# EFFECTIVENESS OF MANIPULATIVE MATERIALS IN TEACHING MENSURATION

**A**

**THESIS**

**BY**

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**FOR PARTIAL FULFILLMENT OF THE REQUIREMENT FOR**

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## LETTER OF CERTIFICATE

This is to certify that Mr. Bishnu Tharu student of academic year **2073/075** with campus Roll No: 167 Exam Roll No: 7328333 and T.U. Registration No: 9-2-413-410-2013has completed his thesis under supervision of Mr. Krishna Prashad Bhatt during the period prescribed by the rules and regulations of Tribhuvan University, Nepal. The thesis entitled "**Effectiveness of manipulative materials in teaching mensuration"** has been prepared based on the results of his investigation conducted during the period of February 2021 to June 2021 under the Department of Mathematics Education, University Campus, Tribhuvan University, Kirtipur, Kathmandu. His thesis number is 1671 I recommend and forward his thesis for the evaluation as the partial requirements to award the Degree of Master of Education.

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## LETTER OF APPROVAL

This thesis entitled **"Effectiveness of manipulative materials in teaching mensuration"** submitted by Mr. BishnuTharuin partial fulfillment of the requirement for the Master's Degree in Mathematics Education has approved.

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## RECOMMENDATION FOR ACCEPTANCE

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

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## DEDICATION

This work is heartily dedicated to my respected parents Mother Shanti Tharuni, Brothers Krishna Bahadur Tharu, Purna Bahadur Tharu & Jung Bahadur Tharu and all family members whose support, love, care and sacrifices made me a person who I am now.

## DECLARATION

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

……..

BishnuTharu

Date:……

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…….

Bishnu Tharu

## ABSTRACT

This study entitled **"Effectiveness of manipulative materials in teaching mensuration"**. The main aims of this study were to compare the achievement of students taught by using instructional materials and without instructional materials and to find out the effectiveness of instructional physical materials on teaching mensuration. The research is based on constructivist view of learning and the design of this study was experimental research design under quantitative approach. Researcher used purposive sampling and selected sample schools from the Bardiya district. For the research purpose, researcher constructed a pre-test for measuring the knowledge level of 60 students of sample schools. Researcher constructed a pre-test on the basis of curriculum prescribed by CDC and administrated it and developed two groups as experimental group and controlled group. After fifteen days teaching and learning process on fifteen lesson plans, researcher had taken post-test on both experimental and controlled group. The collected data were analyzed by statistical method such as mean, standard deviation and t-test and came in conclusions.

The finding of this research revealed that there was no significance difference between both experimental and controlled groups before conducting any treatment while teaching mensuration. But there is significance difference between the achievements of students taught by manipulation of instructional materials and achievement of controlled group who were taught by without using manipulation of teaching materials on mensuration at secondary level. Manipulative materials motivate the students for the mathematics learning. Researcher found that manipulation of materials is very essential for conceptual and meaningful learning.

## ABBREVIATIONS

| | |
|---|---|
| CDC: | Curriculum Development Centre |
| NCTM: | National Council of Teachers of Mathematics |
| T.U. : | Tribhuvan University |
| Ggb: | Geogebra |
| T.S.A.: | Total Surface Area |
| L.S.A.: | Lateral Surface Area |

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# CHAPTER I

# INTRODUCTION

This is the study effectiveness of manipulative materials in teaching mensuration. This introductory part includes the background of the study, statement of the problem, rationale of the study, objectives of the study, research questions, significance of the study, delimitations of the study and definition of the key terms respectively.

## Background of the Study

Learning can be used to refer the process of acquiring knowledge and skills. It is a process by which the individual gains various habits, knowledge, skill and attitudes that necessary to meet the demands of life. The ultimate aim of all learning is to change one's behavior suited to the new situations. The existing behavior may change behavior may be formed. According to Skinner, "Learning is a process of progressive behavior adaption". It is called modification of behavior. Mathematics is one the subject that helps to go ahead with civilization. Mathematics makes our life orderly and prevents disorder. Mathematics is the cradle of all creations, without which the world cannot move an inch. Be it a cook or farmer, a carpenter or a mechanic, a shopkeeper or a doctor, an engineer or a scientist, a musician or a magician, everyone needs mathematics in their day to day life. Even insects use mathematics in their everyday life for existence.

Mathematics is a science of magnitude and number as well as the science that sustains the daily practices of man. It is the only core science subject that acts as pivot on which national development and wealth of any nation is created. Competency in mathematics learning is vital and sustainable to every individual’s meaningful and productive life. Mathematics learning is very important in enhancement and sustainability of human existence because mathematics is all about finding solutions to human problems and physical challenges. All these are indications that mathematics is useful in domestic and business deals, scientific discoveries, technological break through, problem-solving and decision making in different situations in life (Usman and Nwoye, 2010; Unodiaku, 2011; and National Council of Teachers of Mathematics, (NCTM) 2013).

To overcome the various problems on numerals, counting and calculation men themselves created and developed the important discipline called mathematics. The

word mathematics has been derived from the Greek word ‘mathanein’ which mean to learn. This indicates that mathematics is taken as a process of learning and interpreting the natural phenomenon of each individual. It has been explained in other ways such as it is the knowledge of numerals and calculation part of human’s life. Modern mathematics has been making a great effort and progress to make mathematics more meaningful and lively. Mathematics education is concerned with the development and implementation of appropriate mathematics curricula and with all issues associated with the teaching and learning in keeping with the concept of lifelong learning. Mathematics is an important tool to solve daily life problems. It is keys of all sciences. It directly deals with human life. Mathematics has become essential part of school curriculum.

Any materials which might be manipulative or virtual help to the make teaching and learning meaningful and conceptual. For the teaching learning activities of mensuration, instructional materials are very essential. Teaching learning materials are important for the teachers in teaching mensuration effectively as it help to a better interpretation and appreciation of the concepts, contents as well as the subject matter. Teaching learning materials also enables the students to proceeds towards concrete learning. Using teaching materials on learning is very beneficial such as it helps to students for applying the idea that the students learned in school to a real situation is the best outcome their learning could achieve, increase motivation, easiest to learn, promotes critical and creative thinking and fun learning etc. Problems which we solve in mensuration are related to our daily life. So, instructional materials are very essential to make learning meaningful and conceptual in school level.

Mensuration is the branch of geometry which deals with the measurement of area, length or volume. It is also the act or process of measuring. The mensuration took its birth in Egypt. Then it is was applied and expanded by great mathematician like Pythagoras, Euclid, Archimedes, Ptolemy etc. and further developed by Halley, Bernoulli’s Euler and Newton etc.

Manipulative materials have great significance on teaching and learning mensuration. Manipulative materials are physical materials, objects such as tiles, rectangular box, ruler, protector, cone, cylinder made with wood and paper. Manipulative materials are those materials which are designed to be touched or

handled by students. Manipulation is the skillful handling, controlling or using of something or someone. Manipulative make learning math interesting and enjoyable. Give students the choice of working on a page of problems or solving a problem with colorful and interestingly shaped blocks, and there's no contest. Manipulative intrigue and motivate while helping students learn. Manipulative are physical objects that are used as teaching tools to engage students in the hands-on learning of mathematics. They can be used to introduce, practice, or remediate a concept. It improves on the performance of students on learning mensuration.

