporated to motivate most students.

Herceg and Herceg (2010) conducted a study on two groups of students. One group used applets only, whilst the other used the GeoGebra software and applets. The study tested how to incorporate computer-based learning to reduce the working process of numerical integration. The results of this study showed that the GeoGebra experimental group gained more knowledge and skills than the control. This study also suggested that GeoGebra use is helpful for students who face difficulty in solving mathematical problems since they do not have to spend so much time solving by hand. According to Erhan (2013) dynamic software improves students' understanding of mathematics; students were able to explore and form conjectures and therefore had better overall scores.

Bakar, Ayub, Luan and Tarzimi (2002) compared GeoGebra to a software program created by them on two groups of Malaysian secondary school students and found that students using the GeoGebra software to study the transformation topic achieved better results than students using the created software.

Leong (2013) conducted a study to determine the effects of using the dynamic software, Geometer's Sketchpad (GSP) in the teaching and learning of graph functions. This study was conducted among six students in a Malaysian secondary school. A quasi-experimental design using intact sampling was employed. A significant difference was observed in the achievement of the experimental group as compared to the control. This indicates that the dynamic software (GSP) had a positive effect on student achievement and attitude towards learning graphs of functions.

Theoretical Review and Conceptual Framework

In this study GeoGebra has based on Vygotsky's social constructivist perspectives, because knowledge is actively constructed by students while they are making construction and analyzing figures instead of knowledge being passively received and accepted. The Zone of Proximal Development (ZPD), in the learning of circles, the more skilled students were able to assist their peers with information and manner of constructing diagrams and the more capable students were able to fill in gaps in their peers' knowledge or explanations they have missed. The peers then gain a different insight and develop a different manner of understanding circle concepts. In addition, when working in groups due to the differing ZPD of each student, they may have differing views; therefore through interaction with peers they can achieve shared understanding. However, in such a situation, there must be a balance in terms of the insights and ideas contributed by each group member; it is important to have shared views and justifications of opinions to reach mutual understanding. This enables all students to participate in critical thinking skills because one's cognitive development becomes apparent when new views and ideas are taken into the current cognitive state.

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

The study draws upon the constructivist theory of social interaction for cognitive development. The main principles will anchor on the zone of proximal development (ZPD) and scaffolding. Students generally have challenges in understanding mathematical concepts; therefore in this study the GeoGebra software was introduced as a scaffold to enhance student understanding of circles.

The ZPD is described as the variance between one's mental age and the level one might attain in problem solving with guidance. Scaffolding refers to the guidance provided for one to reach the ZPD. In this study the GeoGebra software basically acts as the primary scaffold in assisting and guiding the students to reach their ZPD. The students were required to work in pairs to construct diagrams and make observations based on their constructions. Students formed their own interpretations through shared understanding with the guidance of the GeoGebra where they were able to explore and visualize on their own. On top of that, the teacher and peers also played a part in the scaffolding process.

The teacher advocated instructional intervention at the beginning of the lesson to introduce the software tools to enable the students to work in pairs on their own using the step-by-step guide without the teacher's assistance. The teacher's role hereafter is more of a facilitator, to encourage students to actively participate in the lesson and make significant connections. This relates to Piaget's work, where he stressed the need to provide formal instructions to assist students to reach a developmental stage where they are able to accommodate and assimilate information at a given level of complexity.

Social interaction between peers gave the students opportunities to guide one another and reach a level of shared understanding. Here the higher ability students play a big role in helping the lower ability students to reach their ZPD. The higher ability students also benefit through the new ideas and views of their peers.

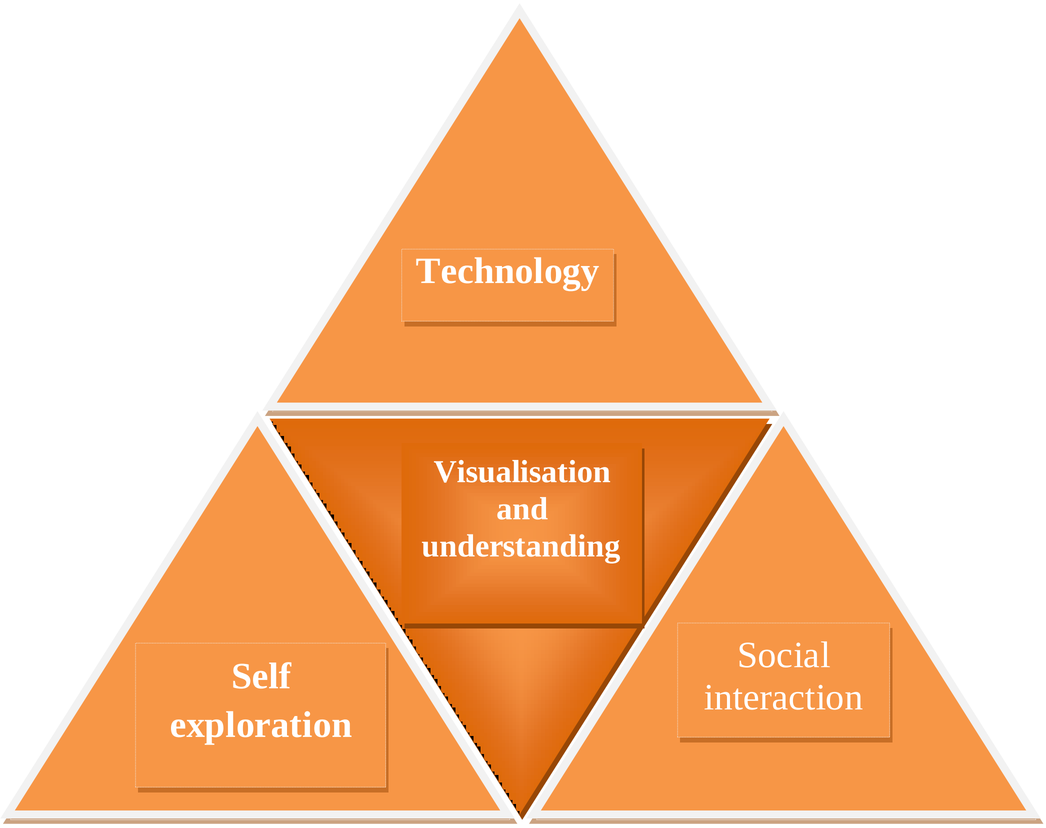


Figure 2: The TS^{2}VU Conceptual Framework

The TS^{2}VU conceptual framework is explained in the following part:

T= Technology. Technology, in this respect the GeoGebra software is an important scaffold to bridge the ZPD.

S= Self-exploration. This is a central concept in constructivism to enable students to project their actual learning level.

S= Social Interaction. This allows the learners to interact and learn from peers and knowledgeable others to reach their potential learning level

As such the 2Ss' are related to the concept of ZPD.

V = Visualization. This is an important process in the learning of circles

U= Understanding. Understanding is a crucial thinking skill to grasp any mathematical concept

According to Vygotsky learning is an active contextualized process of constructing knowledge rather than acquiring it, knowledge is constructed based on personal experiences and hypothesis of environment. Vygotsky's views are closely related to this learning environment where he emphasized that social interaction and cultural environment contribute to cognitive development. However, this must take place within the zone of the individual's potential development. In this study, students were placed in groups where the scaffolding process can take place for them to construct circles based on what they already know and with help accepted from their peers when needed and Technology; in this respect the GeoGebra software was an important scaffold to bridge the ZPD. In this environment the teacher acts as a facilitator. This manner of learning enhances critical thinking skills as students contribute ideas and views to reach a common understanding. However, this process had to be closely monitored to ensure a balance in terms of input from both group members. Here the higher ability students played a bigger role in helping the lower ability students reach their ZPD. The higher ability students also benefit through the insights gained from their peers. After this collaborative process, every student self explore knowledge of circle with in intra-psychological as well as inter-psychological. GeoGebra gave the students an opportunity for peer interaction to enhance understanding and visualization of the concept of circles. The conceptual framework called TS^2VU is represented in Figure 2.

Chapter-III

METHODS AND PROCEDURES

Education research can be divided into two broad categories: *quantitative research* and *qualitative researches* in behavioral and social sciences. Quantitative research consists of research in which the data can be analyzed in terms of numbers. In qualitative research events and persons can be describe scientifically.

Design of the Study

The research design is the detailed plan of the investigation. In fact, it is the blueprint of the detailed procedures of obtaining and analyzing data (Sings, A.K., 2008, p. 450). The purpose of research design is to provide a maximum amount of information relevant to the problem under investigation. Basically, a research design serves two functions. First, it answers the research questions as objectively and validly. Seconds, a research design also acts as a control mechanism. In other words, it enables the researcher to control unwanted variables.

But, in this study the researcher selected the experimental design to answer the formulated research question because usually when there is manipulated variable and a researcher wants to observe the effect of manipulative variable upon the control variable then so the experimental design will be appropriate.

According to Best and Khan (2006) *experimental research* describes *what happen* when certain variables are carefully controlled or manipulated.