The National Council of Teacher of Mathematics (NCTM, 2018) standard stresses the importance of having students' uses of manipulative materials. It must be selected that are appropriate for the concept being developed and appropriate for the development level of the students. By using manipulative materials children have the opportunity to obtain a higher level of thinking as well as transfer their knowledge into long term memory.

Mensuration is a very important topic when it comes to the geometry of the universe. By definition, mensuration refers to the part of geometry concerned with ascertaining lengths, areas, and volumes. Hence, it is easy to see why mensuration is instrumental and plays a big part in real-world applications. It is the branch of mathematics that studies the measurement of geometric figures and their parameters like length, volume, shape, surface area, lateral surface area.

The Ancient Egyptians created and developed effective methods for land surveying, leveling, and mensuration have used mathematics to deal with these methods of mensuration. Mensuration is a branch of mathematical science that is concerned with the measurement of areas and volumes of various geometric figures. Figures such as cubes, cuboids, cylinders, cones and spheres have volume and area. In the broadest sense, the mensuration is all about the process and approach of measurement that addresses the development of formulas to measure their areas and volumes. It is based on the use of algebraic equations and geometric calculations to provide factual information regarding the measurement of width, depth and volume of a given object or group of objects. Whilst the measurement results gained via the use of mensuration are estimates rather than actual physical measurements, the mathematical calculations are usually considered more accurate.

**Statement of the Problem**

In context of Nepal, most of school has been teaching mensuration without proper use of instructional materials. Many theories focus on the use of instructional materials in teaching learning activities. In case of mensuration, instructional materials are very essential to increase the understanding level and make concept clear on mensuration. In mensuration, length, breadth, heights, curve surface area, lateral surface area and volume have to be learned by the students. To make clear understanding on lateral surface area, curve surface area and total surface and volume while teaching three dimensional materials such as different base prism, pyramid, cone, cylinder and different mixed solid diagram, use of instructional materials are very essential. Previously done study on use of materials on mensuration was mainly focus on the use of manipulative materials. Which found only the lack of materials, less concern of subject teacher, less support of administration, insufficient knowledge of materials of subject teacher, busyness of teacher were the major reasons of felling mensuration difficult to the students. This study mainly concerned with the impact of manipulative materials and virtual materials on learning of mensuration at secondary level. This study has investigated on the use of manipulative and virtual materials yield better achievement of students than without using manipulative materials. Also, it was searched on the perception and understanding of students when they taught with using manipulative materials and using the virtual materials made by Geogebra and without using any instruction materials.

**Justification of the Study**

Every research is important in itself because it unfold various unseen facts in any area of the study. This study was research on the effectiveness of instructional materials on teaching mensuration. So, it is very helpful to teachers, students and other stakeholders know about the difference between the achievement of students taught by the instructional materials and without use of instructional materials. It can help to teacher how to use of physical and virtual materials in teaching mensuration. The following points make clear on the justification of this study:

- The study helps teachers and students to improve in their teaching learning strategies by using physical and virtual materials in mensuration.

- It helps to the curriculum planners and textbooks writers to organize the physical and virtual materials in the student's perspective while teaching and learning mensuration.
- This study would help to improve the teaching method adopted by mathematics teachers.
- It helps to compare on the achievement of students using physical and virtual materials and without using the materials.
- It helps to find out the effect of instructional materials in teaching mensuration at secondary level.
- It makes alert to all stakeholders instructional materials are very essential while teaching mensuration.

**Research Objectives**

The following were the major objectives of this study:

- To compare the achievement of students taught by using instructional materials and without instructional materials.
- To find out the effectiveness of instructional materials on teaching mensuration.

**Hypothesis of the Study**

**Research Hypothesis.** The mean achievement of the students who taught by using instructional materials (physical and virtual) was higher than the mean achievement of the students who taught by without using instructional materials in teaching mensuration at secondary level.

**Statistical Hypothesis.** The following statistical hypothesis were formulated

**Null hypothesis.** $H_0 : \mu_1 = \mu_2$(There is no difference between mean achievement scores of experiment and control groups on pre-test)

**Alternative hypothesis.** $H_1 : \mu_1 \neq \mu_2$ (There is difference between mean achievement scores of experiment and control groups on post-test)

Where $\mu_1 \; and \; \mu_2$ are the mean achievement scores of students who were taught by using instructional materials and without using instructional materials in teaching mensuration at secondary level.

**Delimitations of the Study**

The research was related to effectiveness instructional materials in teaching mensuration at secondary level. The delimitations of this study were as follows:

- This study was conducted with experimental and control groups of the students of grade X of Bardiya district.
- Only one or two school was selected as experimental and control group by sample random sampling.
- This study was concerned on mensuration of grade X.
- The study was limited on the area and volume of triangular base prism, square based pyramid, cone and cylinder of grade X.
- The experiment class was taken 15 periods.
- Finding of this study cannot be completely generalized because of the limited time.
- This study used achievement test tool.

**Operational Definition of Key terms**

**Students.** Students are the Students who had studied in samples schools in grade X.

**Achievement.** It is defined in terms of the scores of students of grade X obtained in pre-test and post-test by experimental and control groups.

**Experimental group.** The group of students who were exposed to the regular instructional materials in unit mensuration in the classroom.

**Control group.** The group of the students who were taught without using any instructional materials in teaching mensuration at grade X classroom.

**Effectiveness.** It is defined as the magnitude of the score obtained by experimental and control group in mathematics achievement test.

**Physical materials.** In this study, physical materials refer to the manipulative materials which can be manipulated by students and teacher both in teaching learning mensuration. Such as ruler, rectangular objects, real object of cylinder, cone, triangular prism, square base pyramid etc.

**Virtual materials**. In this study, virtual material refers to the materials which were constructed by GeoGebra mathematical software.

# CHAPTER II

# REVIEW OF RELATED LITERATURE

Review of related literature is an essential part of the research. It is a comprehensive summary of previous research on a topic. Literature review surveys books, scholarly articles, and any other sources relevant to a 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. The purpose of a literature review is to provide foundation of knowledge on topic. Identify areas of prior scholarship to prevent duplication and give credit to other researchers. This chapter presents the review of the related empirical literature, theoretical literature and Conceptual Framework of the study. The related and relevant studies provide the researcher to answer the questions what and how the related studies have been carried out. It provides the researcher in making his problem more realistic, precise, researchable and meaningful. It helps to conduct the research program and gives a better idea for research. Thus the review of literature is an important and essential guideline of research planning. In this study the researcher reviewed the considerable related and relevant literature carried out by various researchers in the field of errors in mathematics.

So, I collected the different unpublished thesis, some books, journals, and articles, researches which are related to effectiveness of teaching materials while teaching mensuration and others topics of mathematics. By deeply study of these reports, I reviewed the following literature as academic writing.

## Empirical Literature

Tiwari (2014) conducted research on impact of manipulative materials in teaching mathematics at basic level in Nawalparasi district. The objectives of this study were to compare the achievement in mathematics of grade V students taught by using manipulative materials and without using manipulative materials and explore the feeling of the students and their activities in the class while teaching them by using manipulative materials. For this research pre-test, post-test and non-equivalent group design was adopted. Two school and 40 students were selected randomly as a sample of this study. This study found that the mean of the achievement of the

students teaching using manipulative materials was higher than the mean of achievement of the students teaching without using manipulative materials.

Chaudhary (2011) conducted study on effectiveness of instructional materials on teaching mensuration at secondary level grade X. This study has objectives to compare the achievement of students taught by using instructional materials and without materials. This study followed pre-test post-test equivalent group design. Researcher has taken the sample of this study from Siraha district. Researcher chooses 44 students as the sample of this study. Experiment and control group was determined by tossing as coin. In this research, researcher found that the achievement of the students of experimental group has better achievement that the students of control group.

Karki (2010) did a research on the topic on a study on the effectiveness of instructional materials in teaching geometry at grade X. The objectives of this study were to find the effectiveness of instructional materials in teaching geometry at grade X in Bhaktapur district. This study had taken 40 students as a sample from a single school. This study found that the mean achievement score of students taught with using different instructional is higher than the mean score of students taught without using instructional materials. Finally, it found that the geometry teaching by using different instructional materials causes better achievement than the achievement come by the teaching without using instructional materials.

Tella (2007) did a study on impact of motivation on students' achievement and learning outcomes in mathematics among secondary school in Nigeria. This study has objectives to explain learning outcomes in senior secondary mathematics in term of motivating students towards academic gains in the subject. The null and alternative hypothesis was tested at 0.05 level of significance of the study. This study was adopted ex-post facto research design. It comprised all senior secondary students of North-West and South-West local government areas of OYO state of Nigeria, as a population of this study. Whereas 450 students were randomly drawn from 10 selected secondary school to make a sample of the study. This study used questionnaire, in-depth interview as a research tools. Data collected from different tools were analyzed by using inferential statistics like as t-test and ANOVA. This study concluded that motivation has impact on academic achievement of secondary

school students in mathematics with respect to gender. It also revealed that highly motivated students perform better academically than the lowly motivated students.

Gautam (2005) conducted a study on the effectiveness of instructional materials in teaching mensuration at secondary level. This study has the objectives to find out the effectiveness of instructional materials in teaching mensuration at secondary level mathematics achievement of boys and girls in content mensuration taught by using instructional materials for experimental and control groups of grade ten. This study found that the performance of the students taught with the use of instructional materials was significantly better than the students taught without the use of instructional materials.

Sharma (2002) conducted a research on a study on the availability and use of instructional materials in teaching mathematics of the primary school of Parbat district of Nepal. The objectives of this study were to investigate the availability and use of instructional materials in teaching mathematics at primary level. In this study, twenty five schools of Parbat School were randomly selected as a sample school. Twenty five teachers teaching at primary level mathematics were interviewed for the collection of data. Simple percentage reporting was applied to conclude that the availability of the materials was not found very encouraging in most of some materials such as scale, compass, clock model and abacus etc.

Yadav (2002) conducted on research on a study on the use of visual aids in instruction of mathematics in the primary school of Dhanusha district. Out of hundred eighty schools, sixty primary schools were selected randomly. One hundred three teachers were selected from sample school. This study found that the trained teachers used teaching aids are frequently that untrained ones and more than 80 percent school lacked the essential teaching aids such as geo-board, geometric and Cubic Square models etc.

Mitra (2001) conducted a study on teaching materials and subject wise classroom observation available in CERID/ SRC: A study report submitted to research and development section department of education by management innovation, training and research academy with a view to investigate the availability and utilization of curriculum materials in public primary school' with the research question. How have these curriculum materials used in the classroom, what have been

the instructional practices. The research team visited fifty schools and observed on hundred fifty classes of mathematics, social studies and Nepali in each school. This study found that for the primary level, teaching materials are extremely helpful to learn and understand the concept of mathematics, principles theorems formulas etc.

Upadhyaya (2001) conducted his study on effect on constructivism on mathematics achievement of grade V students in Nepal. The objectives of this study were to adapt and advocate constructivism in class working on the sample size of 118 students from our schools involving two control and two experimental groups. The research found the possibility of constructivism, in Nepalese schools with significant difference in achievement that of students in favor of teaching method based on constructivism approach than conventional method of teaching.

**Theoretical Literature**

The theoretical framework defines the key concepts of the study. A strong theoretical framework gives a sound scientific basis, demonstrates your understanding of existing knowledge on the topic, and allows the reader to evaluate guiding assumptions. It provides direction for research, allowing strongly interpreting, explaining and generalizing from your findings. In this study, there is also some theoretical framework review to makes the study scientific basis and to make the clear guideline for the study

**Constructivism**

Constructivism is the theory that says learners construct knowledge rather than just passively take in information. As people experience the world and reflect upon those experiences, they build their own representations and incorporate new information into their pre-existing knowledge. Constructivist learning theory underpins a variety of student-centered teaching methods and techniques which contrast with traditional education, whereby knowledge is simply passively transmitted by teachers to students. From this perspective, a teacher acts as a facilitator of learning rather than an instructor. Teacher has to manage everything such as teaching materials, learning environment etc.

Constructivism learning theory is the further development as behaviorism arrives at cognitivism. According to its teaching theory: knowledge is uncertain; the learning process of knowledge is also the construction process of knowledge; students are the

main body of learning activity and they construct knowledge on their own initiatives; teachers are the helpers and the drivers for students constructing knowledge.

**Basic ideas of constructivism learning theory.**

On knowledge: Knowledge is only an explanation and an assumption but not the final answer for all questions. In contrast, it will be discarded along with the human process and new assumption will appear. Besides, knowledge cannot International Education Studies www.ccsenet.org/ies 198 summarize the world rules precisely. In other words, we cannot apply knowledge to certain problems directly. We have to analyze certain issue based on practical conditions. In addition, constructivists agree that knowledge cannot live on its physical form and out of specific entity. Although language and signals endow knowledge with certain forms, it does not mean learners have same understandings toward these statements, just as one hundred people will have one hundred different understandings toward Hamlet. These understandings are based on individual learners' experiences and backgrounds, what is determined by specific learning experience.

On learning: Learning is the process that individuals construct their cognitive structures. "Construction" is a kind of initiative, conscious, and self-organized recognition way. It is the "interaction" between the subject and the object. The learning process is the construction of knowledge. Learning is an initiative construction and the generation of meanings. This process is completed by the interaction of learners' old and new knowledge. In other words, pure external stimulation is meaningless. Only when learners code, process, and construct their unique understandings based on their previous experiences, can it be real learning.

On students: Students enter classrooms with their rich previous experiences. They hold their opinions toward daily life and even universal issues. Even though they do not know some issues and have no experiences, they may form special explanations and assumptions based on previous experiences and cognitive abilities as some issues appear. That is not illogical guess but logical assumption based on previous experiences. Therefore, teaching should take students' previous knowledge and experience as the growth point of new knowledge, and introduce students to generate new knowledge from the former.

On teachers: As we emphasize on the students as the subjects, we should change the role of teachers, from the initiator and the indoctrinator into the helper and the driver for students constructing meanings initiatively. In other words, teachers should be the

designer of teaching environment, the guider for students' learning, and the academic consultant for students. It discards the traditional teaching mode that takes teachers as the center, which merely focuses on conveying knowledge, regarding students as the object for receiving knowledge. The new teaching mode takes students as the center, under the guidance of teachers. Teachers organize and guide the whole teaching process.