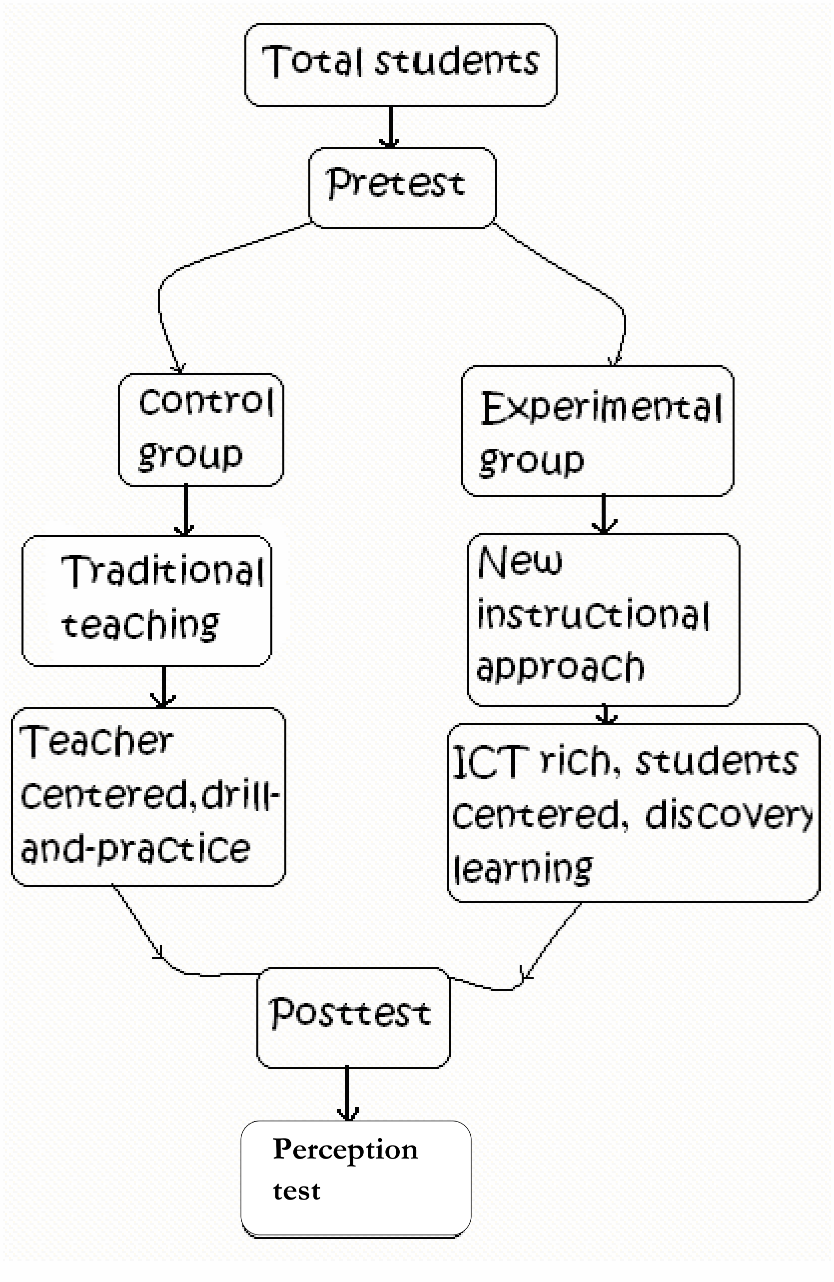
In this study researcher observes the effect of GeoGebra on students' achievement as well as students' perception in learning the topics circles using GeoGebra.

Quasi-experimental research is similar to true experimental research in that sense that one or more experimental variables are involved. However, instead of having subjects randomly assigned to experimental treatments, naturally assembled groups, such as classes, were involved in this research. Therefore, among various types of quasi-experiment design, "***pretest-posttest nonequivalent groups design"*** is selected because this design is often used in classroom experiments when experimental and control groups are such naturally assembled groups as intact classes, which may be similar (Best and Khan, 2009). This design may is diagrammed as shown below:

Table 1: Design of the Study

Groups	**Pretests**	**Treatment**	**Posttest**
Experimental	0_1	X_1	0_2
Control	0_3	X_2	0_4

Figure 3: Visualized Map of Design of the Study



At the process of choosing experimental and control group no randomization has used. This design is the most effective to minimize the treats to external validity. Two groups have made homogeneous as possible as by selecting school of similar status with respect to physical facilities and as per as possible group has made with focusing same cognitive structure of students.

In this design, O_1 and O_3 represent the pre-test for experimental group and control group, while O_2 and O_4 represent the post-test for experimental group and control group. X_1 and X_2 represent teaching methods given to the two treatment groups, GeoGebra software group and a traditional teaching methods group. Both groups have given the same pre-test before and after the completion of the study. Both groups completed post-tests after being exposed to one of the teaching methods. Pre-test has used to assess similarities between groups. The researcher has implemented GeoGebra in the treatment group and the traditional methods of teaching in the control group. After taking post test to compare effectiveness of Geogebra Software, perception test has imposed to the students for measuring perception towards Geogebra in circle.

Population and Sample

In this study all the students of secondary level of Nepal have taken as the population of the study. But I cannot study in whole population due to lack of time as well as many resources. In such scenarios the researcher focus only Kathmandu district for sample. For convenient of researcher, he has taken two public schools to fulfill the motto of this study. In particular, 28 students of Panga Secondary School and 25 students of Shree Janasewa Higher Secondary School have sample of the study. The sample for experimental group has selected purposefully because the study become more valid and no artificial environment has created if the researcher himself does experiments in class. The sample for control group has also selected purposefully to make the equivalent group to experimental group to avoid the possible effect of the manipulative variable on the control group.

Table 2: Composition of samples

No. of Students	Groups of Students	Breakdown of No (n)	Percentage (%)
53	Experimental	28	53
	Control	25	47
Total		53	100

Independent, Dependent and Extraneous Variables

Variables are the conditions or characteristics that the experimenter manipulates, controls, or observes. The independent variables are the conditions or characteristics that the experimenter manipulates or controls in his or her attempt to ascertain their relationship to observed phenomena. The dependent variables are the conditions or characteristics that appear, disappear, or change as the experimenter introduces, removes, or changes independent variables (Best and Khan, 2006, p. 168).

Extraneous variables are those uncontrolled variables (i.e., variables not manipulated by the experimenter) that may have a significant influence on the results of a study. Many research conclusions are questionable because of the influence of these extraneous variables (Best and Khan, 2006, p. 169)

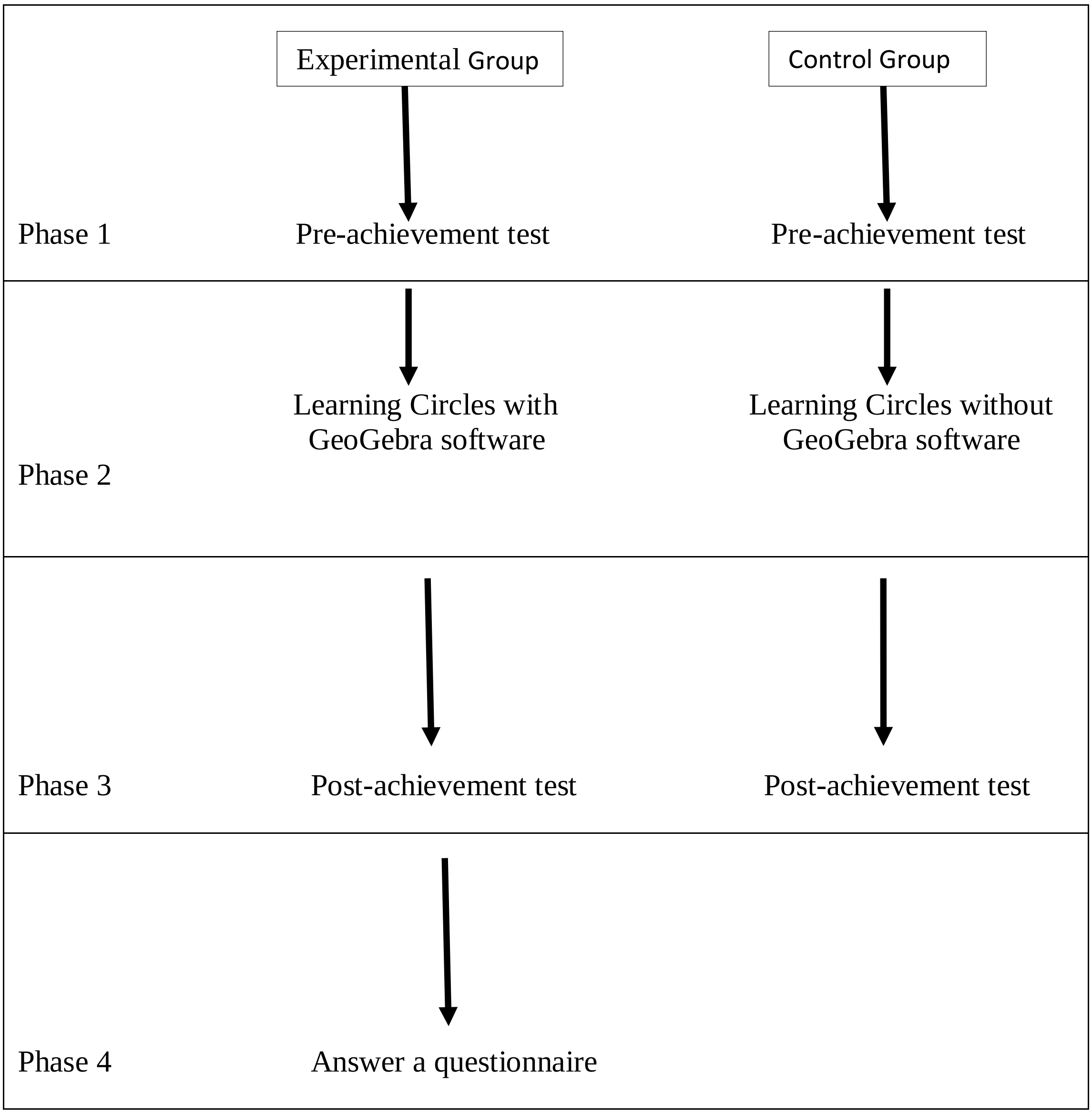
In this study dynamic geometric software GeoGebra was independent variables but students' achievement in circles as well as students' perceptions towards circles was dependent variables.

School characteristics, different characteristics of teacher, students in two groups, subject matter of two groups have non experimental variables. To ensure the equivalency of the experimental and control group the mean, variance, standard deviation of two groups have calculated on the basis of their marks on their first terminal examination and F ratio of two groups have calculated at last in which t-test has applied to ensure whether there has significance difference between two groups. Using all these measures the two groups of students should be made equivalent to experimental and control groups.

Data Collection Tools

The instrument had used in this study is the achievement tests; pre-achievement test and post- achievement test and also a set of questionnaire. The achievement tests had used to compare what they knew before in a pre-performance test and what have they experienced in the post- achievement test.

Figure 4: A summary of the research Procedure



Data collection Procedure

The procedure of data collection describes how to relevant data and information is gathered. This study has manly based on the quantitative data obtains from achievement test. In addition, to quantitative data, some qualitative information has taken in relation to elicit students' perception towards dynamic geometric software GeoGebra in Circles.

Achievement Test

The pre-achievement test was used to determine the achievement level of achievement by students in both groups. This test consists of ten questions to be solved without using GeoGebra software that had answered by both groups experimental and control groups. Post-performance test contains ten questions that have a slightly different with the questions in the pre- performance test, but the question is in the same structure. Post-performance tests used to measure the students' achievement after using GeoGebra software. These tests involved both the control group and the experimental group.

Questionnaires

This questionnaire contains nine items using a Likert scale of '1-Strongly Disagree, 2-Disagree, 3-Undecided, 4-Agree and 5-Strongly Agree'. This study used a modified questionnaire based on Shadaan and Leong (2013) study. This questionnaire contains statements which reflect the students' perception of the use of GeoGebra software.