Based on analysis above, we know that constructivism learning theory puts forward new explanations for learning and teaching. According to this theory, students are the subject in teaching. Teachers should offer more humanism cares for students and create a favorable teaching environment for students. It emphasizes on the initiatives and the interaction in teaching. Students should focus on exploration learning and cooperative learning based on previous knowledge and experiences by means of interactive actions. By this way, students can improve their cognitive ability continuously. Teachers can help students form the positive technique, the affection, the attitude, and the habit in learning.

Finally, this theory helped to researcher to associate the instructional materials with the need and interest of the students. It helped researcher to creative the environment of learning by doing, learning by real experiences with instructional materials and virtual materials.

**Conceptual Framework**

A conceptual framework is a representation, either graphically or in narrative form of the main concepts or variables, and their presumed relationship with each other. A conceptual framework covers the main feathers (aspects, dimensions, factors, variables) of researcher and their presumed relationship.

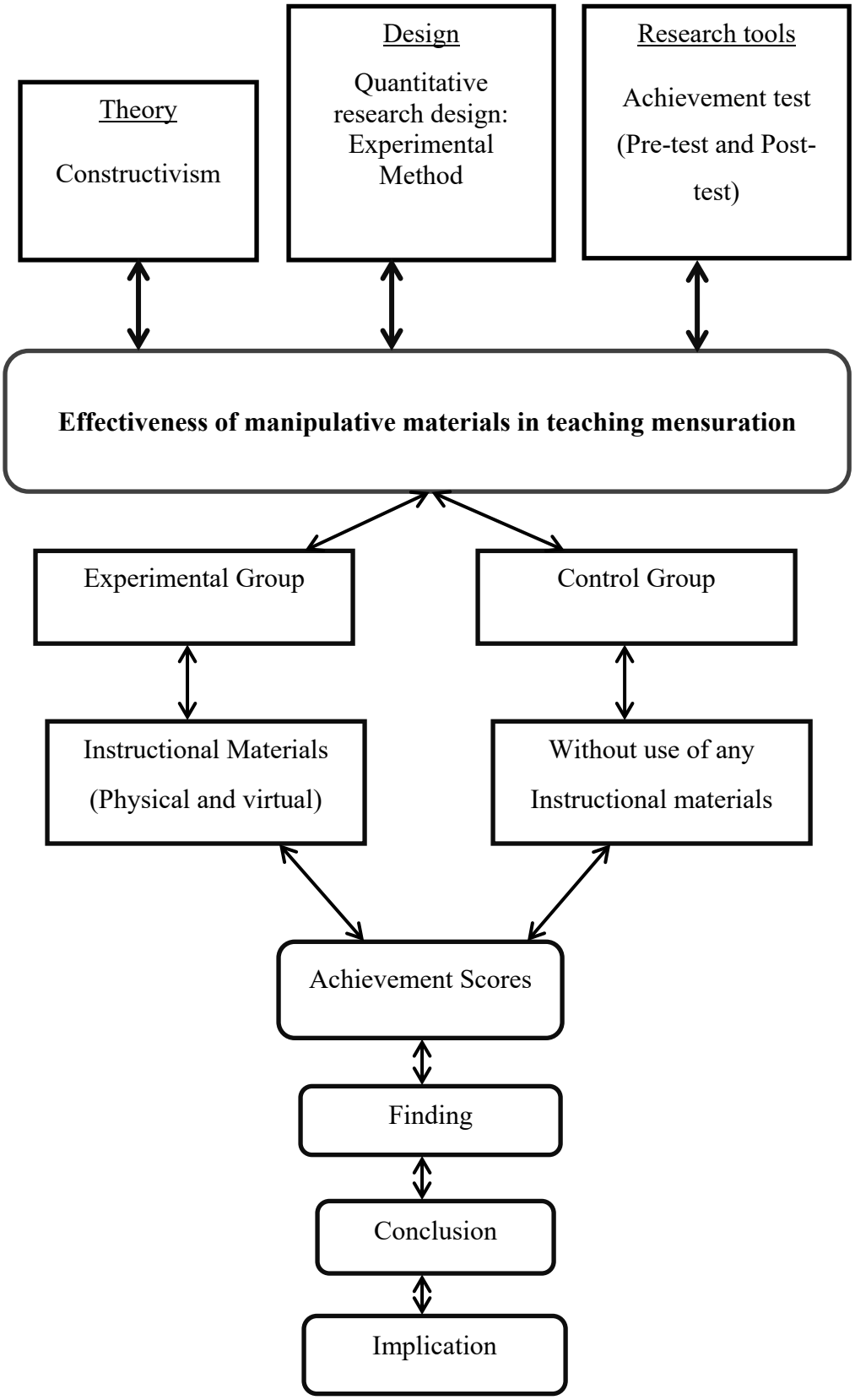


*Figure 1*: conceptual framework of the study

**Implications of the review for the study**

The review of related literature is one the most part of any study or research as it provides the theoretical and empirical backup to the related present study. This provided the fundamental knowledge on the topic, helps to identify the inconstancies gaps in research. The related review provided information that how the proposed research was related to prior research. For this study, the related review of literature exposed the originality and relevance of the study, provide the important aspect of the study, identify the data sources, the population of the study, and familiar with the design of the study, and provide further consideration of the study. Thus the review of related literature was more implicated for this study.

# CHAPTER III
# METHODS AND PROCEDURES

Research design is an important part of the research. So, it is called the heart of the research. This chapter was described the plans and procedures of the study under the separate heading which must be carried out to achieve the objectives of the study, participants of the study, tools for data collection, interview schedule, classroom, observation from, validity and reliability of tools, data collection procedures and date analysis procedures.

## Design of the Study

This study had followed the experimental research design under the quantitative approach. This research had two groups which are the experimental group and the control group. The experimental group was taught by using instructional materials (physical and virtual) and the control group was taught by using usual materials. The researcher used pre-test post-test non-equivalent group designs. In the pre-test and post-test nonequivalent groups design there was a treatment groups' that was given a pretest, receives a treatment, and then was given a posttest. But at the same time there was a non-equivalent control group that was given a pretest, did not receive the treatment, and then was given a posttest. The question, then, was not simply whether participants who receive the treatment improve, but whether they improve more than participants who did not receive the treatment. The design of this study has shown in the following chart.

Table no.1:*Design of the study*

| Group | Pre-test | Treatment | Post-test | Experiment |
|---|---|---|---|---|
| Experimental | $T_1$ | $T_e$ | $T_2$ | Instructional materials (Physical and virtual) |
| Control | $T_1$ | - | $T_2$ | As usual materials |

Where,

$T_1$ = Pre-test was taken to the experimental and control groups.

$T_2$ = Post-test was taken to the experimental and control groups.

$T_e$ = treatment using by instructional (physical and virtual) materials.

This design is one of the most effective to minimize threats to experimental validity. Two groups were made by selecting schools of similar status with respect to physical facilities, size of the class, academic achievement, teachers' qualification, and experiences for experimental and control groups.

**Field of Study**

I will choose two schools of Bardiya District as a research site for the study. Those two schools are Shree Ek Prkiya Rathour Secondary School, Patabhar and Shree Kalika Secondary School Chanaura Sonpur. I will choose that for the study where result of the study was reliable and I can find the participants easily for my study.

**Population of the Study**

A population is a group of items, units or subjects which are under the reference of study. The population may consist of a finite or infinite number of units (Agrawal, 2003,p.184). It is better to study each and every unit of the population for a real condition of learning achievements subject-wise however; it is generally impossible to study each individual that is whole units of the group under consideration (Bhatt, 2020, p.34-37).All the grade X students of the Bardiya district were taken as the population of this study.

**Sample**

In research terms, a sample is a group of people, objects, or items that are taken from a larger population for measurement. The sample should be representative of the population to ensure that we can generalize the findings from the research sample to the population as a whole. Based on the population of these study two school from Bardiya district was chosen as the sample school of this study. The students who were studying at grade X were taken as the sample students of this research.

**Sampling Strategy**

It is a way of choosing or selecting a sample from a large population. All selected students will be from same culture and well equipped and they must have physical infrastructures which are required. By tossing a coin two group (Experimental and Control) are selected from both school. When toss a coin head is occur and its taken experimental group of one school of grade X and next remaining school taken as control group.

**Variable of the Study**

Variables are key ideas that researchers seek to collect information on to address the purpose of their study. A concept that can take on different quantitative values is called a variable. Also, variables is a characteristic or attribute of an individual or an organization that researcher can measure or observe and varies among individuals or organizations studied (Creswell, 2012). In this research, the dependent variable was the achievement of the students in the experimental and control groups. Also, the instructional materials (physical and virtual) were taken as the independent variable.

**Controlling the Extraneous Variables**

In this research, selection of school, instructor, subject matter, selection of teaching materials, school environment, the discipline of the students, experimental time, student labor, home environment, maturation of student and test were considered as extraneous variables.

Many research conclusions of the experimental research are open to question due to the influence directly or indirectly of extraneous variables (Best & Khan, 2006). The researcher should control the extraneous variable to insure the validity of the result of the research. In this research, two schools were selected in the sample which had a similar mean. The researcher himself had taught for both experimental and control groups to minimize teacher variables. The researcher had been taught the chapter mensuration of grade X for both groups in the experimental period. Similarly, the researcher provided equal time to both groups and the same test item was provided for both groups after and before experimentation. So, this variable had not any impact on the achievement of the students. In this way, the researcher controlled extraneous variables.

## Research Tools

Research tools are the instruments that are used to collect the data. In this study, the researcher used achievement tests, class observation, and construction of episodes.

### Achievement test

In this research, the achievement test is the main instrument for the collection of data. An achievement test was made by the researcher in which achievement test was constructed on the basis of the prescribed curriculum and textbook of grade X on the topics of mensuration. The test contained the items from knowledge level, skill levels, and application level. The researcher constructed two achievements tests one for pre-test and another for post-test. The pre-test contained 20 objectives questions. The post-test contained 10 objectives questions, 8 subjective questions of all levels. The pre-test had 20 full marks whereas the post-test had 30 full marks.

### Development process of achievement tests.

On the basis of national goals of class ten mathematics on curriculum, the achievement test was constructed. It has covered major area of mensuration of class X mathematics prescribed by mathematics textbook of curriculum development centre. Furthermore, it has covered three domains of Bloom's Taxonomy: cognitive, affective and psychomotor. A specification chart was developed after examining and evaluating present curriculum, content and lessons in prescribed textbooks in order to determine the content validity. Being based on the above mentioned parameters and researcher constructed achievement test tools for pre-test and post-test of research. Achievement tests were helpful to find the effectiveness of manipulation of materials in teaching mensuration of class X.

### Construction of episodes (Lesson plan)

In this study researcher constructed fifteen teaching episodes in 15 periods for the experimental period. Each episode was constructed to meet the objectives of this study. The researcher was taken the each class according to the pre-planned teaching episodes. Experimental and control both group was taught the same subject matter based on planned. Experimental group students were taught by using

instructional materials (physical and virtual) and control group was taught by conventional way of teaching method and materials.

To ensure the reliability of the episodes, two subjects teacher from the sample school were taken. Also, to ensure the validity of the episodes specification grid prescribed by CDC and supervision of supervisor had used.

**Reliability and validity of achievement tests**

Reliability refers to how dependably or consistently a test measures a characteristic. The reliability of the achievement tests (pre-test and posttest) were determined by pilot tests. The content of written tests schedule was selected on the basis of grade X mensuration's curriculum. Validity of the tests was established with the help of internal supervisor, experts, subject teacher and other related documents.

In the pilot test of pre-test of achievement test, researcher used split half method of reliability test, the reliability coefficient (correlation coefficient) with the help of Pearson's formula, it is found that 0.57 which is substantial (Garret, 2008, p.176). It shows that the pretest of achievement test has a substantial consistency. Similarly, the pilot test of post-test of achievement test, researcher used the same method of reliability test as reliability test of pre-test of achievement test. The researcher found the reliability coefficient by the help of Pearson's formula as 0.60 which is substantial (Garret, 2008, p.176).

**Item Analysis**

In item analysis, the difficulty level p-value and discrimination index D-value of the test was computed to check the quality of the test items of achievement test both pre-test and posttest. Researcher was prepared the achievement tests and administrate to the sample students of sample schools. Researcher indicated the correct answer by 1 and incorrect answer by 0. To calculate the difficulty level of the items, researcher used the mathematical procedure. In which, researcher had calculated the difficulty index-p according to Ronald Fisher method. He had generalized the following formula;

$$\mathrm{P} = \frac{R}{T} \times 100\%$$

where, P= Difficulty index of the item

R= Number of examinee who gave correct answer

T= Total number of examinee

Similarly, researcher had calculated the discrimination index according to Ebel and Frisbie, 1991. They generalized the following formula;

$$D = \frac{RU-RL}{T/2}$$

where, D= Discrimination Index

RU= above 27% student's correct answer numbers

RL=below 27% student's correct answer numbers

T = Total students numbers below and above 27%

The researcher did the item analysis and found the difficulty level of both tests as pre-test and post-test of achievement test. From the item analysis, it helps in selecting the best items for final test, reject poor items and modify some of them (Bajracharya, 2007). It was decided that the three items Question no. 19, 23 and Question no. 22 eliminate from the pre-test of achievement test. Because Q. no. 19 and 23 has p-value 0%, so it can't able to measure the achievement level of students as well as Q. no. 22 have 100% p-value, so it can't able to measure the level of knowledge of students (Appendix-B and E).Similarly, it was decided that the five items Question no. 7, 17, 29, 31 and Question no. 35 eliminate from the post-test of achievement test. Because eliminated five questions has either most or least D-value and P-value. In this way, achievement tests were constructed for both pre-test and post-test.

**Data Collection Procedure**

The date collection procedure is a very important part of every research. To creative the suitable environment and to collect data, the researcher contacted and visited government schools. Then the researcher was taken permission from the administration of sample schools. Researcher consulted to the related stakeholders of schools and conduct exam and take interview with head teacher, subject teacher and students. The researcher collected the data by taking achievement test from experimental and control groups of this research.

**Data analysis and interpretation procedures**

The collected data was analyzed and interpreted by using different statistical tools such as mean, standard deviation, t-test and variance. The t-test at 0.05 level of significance was used to compare the achievement score of students of experimental and controlled groups. At last, descriptive analysis was used to find the effectiveness of instructional materials in teaching mensuration at secondary level.

**Ethical Considerations**

This study was conducted for the academic purpose while collecting data, ethical considerations was ensured for the primary data privacy. with regarding this study, researcher was clearly informed his objectives to respondents. He did not use the data for other purpose except his research.