Estimation of Reliability and Validity

Since pilot study is a small scale preliminary study conducted in order to evaluate feasibility, time, cost, adverse events, and effect size (statistical variability) in an appropriate sample size and improve upon the study deign prior to performance of a full - scale research work. But here, the pilot study was conducted for estimation of reliability as well as items analysis. In this present study, researcher conducted piloting test among 28 students of Jnanoday higher secondary school, Kalanki who were not included in the sample of the study.

The reliability of a test refers to the extent to which the test is likely to produce consistent scores. In my present study, after piloting test among 28 students, it was found that reliability coefficient of achievement test was 0.94 (see appendix-E). Hence we conclude that the achievement test was reliable.

Item analysis of the test

It is a process which examines student's responses to individual test items in order to assess the quality of those items and of the test as a whole. Item analysis is the process of collecting, summarizing and using information from students' responses to assess the quality of test items. Difficulty index (P) and discrimination index (D) are two parameters which help to evaluate the standard of a test. The researcher conducted the test among 28 students of Jnanoday secondary school, Kalanki. Since the level of difficult (p-value) and index of discrimination (d-index) of each item was calculated from the tabulated 27% of higher scores, i.e. 7 students of higher scores and 27% of lower score, i.e. 7 students of lower scores. The criteria for the acceptance or the rejection of the items were given in appendix-D in which 4 items were rejected. In this study the researcher was developed the test items on the basis of specification grid so that the objectivity of the test could be maintained.

Instruments Used in the Experiment

The researcher developed the teaching episodes before conducting the experiment. Researcher developed such teaching episodes on the basis of topics as well as exercises given on test book (see appendix-A). Geogebra software instead in Laptop, Projectors were main instruments in the experiments.

Control Exercise during Experiment

In my present research work, some non experimental variables such as teacher variables, subject matter, teaching aids, length of experiment, evaluation applied to students and school environment and group formation were controlled in order to minimize the effect on dependent variables. Since the experiment was conducted in two different schools in both schools, grade ten students were taught by applying to different method by researcher himself. In this study, students were selected in naturally assembled class so that there was no artificiality constructed. Students were taught circle in both group by giving equal time. There were given same teaching materials, homework, and class work on both groups. To control the influence such type of variables following exercise were done:

Teacher Variable

To control the teacher variables as beheaviour, personality, emotion, and qualification, the researcher himself taught both the experimental and control groups.

Subject Matter

Same contents were taught to the both the experimental and control groups from the same text book prescribed by government of Nepal.

Evaluation Applied

In this research work, after the end of experiment same test was given to evaluate the students of control and experimental groups.

Experimental Validity Treats

Every researcher attempts to achieve maximum validity in his/her research work. To make a significant contribution to the development of knowledge, an experiment must be valid (Best and khan). There are two types of experimental validity which are following discussed:

Internal Validity

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

History

Events outside of the study/experiment or between repeated measures of the dependent variable may affect participants' responses to experimental procedures. Often, these are large scale events (natural disaster, political change, etc.) that affect participants' attitudes and behaviors such that it becomes impossible to determine whether any change on the dependent measures is due to the independent variable, or the historical event. But in this present study was done in the short time period of time so these treat no more effect in my research.

Subject characteristics

First of all, subject characteristics are one of the possible threats to internal validity in the present study. The characteristics of subjects which might affect the internal validity were students' ages and their socioeconomic statuses. Students who participated in the present study were at the same grade level, so their ages were close to each other. So, these characteristics did not influence the results accidentally.

Selection Bias

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

Experimental Mortality

Experimental mortality means the loss of subjects during the period of experimentation. But here, no participant of the experimental and the control group lost during the experiment. There were same number of respondent in the pre test and post on both groups.

External Validity

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

Artificial Situation of the Experiment

The researcher tries his/her best to control all extraneous variables so that they may not produce any experimental change. As a consequence of this effort, the experimental situation becomes more artificial and less resembles the life situation regarding which generalizations are to be made. But to control such problem the groups were formed in the naturally assembled class.

Interaction Effect of Testing

The use of a pretest at the beginning of a study may sensitize individuals by making them more aware of concealed purposes of the researcher and may serve as a stimulus to change. The study was doing short period of time as well as the researcher made question structure of pre and post-test differ.

Result and Discussion Procedure

Result and Discussion are considered as the blueprint of any research work. After collecting data with the help of relevant tools and techniques, the next important step, is to analyze and interpret data with a view to arriving at empirical solution of problem (Singh, A.K., 2009). The data analysis for this research has done by quantitatively as well as qualitatively with the help of both descriptive and inferential statistics. Thus, achievement test scores have analyzed using inferential statistics. Specifically, the *t*-test has executed for hypothesis testing. The *t*-test has used to test for statistical significance difference between the control and experimental groups at the beginning of the study and at the end. This was done primarily by comparing the mean score of the pre test and post score of both the groups. Descriptive statistics has also used to analyze the data from the questionnaire to elicit students' perception towards dynamic geometry software GeoGebra in circles of experimental group only.

Chapter-IV

RESULT AND DISCUSSION

In that section of the main body is the results whose purpose is to provide sufficient data and information about how the conclusion was reached. The heart of this section is the presentation of data relevant to test the hypothesis. After presenting relevant data, we also discuss about data. The major function of this discussion is to interpret the result of the study. For fulfill our motto, the data are organized and tabulated as follows:

Table 3: Result of pretest

Group	**N**	**Mean**	**Variance**	**Standard Deviation**	**F**	α	**Calculated t-value**	**Tabulated t-value**
Experimental	28	18.14	23.98	4.90	1.05	0.05	0.13	1.96
Control	25	17.96	22.76	4.77				

The above table shows us, there were 28 and 25 number of students in Experimental and Control Group. In pre test 30 marks of mathematics achievement test was administrated in which pass mark was 10 (See test questions in appendix-H and score of students in appendix-F). The mean, variance and standard deviation of the experimental group were 18.14, 23.98 and 4.90 respectively. Similarly the mean, variance and standard deviation of control group were 17.96, 22.76 and 4.77 respectively. Since the value of F was 1.05 so the groups were homogeneous that's why t-test for pooled variance was applied. Since it is two-tailed test so $\frac{\alpha}{2} = 0.025$ hence tabulated t-value was 1.96 at 0.05 level of significance. But the calculated t-value was 0.13 which was not lying in critical region i.e. 0.13<1.96 so H_0 was accepted. Hence it could be concluded that there is no significance difference between experimental and control group in the pre-test of achievement. Both the group had nearly same ability in pre-test.

Table 4: Result of posttest

Group	N	Mean	Variance	Standard Deviation	F	α	Calculated t-value	Tabulated t-value
Experimental	28	21.5	26.39	5.14	1.01	0.05	2.38	1.645
Control	25	18.08	26.23	5.12				

The table shows that there are 28 and 25 students in experimental and control group respectively. The mean, variance and standard deviation of experimental group were 21.5, 26.39 and 5.14 respectively. But, the mean, variance and standard deviation of control group were 18.08, 26.23 and 5.12 in which these values were calculated by mathematics achievement test in post test. The score of each individual was kept in appendix-G. Since the value of F was 1.01 so both groups were homogeneous hence the method of pooled variance for t-test was applied. Here, it is one tailed test at $\alpha = 0.05$. The calculate value of t-test was 2.38 but tabulated value of t-test was 1.645 at 0.05 level of significance. Here, 2.38 > 1.645 so that H_0 was rejected. Hence it is concluded that the average achievement of the students at mathematics of experimental group is higher than the average achievement of the students at mathematics of control groups on post-test. Thus, GeoGebra software is more powerful strategy to gain more achievement for students.

Result of Student perceptions towards GeoGebra in the learning of circles

The students' perception was identified through a set of questionnaire consists of nine items. The questionnaire was distributed to the experimental group only to know their perception based on their experience using the GeoGebra software. The results gained from the questionnaire show positive results.

The study found that the items in the questionnaire that had the lowest mean was the item which stated that students can think creatively and critically with a mean of 3.93. While the highest mean is 4.62, which is obtained for the first item: 'I like using GeoGebra'. Based on Table 5, the overall mean is 4.26. It shows the overall students agreed with positive statements about GeoGebra. Students also found that GeoGebra can also give a good impression of their learning in Mathematics class.

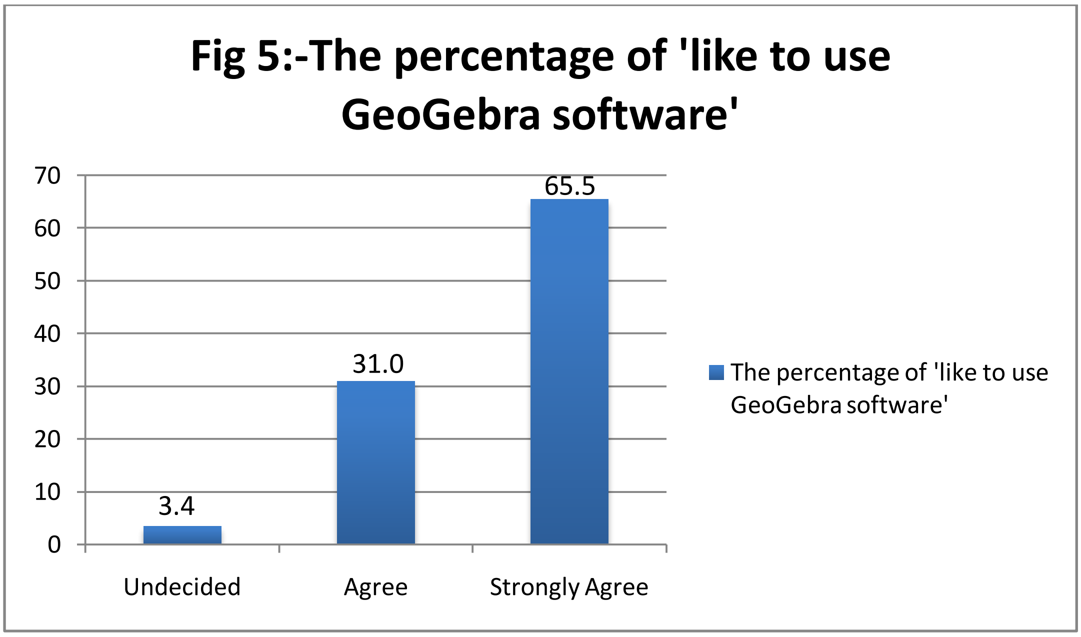
From the results, it can be concluded that the using of Geogebra software can increase students' interest, confidence and their motivation in learning Mathematics.

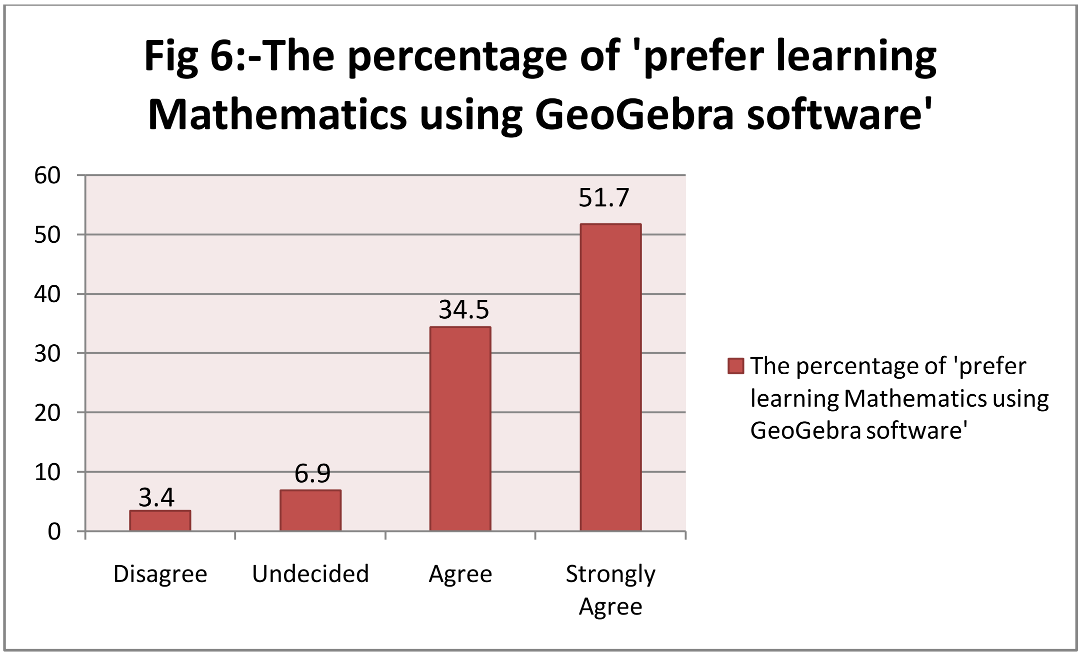
Table 5 shows the highest mean of the questionnaire is the first statement:"I like to use GeoGebra software". These students had never used GeoGebra before. Probably these are the reasons why they enjoyed using GeoGebra software in learning Mathematics. Lunar et al., (2010) stated that the use of computers in teaching and learning is not only to improve student performance, but also motivation. Based on Fig. 5 and Fig. 6, students who responded strongly agree shows the highest percentage compared to other responses. This shows that the students' interest in using GeoGebra software in learning Mathematics. In the study by Noorbaizura and Leong (2013), they found that learning process experienced by the experimental group (using GeoGebra), allows them to communicate openly with the teachers and students and among the students themselves. It shows that learning with software could also trigger on-tasks interactions. The interactions as a result of learning increased students' interest in learning Mathematics.

S.N	**Items**	**Maximum**	**Minimum**	**Mean**	**Standard Deviation**
1.	I like to use GeoGebra Software.	3	5	4.62	0.561
2.	GeoGebra software helps to learn Mathematics concepts.	3	5	4.22	0.641
3.	I feel confident when the activities do by using GeoGebra software.	3	5	4.10	0.618
4.	I learnt a lot about Mathematics when using GeoGebra software.	2	5	4.21	0.819
5.	I can think creatively and critically when using GeoGebra software.	2	5	3.93	0.842
6.	I prefer to learn Mathematics with GeoGebra software.	1	5	4.28	0.996
7.	GeoGebra software can help to increase my achievement in Mathematics.	3	5	4.31	0.761
8.	I am excited when asked to explore the GeoGebra software.	3	5	4.25	0.752
9.	I am happy if the teacher uses the GeoGebra software in teaching Mathematics.	1	5	4.45	0.948
			Overall Mean	**4.26**	

Table 5: Result of Perception Test

Students may take advantage on the used GeoGebra software in learning Mathematics because they can interact with technology. Students in the 21st century are computer-literate and the opportunities to learn using technology support will attract major attention. They use the Internet, cell phones, computers, laptops, tablets and other software to communicate with others. Digital environment motivates students in the teaching and learning of Mathematics. It also encourages both teachers and students to engage in learning and teaching. At present, many scientific studies show that computers have made it easier not only to understand mathematical concepts, but also enhance students' motivation and self-confidence.





Discussion

The GeoGebra software can be used as an enabler in the teaching and learning of Mathematics, and more specifically of circles, as there was a significant increase in experimental students' conceptual understanding of circles as compared to the control group. The use of the GeoGebra software not only increased student scores, it was observed that the software enabled realization of a vibrant classroom where cooperative and collaborative principles of learning were evident. This study was conducted with two groups using the pre and post achievement test to learn mathematical concepts.

The result of hypothesis one which stated that "There is no significant difference between the pre-test and post-test performance of students taught circle with the use of GeoGebra software" revealed that the students in experimental group gained higher scores in their post-test performance than the pre-test performance. By implication, there was significant difference between the pre-test and post-test performance of students taught Mathematics with the use of GeoGebra software.

The above results also corroborate other studies done to determine the effects of a technology-rich environment on students learning. This improvement can be attributed to the design of the constructivist learning environment anchored on the twin concepts of scaffolds and zone of proximal development. Thus, it is equally important that the teacher as the main curator of the learning environment be equally enlightened regarding the advantages of a technology-enabled classroom. Studies done by professional mathematics bodies should be constantly referred to when reviewing the impact of new learning technologies. The document "Principles and Standards for School Mathematics" listed technology as one of the key principles to enhance the quality of mathematics, suggesting, "Teachers should use technology to enhance their students' learning opportunities by selecting or creating mathematical tasks that take advantage of what technology can do efficiently and well – graphing, visualizing and computing" (NCTM, 2000, p. 21).

The results also suggest that technology is a great motivational tool as students' confidence increased when both the GeoGebra and learning videos were used to enhance the students' learning process. This was especially beneficial for the lower ability students. Technology acted as a scaffold which enabled learners to reach their zone of proximal development (Vygotsky, 1978). This finding is supported Dogan’s (2010) study whereby it was observed that computer based activities encouraged higher order thinking skills, and had a positive effect in motivating students toward learning.

When students were asked how the software affected them, they had many positive things to say, such as: it made them more engaged in the learning and enabled them to think at higher levels. In a similar study, Kemp (2006) found that high ability Year 9 boys felt the lesson was interesting, and students were able to explore their learning beyond what was assigned by the teacher and were happy and engaged in the lesson. Furthermore a study by Leong (2013) on Form Six students in a Malaysian secondary school discovered that using Geometer's Sketchpad software had positive effects on students’ achievement and attitude toward mathematics.

Chapter-V

SUMMARY, CONCLUSIONS AND IMPLICATIONS

Summary

The research entitled "Effectiveness of GeoGebra Software on Mathematics Achievement" was intended to investigate whether GeoGebra produces better result in term of the students' achievement and their perception towards GeoGebra in circles in comparison as usual method.

The study adopted the non-equivalent pre-test post test control group design. The purposes of this study were to investigate the effectiveness of using GeoGebra on students' understanding of circles and to elicit students' perception in learning circle using GeoGebra.

After teaching one week in Panga secondary school by using Geogebra software, researcher collect data from mathematics achievement test and perception test of this experimental group whereas control group was taught by as usual conventional method in Janasewa higher secondary school.

Two hypotheses were generated for this study as indicated in chapter one. The results of pre-test were subjected to t- test to determine the initial mathematical background of the students. The result of t- test as displayed in Table 3 showed that there was no significant difference between the mean scores of the two groups. The second hypothesis, as displayed in Table 4, was rejected at 0.05 level of significance by using a t- test statistics. By implication, students taught with GeoGebra performed better in the post-test than the pre-test in Student Achievement Test in Mathematics.

In this study, the teaching and learning of circles using GeoGebra has been effective. This was shown through the improved scored of the students in the experimental group. The result highlighted that students in the experimental group performed better using Geogebra than the control group that uses the traditional learning method. In addition, students in the experimental group better in the post-test compared to the control group. The students' perception was identified through a set questionnaire consists of nine items. The questionnaire was distributed to the experimental group only to know their perception based on their experience using the GeoGebra software. The result gained from the questionnaire show positive result.

Conclusions

In this study, the GeoGebra software has proven to be an effective tool in enhancing Mathematics teaching and learning, specifically in learning circles. Students were able to experience a hands-on method of learning which had a positive effect in enabling them to understand the concepts better rather than just being passive learners.

The software also gave the teacher and students the opportunity to work through the concepts together through exploration and visualization. This encouraged a more interactive teacher-student interactional environment where everyone worked as a team to guide, help and assist one another to reach the required goals. The **TS^2VU** conceptual framework (T= Technology whereby the GeoGebra software was an important scaffold to bridge the ZPD; S= Self exploration which was a central concept in constructivism enabling students to project their actual learning level; S= Social Interaction to allow learners to interact and learn from peers and knowledgeable others to reach their potential learning level as specified in the ZPD. The cognitive aspect of learning circles was represented by V = Visualization and U = Understanding). Overall, GeoGebra is an effective tool in assisting the teacher and students in the mathematics classroom to achieve the principles of constructivist learning. This supports the findings of Akkaya, Tatar, and Kagizmanli (2011). Based on the findings of the current study, it is highly recommended that teachers be encouraged to use GeoGebra software in teaching Mathematics. This should be coupled with research to establish better findings to conclusively ascertain whether GeoGebra does actually have an effect on learning of broader mathematical concepts and on different levels of students.

Learning and teaching of Mathematics should not be focused on purely theoretical, but also a variety of learning approaches that involve the use of teaching aids proven to help stimulate students' interest in Mathematics. The Mathematics software available in the market or even online has facilitated the task of the teacher to impart knowledge beneficial to the students. However, it depends on the teacher to utilize existing materials without the need to allocate extra time to develop other teaching aids.

Conclusively, this study has shown that GeoGebra software has a positive impact on students’ achievement in the topic Circles. The students also have positive perceptions on GeoGebra software in terms of enthusiasm, confidence, and motivation. This software should be introduced to Mathematics educators so that students can explore the world of Mathematics in a wider and make the students able to think critically and creatively.