# CHAPTER IV

# ANALYSIS AND INTERPRETATION OF THE DATA

This chapter is the main body part of this study. The primary and secondary data are collected in unprocessed form. So, in this chapter, such unprocessed data are presented in systematic formats and analyzed using different statistical tools and techniques. The collected data from different sources are presented and analyzed separately using both qualitative and quantitative measure. In this course of analysis, data gathered from various sources have been inserted in the tabular form. The research finding are interpreted, explained and presented with regards to the objectives specified for the study.

This study has two groups as group 'A' (experimental group) and group B (Control group). Each group contains 30/30 students from a sample school. The data were collected from 60 students by taking pre and post-achievement tests; interviews has taken with sample respondents including twelve students, two subject teachers, and principals from sample schools. The result of achievements obtained from experimental and control groups have been compared to each other. The data score on achievement tests was analyzed by using quantitative techniques. The main parameter of the study to explore the effectiveness of manipulative materials teaching mensuration is the performance and achievement of the students. In this chapter to gain the objectives of this study and come in a conclusion, the following headings were built to analyze the data obtained from the achievement tests:

- Analysis of Pre-test Result
- Analysis of Post-test Result
- Comparison between achievement scores on pre-test and post-test
- Impact of manipulative materials on students' learning

## Analysis of Pre-Test Result

In this study, pre-test refers to test on the control group and experimental group before conducting the experimental treatment on the experimental group. A test is given to determine if students are sufficiently prepared to begin a new course experiment of study or not is a pre-test. This test had been asked the questions from the basic part of mensuration. The researcher had taken the questions from the area

and perimeter of plane figures in the pre-test. The pre-test contained 20 objectives questions each carried one mark. Therefore, the total mark of the pre-test was 20. The achievement test for pre-test was prepared on the basis of the specification grid of class X prepared by the curriculum development center as well as consult to the subject teachers and supervisor of this study. The purpose of this test was to measure the level of knowledge/ pre-capacity of the students on both groups whether they had the same level of knowledge on mensuration or not. The achievement test paper was same for the both groups (APPENDIX: C).

A pre-test was taken in class X of both experimental and control groups before conducting any treatment. The obtained marks of 30 students from the experimental group and 30 students from the control group were taken for the study which is given in the table below. The calculated mean, standard deviation and t-value on the pre-test result are shown in the following table.

Table 2:*Comparison of student's achievement on pre-test*

| Group type | Sample | Mean | S.D. | Variance | Calculated t-value | Decision |
|---|---|---|---|---|---|---|
| Experimental | 30 | 14.76 | 2.59 | 6.7081 | 0.072 | There is no significance difference |
| Control | 30 | 14.9 | 2.106 | 4.435 | | |

Above table 2 shows that the mean, standard deviation and variance of pre-test scores of experimental and control groups. The mean scores of pre-test of experimental and control groups are found to be 14.76 and 14.9 respectively. The means obtained from both groups reveal that the average score value between the experiment and control groups is almost the same. From this we can claim that the levels of pre-knowledge on mensuration to the both samples are almost same. Similarly, we found that the standard deviation of experimental and control groups are found to be 2.59 and 2.106 respectively. The variance of experiment and control groups is found to be 6.7081 and 4.435 respectively. This shows that there is a similar type of variance between the scores of the experiment group and the control

group. In order to test the null hypothesis of the study, the researcher established two non-equivalent groups of students. The pre-test was taken as the purpose to find out the level of achievement of scores in mathematics (mensuration) of both experimental and control groups before conducting treatment. The above analysis shows that on average both groups have equivalent levels of knowledge on content mensuration. From the above table, we found the calculated t-value 0.072 which does not exceed the critical value t=1.96 at a 5 % of level of significance with a degree of freedom 58. This indicated that the difference between these two groups was not significant at 0.05 level of significance. The null hypothesis was accepted. It meant there is no significant difference between the experimental and control group. Both groups were at the same level of achievement at the start of the study. Hence, we concluded that we could go further more ahead to study the effectiveness of manipulative materials on teaching mensuration in the sample groups.

**Analysis of Post-Test Result**

A pre-test is given to students at the beginning of research to determine their initial understanding of the measures stated in the learning objectives, and Posttest is conducted just after completion of the treatment to determine what the students have learned. In this step, which used two groups, one group was given the treatment and the results were gathered at the end. The control group received no treatment, over the same period of time, but underwent exactly the same tests. The achievement test for post-test was constructed for both experimental and control groups based on the same topic of class X mensuration.

This test had been asked the questions from the area and volume of a triangular base prism, square-based pyramid, cone, and cylinder of grade X from the content of mensuration. The researcher had made the thirty objectives questions from the area and volume of a triangular base prism, square-based pyramid, cone, and cylinder of grade X in post-test. Each objectives question carried one mark. Therefore, the total mark of the pre-test was 30. The achievement test for post-test was prepared on the basis of the specification grid of class X prepared by the curriculum development center as well as consult to the subject teachers and supervisor of this study. The purpose of this test was to measure the level of knowledge of the students in both groups whether they had the same level of

knowledge on mensuration or not. The achievement test paper was same for the both groups (APPENDIX: F).

Post-test was taken in class X of both experimental and control groups after conducting treatment on experiment group. It meant there were 15 lesson plans in which the lesson plan prepared to the experimental group had different manipulative physical and virtual materials as an instructional material at the same time the lesson plans prepared to the control group had a simple plan without any type of instructional materials accept used of as usual materials such as marker, duster, whiteboard, textbook. Accordingly, the researcher taught the students of experimental group by using manipulative materials and taught the same students of control group without using manipulative materials. After completion of teaching and learning on 15 lesson plans according to the research's proposal on the both experimental and control groups, the researcher took the post-test. There were 30/30 students on both experimental and control group. But the obtained marks from the post-test of 30 students from the experimental group and 27 students from the control group were taken for the study which is given in the table below. The marks of two students were not included in this study due to their tuition class, their parents higher education, and the high economic status of parents. To compare the achievement of both groups, the calculated mean, standard deviation, and t-value on the post-test result are shown in the following table.

Table 3:*Comparison of students' achievement on post-test*

| Group Type | Sample | Mean | S.D. | Variance | Calculated t-value | Decision |
|---|---|---|---|---|---|---|
| Control | 30 | 18 | 4.11 | 6.7081 | 2.96 | There is significance difference |
| Experimental | 27 | 24.96 | 2.82 | 16.8921 | | |

The above table 3 shows that the mean, standard deviation and variance of post-test scores of experimental and control groups. The mean scores of post-test of experimental and control groups are found to be 24.96 and 18 respectively. The

mean obtained from the experimental group is greater than the mean obtained from the control group by 6.96. From this, we can claim that the level of knowledge on mensuration to the experimental group is more than the control group. Similarly, we found that the standard deviation of experimental and control groups were 2.82 and 4.11 respectively. The variance of experiment and control groups is found to be 6.7081 and 16.8921 respectively. This shows that there was less variance in the experimental group compared to the variation of the controlled group of research. In order to test the null hypothesis of the study, the researcher established two non-equivalent groups of students. The post-test was taken as the purpose to find out the level of achievement of scores in mathematics (mensuration) of both experimental and control groups after conducting treatment. The above analysis shows that on average both groups do have not the equivalent level of knowledge on content mensuration. From the above table, we found the calculated t-value of 2.96 which was exceeded the critical value t=1.96 at a 5 % level of significance with a degree of freedom 55.This indicated that the difference between these two group were significant at 0.05 level of significance. Null hypothesis was rejected and alternative hypothesis was accepted. It meant there was significance difference between the experimental and control group. Both groups were at the same level of achievement at the start of the study but after treatment on experimental group, it was found that better performance of experimental group over control group on the post-test scores might be attributed due to new treatment given to experimental group in references of control group exercised in the experiment. Findings by some researchers which suggest that most students gain very little regarding the understanding of mathematical concepts through the use of manipulative are not supported by the findings of this study. Findings from this study rather uphold the assertion that manipulative offers an important opportunity for students to link hands-on experience to the understanding of mathematical concepts (Kurumeh, Chiawa& Ibrahim, 2010; Suydam& Higgins, 1977).