Implications

From the result and discussion of present study, the researcher suggests the following implications:

Implication for Policy Level

Ministry of education and NCED should encourage the teacher through training to improve the existing mug and jug method by use of GeoGebra. For these NCED and MOE should organize the various training programmers, workshops, conferences etc. The result of this study also suggests that policy makers can more actively encourage the use of GeoGebra software with poor learning outcomes.

Implication for Practice Level

Traditional teaching in Nepal is based on the teaching and learning model of transmission of knowledge and skills through a drill-and-practice method: the teacher explains the theory and some examples, and the students have to make exercises to practice a bit more. In other words, teaching and learning is content-driven and teacher-centered. In my experiment I designed a lesson sequence on circles that was not focusing on pouring the knowledge and skills into the students’ heads. On the contrary, I focused more on the process of learning of the students and gave students an important role in their own learning, i.e., I had the goal to actively engage them in learning activities. I gave students ample opportunities to link theory with practical experiences. I took their findings into account and I let them discuss with peers and with the entire classroom. Under my supervision the student were more or less building up by themselves a network of knowledge and skills about the subject of circles. Thus, Mathematics teacher should be encouraged to use and adopt GeoGebra together with teaching method. The mathematics teacher should be encourage to emphasize the group discussion and students' centered method instead of regular lecture method by using GeoGebra.

Implications for Further Level

Technology is essential in teaching and learning mathematics. The result of this study could have an implication on the teaching and learning of mathematics in schools. This study shows that there is improvement on student achievement for students who are using open source software and those using a self-developed courseware. However, it does not show any evidence that state which software is better. Further studies need to be undertaken to identify other factors that the integration of technology in teaching and learning of mathematics can benefit educators and students.

One limitation of my research study was the short period of time in which I conducted the study, which also means that I was not able to get results that could be easily generalized. In addition, lack of enough computer facilities in the school affected the practice teaching that was part of my workshop. Therefore not all pupils were able to interact with computers to the extent that I had in mind, although this was also partly because of over-enrolment in the classes. However, result and discussion of this study could provide insight in how technology could be deployed by Nepalese mathematics teachers, as well as by teachers of other subjects.

REFERENCES

Akkaya, A., Tatar, E., & Kagizmanli, T (2011*). Using dynamic software in teaching of the symmetry in analytic geometry:* The case of Geogebra. Procedia Social and Behavioral Sciences,15, 2540-2544.

Bakar, K. A., Ayub, A. F. M, Luan, W. S., & Tarmizi, R. A. (2002). *Exploring secondary school students' motivation using technologies in teaching and learning mathematics.* Procedia-Social and Behavioral Sciences, 14, 4650-4654.

Battista, M. T. (1999). *Geometry results from the Third International Mathematics and Science Study*. Teaching Children Mathematics, 5(6), 367-73.

Bennet, D (1999). *Exploring geometry with geometer's sketchpad.* Emeryville, CA: Key Curriculum Press.

Best and Khan (2006). *Research in Education*, Tenth Edition, New Delhi, Prentice Hall of India Pvt.Ltd.

Borich, G., & Tombari, M. (1997). *Educational psychology*. New York, NY: Longman

Dewey, J. (1910*). How we think. Boston*, MA: D.C. Heath & Company Publishers.

Dogan, M. (2010). *The role of dynamic geometry software in the process of learning: GeoGebra example about triangles*. Retrieved from: http://www.time2010.uma.es/Proceedings/Papers/A026_Paper.pdf

Edwards, J.A. and Jones, K. (2006*). Linking geometry and Algebra with GeoGebra. Mathematics Teaching*, 194, 28-30.

Ennis, R. H., Millman, J., & Tomko, T. N. (1985). *Cornell Critical Thinking Tests Level X & Level Z: Manual. Pacific Grove*, CA: Midwest Publications.

Ennis, R. H., & Weir, E. E. (1985). *The Ennis-Weir Critical Thinking Essay Test: An instrument for teaching and testing.* Pacific Grove, CA: Midwest Publications.

Erhan S. Haciomeroglu, & Andreasen, Janet. (2013). *Exploring calculus with dynamic mathematics software. Mathematics and Computer Education*, 47(1), 6-18.

Grandgenett, N. (2007). *Mathematics and Computer Education*. ProQuest Education Journal, 41(3), 276.

Hannafin, R.B., Burrus, J.D., and Little, C. (2001). *Learning with Dynamic Geometry Programs: Perspectives of Teachers and Learners. The Journal of Educational Research*, 94(3) 132-144.

Hatfield, M. M., & Bitter, G. G. (1994). *A multimedia approach to the professional development of teachers: A virtual classroom.* NCTM, 102-115.

Herceg, D., & Herceg, D. (2010). *Numerical integration with GeoGebra in high school. The International Journal for Technology in Mathematics*, 17(4), 205-210.

Hohenwarter, M., Jarvis, D., & Lavicza, Z. (2009). *Linking Geometry, Algebra and Mathematics teachers: GeoGebra software and the establishment of the International GeoGebra Institute.* The International Journal for Technology in Mathematics Education, 16 (2), 83-86.

Idris, N. (2006). *Exploring the effects of T1-84 plus on achievement and anxiety in mathematics. Eurasia Journal of Mathematics, Science and Technology Education*, 2 (3), 66-78.

Jacks, M. J. (1996). *An Evaluation of a model technology program intended to develop critical thinking abilities of junior high school students*. Unpublished doctoral dissertation, University of Southern California.

Kemp, A. (2006). *Clocks, angles and functions.* Mathematics Teaching, 198, 35-37.

Kennedy, E. (1999). *Circles in Dynamic Software Environment. A project submitted to the School of Graduate Studies in partial fulfilment of the requirements for the degree of Master of Education,* Memorial University of Newfoundland.

Laborde,C.(2001). *Integration of Technology in the design of geometry tasks with Cabri- Geometry. International Journal of Computers for Mathematical Learning,* 6 (3) 283-317.

Leong, K. E. (2013*). Impact of Geometer's Sketchpad on* students' *achievement in graph functions.* The Malaysian Online Journal of Educational Technology, 1(2), 19-31.

Martinovic, D., Karadag, Z., & Freiman, V. (2011). *First decade of GeoGebra: Looking back through Socio-Cognitive Lenses (pp. 29-34)*. Retrieved from: http://ggijro.files.wordpress.com/2011/07/article-4.pdf

Matthews, J., Jaworski, B., Robinson, C. L., & Croft, A. C. (2012) *Engineering Students Understanding Mathematics (ESUM): Increasing conceptual understanding and engagement.* Presentation at the 16th SEFI Maths Working Group Seminar, University of Salamanca, Spain.

Myers, R. J. (1993*). Problem-Based Learning: A case study in integrating teachers, students, methods and hypermedia data bases.* Unpublished doctoral dissertation, Virginia Polytechnic Institute and State University.

NCTM. (2000*). Principles and Standards for School Mathematics.* Reston, VA: National Council of Teachers of Mathematics.

Piaget, J. (1950). *The psychology of intelligence.* London, UK: Routledge. Pomerantz, H. (1997). The role of calculators in mathematics education. Retrieved from: http://education.ti.com/sites/US/downloads/pdf/therole.pdf

Prescott, A., Mitchelmore, M., & White, P. (2002). *Student difficulties in abstracting angle concepts form physical activities with concrete materials*.

Raymer, D (2011) . *Extended Mathematics for Cambridge IGCSE (3rd ed.).* Oxford University Press.

Roberts, G. R. (2012). *Technology and learning expectations of the net generation.* University of Pittsburgh, Johnstown.

Russell, D. R. (1993). *Vygotsky, Dewey, and externalism: Beyond the student/discipline dichotomy. Journal of Advanced Composition,* 13(1), 173-197.

Sahaa, R., Ayub, A., & Tarmizi, R. (2010). *The effects of GeoGebra on Mathematics achievement: Enlightening coordinate geometry learning.* Procedia Social and Behavioral Science, 8, 686-693.

Sapkota, B. K. (2015). *Effectiveness of information communication technology integrated pedagogy at secondary level*. An unpublished master thesis , department of Mathematics Education, T.U., Kathmandu.

Upadhyay, H.P. (2001). *Constructivism in Teaching Mathematics.* Doctoral Dissertation: Chandigadha University India.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

White, J. (2012). *The impact of technology on student engagement and achievement in mathematics classroom*. Paper submitted in partial fulfilment of the requirements for the degree of Masters of Education, Memorial University, NL.

White, P., & Mitchelmore, M. C. (2002). *Teaching and learning mathematics by abstraction.* Intelligence and understanding in mathematics (pp. 235-256).

Zakaria E., & Lo, S. L. (2012*). Teacher's perceptions toward the use of GeoGebra in the teaching and learning of Mathematics*. Journal of Mathematics and Statistics, 8(2), 253-257.

APPENDIX-A

Teaching Episode-1

Subject: *Introduction to GeoGebra software*

Duration of lesson: *45 minutes*

Target group: *10 th graders (14-16 years old)*

Teachers: *Tika Ram Acharya*

Cooperating teacher: *Shyam Sundar Maharjan*

Date: 2072/06/18

****

I. Prerequisites:

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

II. Required Materials:

Computer, beamer/projector, projection screen (or cotton sheet) etc. GeoGebra 5.0 software is required.

III. Learning Objectives:

At the end of the first lesson the students should be able to:

- Recognize the working environment and some menu and toolbar of Geogebra window.
- Recognize some basic tools as well as motion slider in GeoGebra.

IV. Activities:

Lesson *(This was first day for experiment so that researcher not teaches about circle but he primarily focus about introducing students to GeoGebra software, features and application of this software with demonstrating following activities by PowerPoint.)*

1. Students were watchfully motivated when researcher saying various quotations related to the mathematical definition.

2. He was briefly explained about development as well as application of mathematics by the used of slides.
3. After that he was described about GeoGebra software.
4. All parts of circles in animated slides was demonstrated by me.
5. Then, various features and applications was explained by me.
6. GeoGebra software was opened by me then algebraic view, graphical view, spreadsheet view as well as many menu bar, tool bar, motion slider and so on of GeoGebra window were demonstrated to students with brief explanation where and how they could be used in teaching scenario.

Teaching Episode-2

Subject: *Circle (Theorem- 8)*

Duration of lesson: *45 minutes*

Target group: *10 th graders (14-16 years old)*

Teachers: *Tika Ram Acharya*

Cooperating teacher: *Shyam Sundar Maharjan*

Date: 2072/06/19

****

I. Prerequisites:

Students are familiar with basic concept about circle such as radius, centre, and circumference and so on.