Therefore, the result performance indicates that using instructional materials both physical and virtual in teaching mensuration is more effective than the traditional way of teaching mathematics in secondary level class X. We conclude that the manipulative materials (physical and virtual) increase the achievement

scores of students. Hence, manipulative materials assist learning mensuration had better achievement than the conventional learning group at the post-test.

**Comparison between Achievement Average Scores on Pre-Test and post-Test**

The comparison between achievement average scores of pre-test and post-test of both experimental and control groups have given on the following bar-graph.

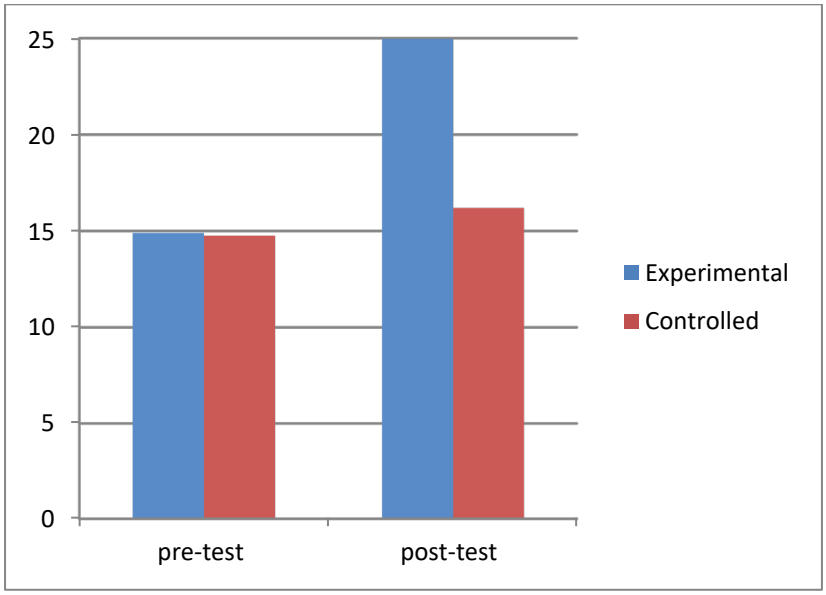


*Figure 2:*comparison on mean achievement on pre-test and post-test

From the above figure 2, the average mean between the experimental group and control group is almost equal in the pre-test of research. It illustrates that there is no significant difference between the experimental group and control before treated the experimental group by any treatment of experiment. But average mean between experimental and controlled groups has a vast difference after taking action treatment on the experiment group of the research. It shows that there is significance difference between experimental and controlled after taking treatment on experiment group of research. Finally, those students who taught through manipulative materials can show better performance than the students who did not teach through the manipulative materials.

**Impact of Manipulation of Materials on Student's Learning**

In an era when the demands for better schools, higher student learning, and school accountability are intense, any factor that directly affects an increase in

student learning must be taken seriously (Liggett, 2017). In the teaching and learning process of mathematics, instructional materials play a vital role. The use of mathematical manipulates in answering mathematical problems would be an asset to improving the student's learning and development.

In case of impact of manipulation of materials on student's solution, the following solutions illustrate better.

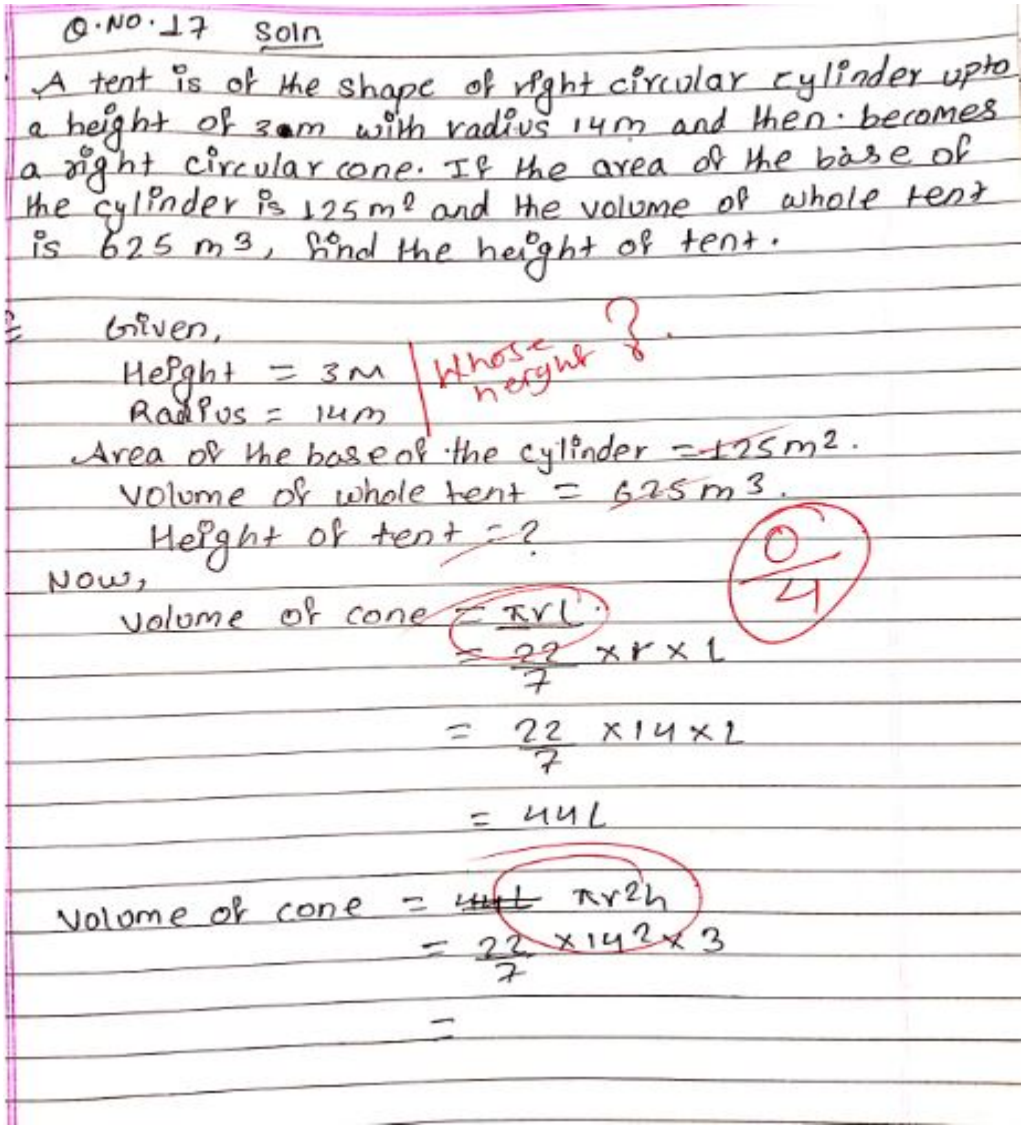


*Figure 3:* Performance of student on controlled group

The figure number 3 presents that the solution of a student who was taught by without using manipulation of materials. In this question no. 17, student could not understand the question properly. So that, student A did not able to solve the question. This student did not know even what were given in the question and what should he

she had to find. Basically, when students did not visualize the 3D questions through the manipulation of teaching materials while learning in the classroom, then they could not able draw the mental map of the solution of the given question. In this case, they cannot solve the given question.