II. Required Materials:

Computer, beamer/projector, projection screen (or cotton sheet) etc. GeoGebra 5.0 is required to be installed in computers.

III. Learning Objectives:

At the end of the lesson the students should be able to:

- Prove the theorem the central angle of a circle is double of the inscribed angle standing on the same arc by experimental verification.
- Prove theoretically the theorem the central angle of a circle is double of the inscribed angle standing on the same arc.

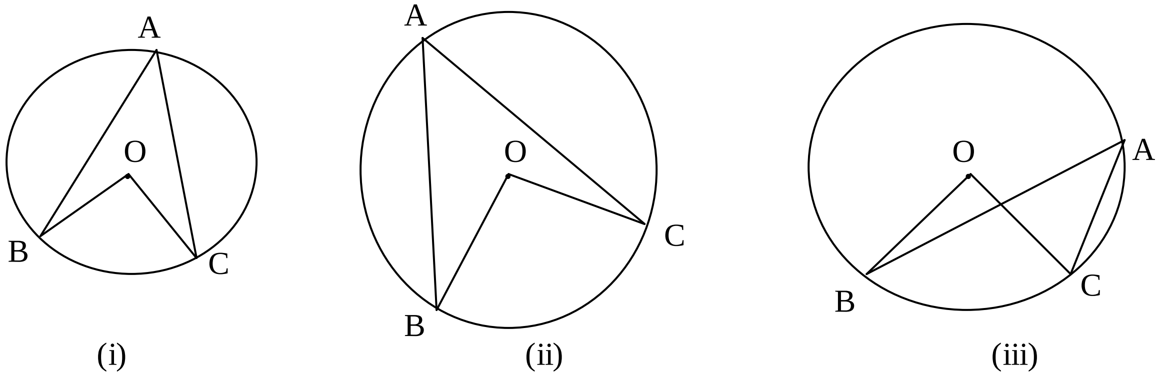
IV. Activities:

Lesson

A. Teaching learning activities by using GeoGebra is a new strategy for our Nepalese students therefore the researcher demonstrates the activities by using GeoGebra software.

Experimental Verification (25 Minute)

B. Researcher draw three circles of different sizes, Taking an arc BC, draw an inscribed angle < BAC and a central angle < BOC standing on same arc in graphical view of GeoGebra and then researcher ask to students to make above mentioned facts by using compass as well as protector in their copy.



C. Researcher should measure the central angle and the inscribed angle by using Geogebra software and tabulate the measurement in the following table in which researcher used PowerPoint to fill the following table. But student should measure the central angle and the inscribed angle by using protector software and tabulate the measurement in their copy.

Figure	Central angle < BOC	Inscribed angle < BAC	Result
(i)			< BOC = 2 < BAC
(ii)			
(iii)			

D. Researcher should ask to students what conclusion was derived. Students should give answer as here, the central angle BOC is double of the inscribed angle BAC standing on the same arc BC. Thus, the central angle of circle is double of the inscribed angle standing on the same arc was conclusion.

Theoretically Proof (20 Minute)

- Researcher used to GeoGebra software for figure. He demonstrates the figure of this theorem in Graphical view of GeoGebra window. After that researcher and students both interaction each other about figure as well as statement of the theorem together. In which researcher first give priority to students for answer and some time teacher discuss students' answer and last he demonstrate 'Given', 'To prove', 'Construction (if necessary)', 'Statements' and 'Reasons' in PowerPoint. In same time students write answer by watching slides.

Teaching Episode-3

Subject: *Circle (Theorem- 9)*

Duration of lesson: *45 minutes*

Target group: *10 th graders (14-16 years old)*

Teachers: *Tika Ram Acharya*

Cooperating teacher: *Shyam Sundar Maharjan*

Date: 2072/06/20

****

I. Prerequisites:

Students are familiar with the theorem of central angle of a circle is double of the inscribed angle standing on the same arc.

II. Required Materials:

Computer, beamer/projector, projection screen (or cotton sheet) etc. GeoGebra 5.0 is required to be installed in computers.

III. Learning Objectives:

At the end of the lesson the students should be able to:

- Prove the theorem angle standing on the same arc of a circle equal by experimental verification.
- Prove theoretically the theorem angle standing on the same arc of a circle equal by.

IV. Activities:

Lesson

1. Researcher draw three circle ABC of different radii by GeoGebra software in which he take a point A in the segment BC of each circle and draw < BAC. Again, take another point D in the same segment BC and draw < BDC and then researcher ask to students to make above mentioned facts by using compass as well as protector in their copy.
2. Researcher should measure the angle < BAC and < BDC subtended by the same arc BC of each circle by using GeoGebra software and tabulate the measurement in the following table in which researcher used PowerPoint to

fill the following table. But student should measure the central angle and the inscribed angle by using protector software and tabulate the measurement in their copy.

Figure	< BAC	<BDC	Result
(i)			< BAC = < BDC
(ii)			
(iii)			

3. Researcher should ask to students what conclusion was derived. Students should give answer as here, the angles formed on the same arc BC, < BAC = < BDC. Thus, the angle standing on the same arc of a circle are equal was main conclusion.

Theoretically Proof (20 Minute)

- Researcher used to GeoGebra software for figure. He demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that researcher and students both interaction each other about figure as well as statement of the theorem together. In which researcher first give priority to students for answer and some time teacher discuss students' answer and last he demonstrate 'Given', 'To prove', 'Construction (if necessary)', 'Statements' and 'Reasons' in PowerPoint. In same time students write answer by watching slides.

Teaching Episode-4

Subject: *Circle (Theorem-9)*

Duration of lesson: *45 minutes*

Target group: *10 th graders (14-16 years old)*

Teachers: *Tika Ram Acharya*

Cooperating teacher: *Shyam Sundar Maharjan*

Date: 2072/06/21

****

I. Prerequisites:

Students are familiar with basic concept about circle such as radius, centre, and circumference as well as have the knowledge of both of above theorem.

II. Required Materials:

Computer, beamer/projector, projection screen (or cotton sheet) etc. GeoGebra 5.0 is required to be installed in computers.

III. Learning Objectives:

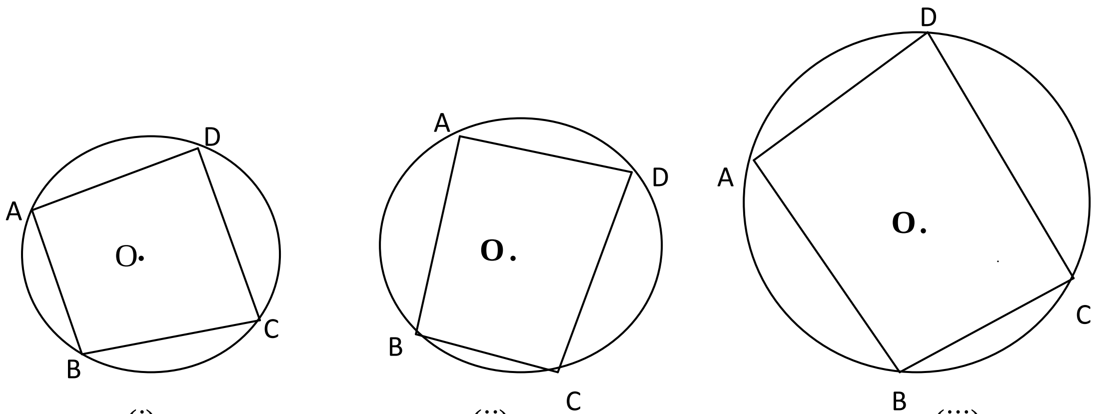
At the end of the lesson the students should be able to:

- Prove the theorem the sum of the opposite angles of a cyclic quadrilateral is equal to two right angles by experimental verification.
- Prove theoretically the sum of the opposite angles of a cyclic quadrilateral is equal to two right angles by experimental verification.

IV. Activities:

Lesson

- Researcher draw three circle ABCD of different radii with centre O by GeoGebra software. Take any four points A, B, C and D on its circumference and draw a cyclic quadrilateral ABCD in each circle and then researcher ask to students to make above mentioned facts by using compass as well as protector in their copy.



- Researcher should measure each pair of the opposite angles of each cyclic quadrilateral ABCD by GeoGebra and tabulate the measurement in the following table in which researcher used PowerPoint to fill the following table. But student should measure the central angle and the inscribed angle by using protector software and tabulate the measurement in their copy.

Figure	**< BAD**	**< BCD**	**<BAD+<BCD**	**<ADC**	**< ABC**	**<ABC+<ASC**	**Result**
(i)							<BAD+<BCD=180° <ABC+<ASC=180°
(ii)							
(iii)							

- Researcher should ask to students what conclusion was derived. Students should give answer as here, in the cyclic quadrilateral ABCD, < A + < B = 180° and < B + < D = 180°. Thus, the sum of the opposite angles of a cyclic quadrilateral is equal to two right angles was main conclusion.

Theoretically Proof (20 Minute)

- Researcher used to GeoGebra software for figure. He demonstrate the figure of this theorem in Graphical view of GeoGebra window. After that researcher and students both interaction each other about figure as well as statement of the theorem together. In which researcher first give priority to students for answer and some time teacher discuss students' answer and last he demonstrate 'Given', 'To prove', 'Construction (if necessary)', 'Statements' and 'Reasons' in PowerPoint. In same time students write answer by watching slides.

Teaching Episode-5

Subject: *Circle (Exercise)*

Duration of lesson: *45 minutes*

Target group: *10 th graders (14-16 years old)*

Teachers: *Tika Ram Acharya*

Cooperating teacher: *Shyam Sundar Maharjan*

Date: 2072/06/22

****

I. Prerequisites:

Students are familiar with basic concept about circle such as radius, centre, and circumference as well as have the knowledge of above theorems.

II. Required Materials:

Computer, beamer/projector, projection screen (or cotton sheet) etc. GeoGebra 5.0 is required to be installed in computers.

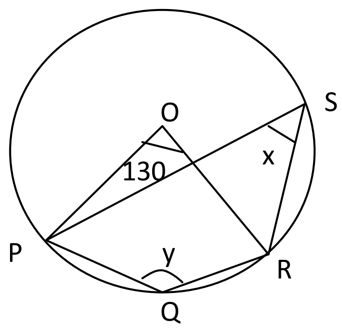
III. Learning Objectives:

- ✓ Solve the problem related to the above three theorem

IV. Activities:

Lesson

- In the beginning, the students are involved in a revision of their previous learning and activities as well as thinking on relevant questions concerning above three theorem.
- First of all, researcher makes the alongside figure in GeoGebra window



- After demonstrating the figure by projector, students also make the figure in their copy.
- Researcher interacts with students about finding the value of x & y.
- Students are involved in the interaction and same time teacher discuss about students point of view towards such type of problems.
- After that researcher measures the angles x & y by GeoGebra software and he gives reasons behind these unknown angles.
- After measuring angles in GeoGebra, he demonstrates the all solving process by slides in PowerPoint.
- Researcher gives such type of problem to the students by making the figure in GeoGebra window.
- Students are able to give the answer if they are not able, researcher will provide suitable suggestions for finding the unknown angles.

APPENDIX-B

Mathematics Achievement Test in Pre-test

Class: - X **Full mark:- 30**

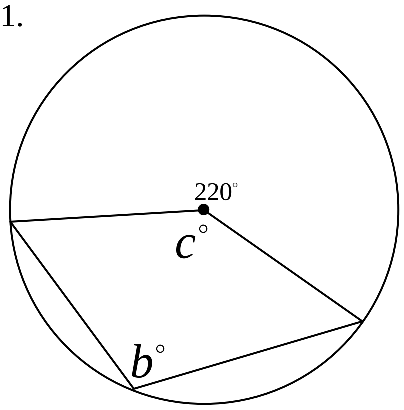
Sub: - C. Math **Pass mark: - 10**

Attempt all Questions.

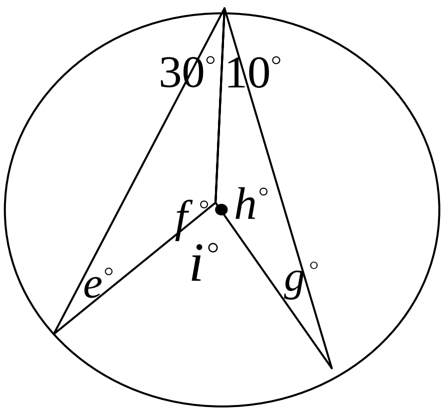
Group A:- [5x2=10]

From the following figures, find the value of missing character.

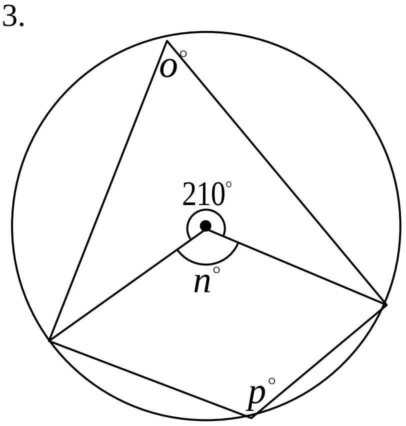
1.



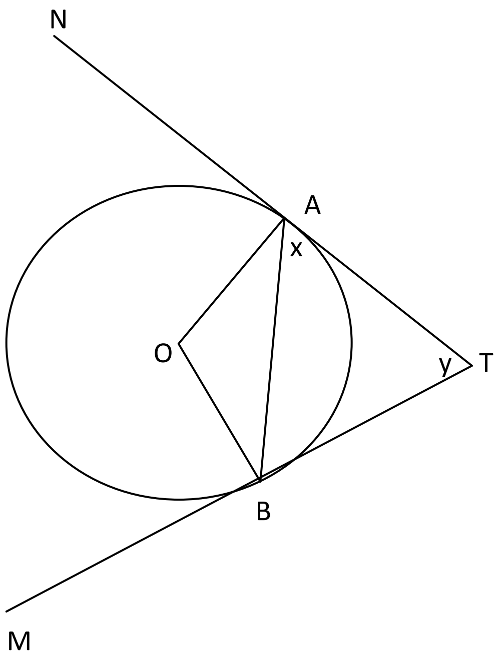
2.



3.



4.



5. Two cords AB and CD of a circle are intersected each other at a point Z inside the circle. IF BZ = 12 cm, DZ = 6 cm, and CZ = 16 cm, then find the length of AZ.

Group B:- [5x4 = 20]

6. Prove experimental verification of a perpendicular drawn from the centre of a circle to a chord bisects the chord.

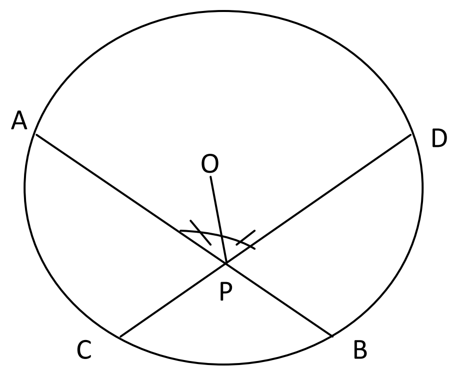
7. Prove experimental verification of the central angles subtended by equal arcs of a circle are equal.

8. Prove theoretically of equal chords of a circles are equidistant from the centre of the circle.

9. Prove theoretically of the central angle of a circle is double of the inscribed angle standing on the same arc.

10. In the figure, O is the centre of the circle. If ∠ OPA = ∠ DPO,

prove that AB = CD.



APPENDIX-C

Mathematics Achievement Test in Post-test

Class: - X **Full mark: - 30**

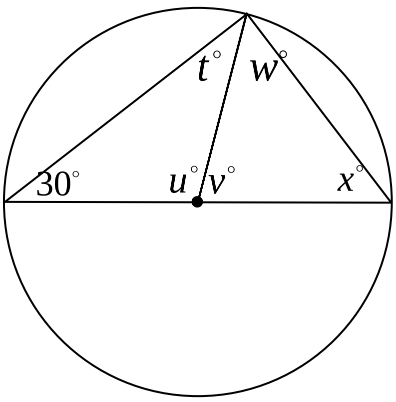
Sub: - C. Math **Pass mark: - 10**

Attempt all Questions.

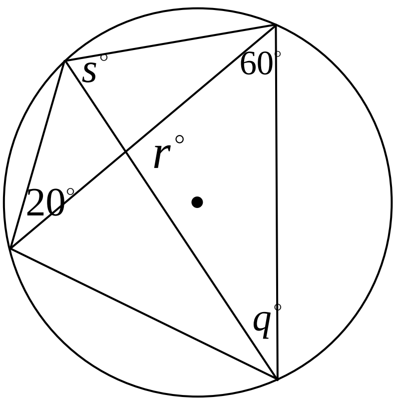
Group A: - [5x2=10]

From the following figures, find the value of missing character.

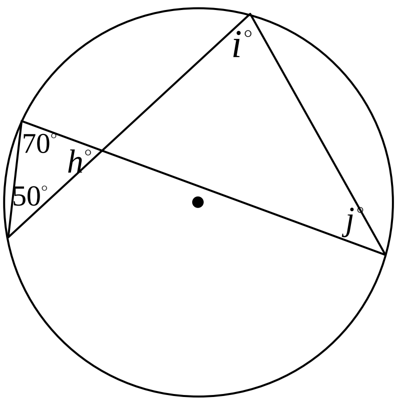
1.



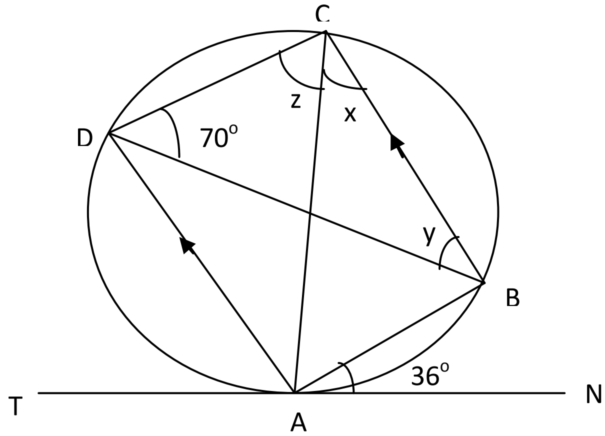
2.



3.



4.



5. Two chords MN and OP of a circle are intersected each other at a point Z inside the circle. If NZ = 14 cm, OZ = 7 cm, and PZ = 18 cm, then find the length of AZ.

Group B: - [5x4 = 20]

6. Prove experimental verification of a line joining the centre at a circle and the midpoint of any chord is perpendicular to the chord.

7. Prove experimental verification of if the arcs cut off by two chords of a circle are equal, the chords also are equal.

8. Prove theoretically of chords equidistant from the centre of a circle are equal.

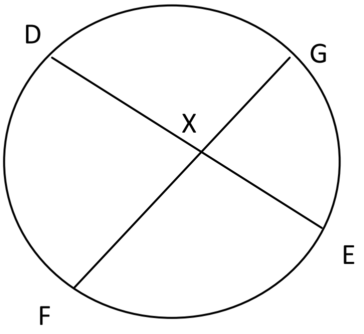
9. Prove theoretically of the sum of the opposite angles of a cycle quadrilateral is equal to two right angles.

10. In the given circle, two chords DE and FG

intersect each other at X inside the circle,

prove that:

$$\angle DFX \equiv \frac{1}{2}(\overset{\frown}{DF} + \overset{\frown}{GE})$$



Appendix - D

Item Analysis of the Test

Students / Items	Upper 27% students who giving correct response								Upper 27% students who giving correct response								P (%)	D Value	Remarks
	1	2	3	4	5	6	7	Total	1	2	3	4	5	6	7	Total			
1	1	1	1	1	0	1	1	6	1	0	1	1	1	0	0	4	71.43	0.29	
	1	1	1	1	0	1	1	6	1	0	1	1	1	0	0	4	71.43	0.29	
																	71.43	0.29	Accepted
2	1	1	1	1	1	1	1	7	0	0	0	0	1	0	1	2	64.28	0.71	
	1	1	1	1	1	1	1	7	0	0	0	0	1	0	1	2	64.28	0.71	
																	64.28	0.71	Accepted
3	1	0	1	1	1	0	1	5	1	0	0	0	0	0	0	1	54.17	0.57	
	1	0	1	1	1	0	1	5	1	0	0	0	0	0	0	1	54.17	0.57	
																	54.17	0.57	Accepted
4	1	0	1	1	0	1	0	4	0	1	1	1	1	0	1	5	64.29	-0.14	
	1	0	1	1	0	1	0	4	0	1	1	1	1	0	1	5	64.29	-0.14	
																	64.29	-0.14	Rejected
5	1	1	0	1	0	1	1	5	0	0	0	0	0	1	0	1	54.17	0.57	
	0	1	0	1	1	0	1	4	0	0	0	0	0	1	0	1	54.17	0.57	
																	47.67	0.43	Accepted
6	1	1	0	1	1	0	1	6	1	0	0	1	1	1	0	4	71.14	0.29	
	1	1	0	1	1	0	1	6	1	0	0	1	1	1	0	4	71.14	0.29	
																	71.14	0.29	Accepted
7	1	0	1	0	1	1	0	4	0	0	0	0	1	1	1	3	50.00	0.14	
	1	0	1	0	1	1	0	4	0	0	0	0	1	1	1	3	50.00	0.14	
																	50.00	0.14	Rejected
8	0	1	0	1	1	1	1	5	1	0	0	1	0	0	0	2	50.00	0.43	
	0	0	0	1	1	1	1	4	1	0	0	0	0	0	0	1	35.71	0.43	
																	42.86	0.43	Accepted
9	1	1	1	1	1	1	1	7	1	1	0	0	1	0	1	4	78.57	0.42	
	1	1	1	1	1	1	1	7	1	1	0	0	1	0	1	4	78.57	0.42	

																	78.57	0.42	Accepted
10	1	1	0	0	0	0	1	3	0	1	0	0	0	0	0	1	28.57	0.29	
	1	1	0	0	0	0	1	3	0	1	0	0	0	0	0	1	28.57	0.29	
	1	1	0	0	0	0	1	3	0	1	0	0	0	0	0	1	28.57	0.29	
	1	1	0	0	0	0	1	3	0	1	0	0	0	0	0	1	28.57	0.29	
																	28.57	0.29	Accepted
11	1	1	1	1	1	1	1	7	0	0	0	0	1	0	0	0	57.14	0.86	
	0	1	1	1	1	1	1	6	0	0	0	0	0	0	0	0	42.85	0.86	
	0	1	0	1	1	1	1	5	0	0	1	0	0	0	0	1	42.85	0.57	
	0	1	0	1	0	1	1	4	0	0	0	0	0	0	0	0	28.57	0.57	
																	42.99	0.71	Accepted
12	0	1	1	1	1	1	1	6	0	0	1	0	1	0	0	2	57.14	57.14	
	0	1	1	1	1	1	1	6	0	0	1	0	1	0	0	2	57.14	57.14	
	0	0	1	1	1	1	1	5	0	0	0	0	0	0	0	1	42.56	57.14	
	0	0	1	1	1	1	1	5	0	0	0	1	0	0	0	1	42.56	57.14	
																	49.85	57.14	Accepted
13	1	1	0	1	0	1	1	5	0	0	1	0	0	0	0	1	42.86	0.57	
	1	1	0	1	0	1	1	5	0	0	1	0	0	0	0	1	42.86	0.57	
	1	1	0	1	0	1	1	5	0	0	1	0	0	0	0	1	42.86	0.57	
	1	1	0	1	0	1	1	5	0	0	1	0	0	0	0	1	42.86	0.57	
																	42.86	0.57	Accepted
14	1	0	1	0	0	0	0	2	1	0	0	0	0	0	0	1	21.43	0.14	
	1	0	1	0	0	0	0	2	1	0	0	0	0	0	0	1	21.43	0.14	
	1	0	1	0	0	0	0	2	1	0	0	0	0	0	0	1	21.43	0.14	
	1	1	1	0	0	0	0	2	1	0	0	0	0	0	0	1	21.43	0.14	
																	21.43	0.14	Rejected
15	1	1	0	0	1	1	1	5	1	0	0	0	0	0	1	2	50.00	0.43	
	1	1	0	0	1	1	1	5	1	0	0	0	0	0	1	2	50.00	0.43	
	0	0	1	1	1	1	0	4	0	1	0	0	0	0	0	1	35.71	0.43	
	0	0	1	1	1	1	0	4	0	1	0	0	0	0	0	1	35.71	0.43	

																		42.86	0.43	Accepted
16		1	1	1	1	1	1	1	7	1	0	1	1	0	1	1	5	85.71	0.28	
		1	1	1	1	1	1	1	7	1	0	1	1	0	1	1	5	85.71	0.28	
		1	1	1	1	1	1	1	7	1	0	1	1	0	1	1	5	85.71	0.28	
		1	1	1	1	1	1	1	7	1	0	1	1	0	1	1	5	85.71	0.28	
																		85.71	0.28	Rejected
17		0	1	1	1	1	1	1	6	0	1	0	0	0	1	0	2	57.71	0.57	
		0	1	1	1	1	1	0	5	0	1	0	0	0	1	0	2	50.00	0.43	
		0	1	1	1	0	1	0	4	0	0	0	0	0	1	0	1	50.00	0.43	
		0	0	1	1	0	1	0	3	0	0	0	0	0	0	1	1	25.57	0.29	
																		45.82	0.43	Accepted
18		1	1	1	1	1	1	1	7	0	0	0	0	1	0	0	0	57.14	0.86	
		0	1	1	1	1	1	1	6	0	0	0	0	0	0	0	0	42.85	0.86	
		0	1	0	1	1	1	1	5	0	0	1	0	0	0	0	1	42.85	0.57	
		0	1	0	1	0	1	1	4	0	0	0	0	0	0	0	0	28.57	0.57	
																		42.99	0.71	Accepted
SUM	**Odd**	16	19	16	22	16	23	17		8	6	7	2	7	6	7				
	Even	19	16	18	20	17	18	22		12	6	9	10	9	6	8				
	Total	35	35	34	44	33	41	39		20	12	16	12	16	12	15				

APPENDIX - E

Reliability of the Achievement Test

S.N	Scores on Odd Items (X)	Scores on Even Items (Y)	X^2	Y^2	XY
1	16	19	256	361	304
2	19	16	361	256	304
3	16	18	256	324	288
4	22	20	484	400	440
5	16	17	256	289	272
6	23	18	529	324	414
7	17	22	289	484	374
8	8	12	64	144	96
9	6	6	36	36	36
10	7	9	49	81	63
11	2	10	4	100	20
12	7	9	49	81	63
13	6	6	36	36	36
14	7	8	49	64	56
Total	$\sum X = 172$	$\sum Y = 190$	$\sum X^2 = 2718$	$\sum Y^2 = 2980$	$\sum XY = 2766$

Correlation Coefficient (r_{xy}) $= \dfrac{N\sum XY - \sum X.\sum Y}{\sqrt{N\sum X^2 - (\sum X)^2}\sqrt{N\sum Y^2 - (\sum Y)^2}}$

$= \dfrac{14\ X\ 2766 - 172\ X\ 190}{\sqrt{14\ X\ 2718 - (172)^2}\sqrt{14\ X\ 2980 - (190)^2}}$

$=$ **0.88**

Reliability Coefficient (r) $= \dfrac{2\ r_{xy}}{1 + r_{xy}} = \dfrac{2\ X\ 0.88}{1 + 0.88} =$ **0.94**

APPENDIX-F

SCORE OF PRETEST

S.N	Scores of Students in Experimental Group	Scores of Students in Control Group
1	23	24
2	22	21
3	23	22
4	20	20
5	20	21
6	21	20
7	17	18
8	8	9
9	6	5
10	19	20
11	19	19
12	21	19
13	17	15
14	24	20
15	23	19
16	14	18
17	20	21
18	23	25
19	7	8
20	15	16
21	11	13
22	16	17
23	18	16
24	22	23
25	17	20
26	19	
27	21	
28	22	
	$\bar{x}$ = 18.14, S_1^2 = 23.98, S_1 = 4.90	**$\bar{x}$ = 17.96 S_1^2 = 22.76 S_1 = 4.77**

APPENDIX-G

SCORE OF POSTTEST

S.N	Scores of Students in Experimental Group	Scores of Students in Control Group
1	29	25
2	26	24
3	23	22
4	24	20
5	23	21
6	22	20
7	20	10
8	12	6
9	11	7
10	22	21
11	23	20
12	28	19
13	26	16
14	30	21
15	22	20
16	21	18
17	23	22
18	24	23
19	10	9
20	16	17
21	13	14
22	17	18
23	21	15
24	23	24
25	20	20
26	21	
27	25	
28	27	
	$\bar{x}$ **= 21.5, S_1^2 = 26.39, S_1 = 5.14**	$\bar{x}$ **= 18.08 S_1^2 = 26.23 S_1 = 5.12**

APPENDIX-H

MATHEMATICS PERCEPTION SCALE

S.N	Items	SD	D	UD	A	SA
1.	I like to use GeoGebra Software.					
2.	GeoGebra software helps to learn Mathematics concepts.					
3.	I feel confident when do the activities by using GeoGebra software.					
4.	I learnt a lot about Mathematics when using GeoGebra software.					
5.	I can think creatively and critically when using GeoGebra software.					
6.	I prefer to learn Mathematics with GeoGebra software.					
7.	GeoGebra software can help to increase my achievement in Mathematics.					
8.	I am excited when asked to explore the GeoGebra software.					
9.	I am happy if the teacher uses the GeoGebra software in teaching Mathematics.					

APPENDIX-I

Statistical Formula Used in Data Collection and Analysis Procedure

S.N.	Subject	Notation	Formula
1	Mean	$\bar{x}$	$\frac{\sum fx}{N}$
2	Variance	S^2	$\frac{\sum f(x-\bar{x})^2}{N} - \left(\frac{\sum f(x-\bar{x})}{N}\right)^2$
3	Pooled Variance	S_{p^2}	$\frac{(n_1-1){S_1}^2 + (n_2-1){S_2}^2}{n_1+n_2-2}$
4	Standard Deviation	S	$\sqrt{\frac{\sum f(x-\bar{x})^2}{N} - \left(\frac{\sum f(x-\bar{x})}{N}\right)^2}$
5	Pearsons's Correlation Coefficient	r_{xy}	$\frac{N\sum XY - \sum X.\sum Y}{\sqrt{N\sum X^2 - (\sum X)^2}\sqrt{N\sum Y^2 - (\sum Y)^2}}$
6	Difficulty Level of Items	P%	$\left(\frac{R_u + R_l}{N} X\ 100\right)\%$
7	Discrimination Index of Item	D	$\left(\frac{R_u - R_l}{\frac{N}{2}}\right)$, where R_u *and* R_l are the number of correct response given by upper 27% and lower 27% students respectively. N is the total number of lower 27% students plus total number of upper 27% students.
8	Reliability Coefficient	r_{tt}	$\frac{2\,r_{xy}}{1+\,r_{xy}}$
9	F-distribution	F	$\frac{{S_1}^2}{{S_2}^2}$