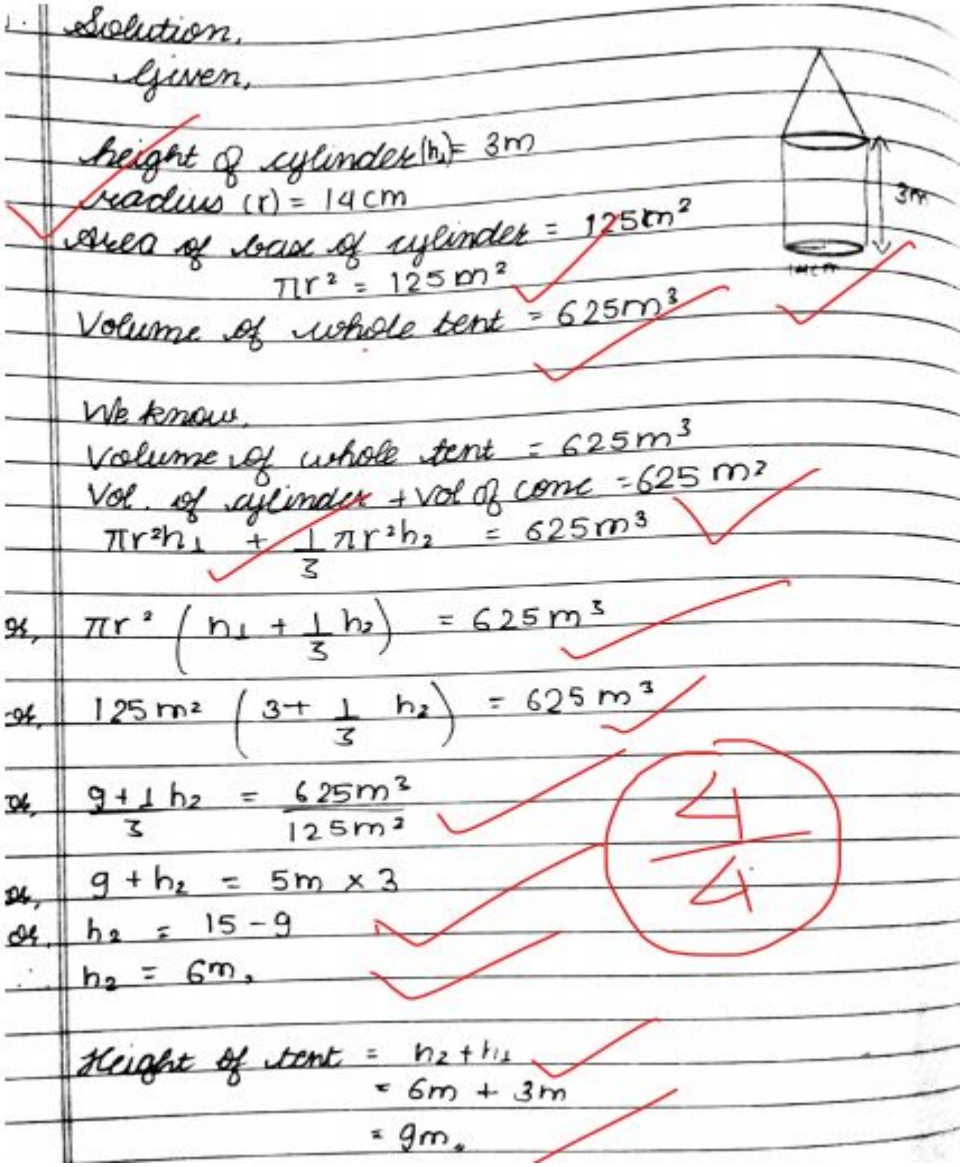


*Figure 4:* Performance of student on experimental group

Figure number 4 presents that the solution of student B who was taught by using manipulation of materials on teaching mensuration at class X. In this question no. 17, student B understood the question properly. So student B solved question no. 17 properly. This respondent has made the diagram of a combined solid figure corresponding to the given question. Also, he/she has been written on solution what was given in the question and what should be found. A critical analysis of Table 3 and

4 indicate that which students in the experimental group seem to obtain high scores, the performance of students in the control group is relatively lower. Students in the experimental group performed better than their control group counterparts indicating that continual exposure of the students to the manipulation of materials in learning could alleviate their learning in the mensuration. The performance of the experimental and control group seems to be inversely related in favor of the experimental group.

**Analysis of Effectiveness of Manipulation of Materials**

There is a significant difference between the achievements in mensuration of the secondary level students exposed to the teaching with manipulation of materials and without manipulation of materials. Group wise (experimental and control) mean, standard deviation and variance were calculated and their obtained marks on the pre-test and post-test. For the test of the research hypothesis, there is a significant difference between the mean scores of the experimental and control group of students in the achievement test.

To see the effectiveness of manipulation of materials on teaching mensuration, the bar graph is shown above is also sufficient to claim the students who were taught by manipulation of materials have more achievement scores than the students who were taught through conventional pedagogy. This indicates that the experimental group, in which instructional materials were used, learned more adequately the unit mensuration than the control group, which was taught without using materials. Finally, we can claim that the effectiveness of manipulation of materials in teaching and learning mensuration at class X.

# CHAPTER V

# FINDINGS, CONCLUSIONS AND IMPLICATIONS

This heading contains the major finding and summary of this study. The Finding of this research is based on collected data and summary is an overview of the main points of this thesis. The major finding and summary of this research were described in the following heading.

## Summary

This study emphasizes the effectiveness of manipulation of materials while teaching mensuration at the secondary level. This study intended to compare the achievement of students taught by using instructional materials and without instructional materials and to find out the effectiveness of instructional materials on teaching mensuration while teaching at the secondary level. This study is composed of five chapters, each of them dealing with different aspects.

This research was based on an experimental research design under a quantitative approach. The two non-equivalent groups were established on the basis of pre-test results. The researcher himself taught both experimental and controlled groups. The researcher conducted two types of achievement tests (pre-test and post-test) for quantitative analysis and data obtained from different research tools were analyzed through SPSS with calculating the mean, standard deviation, and t-test. The reliability and validity of the pre-test and post-test were calculated. The researcher used and gave an opportunity to the students to manipulate different instructional materials in an experimental group. But the controlled group was not treated by the manipulation of materials. They were taught without using any manipulation of materials. After completion of fifteen days lesson plans on both groups, the researcher had been prepared and taken a post-test on the study. A post-test was taken on both groups. In order to ascertain item difficulty level, discrimination index, reliability and validity of the items, a post test was conducted. Along with another statistical measure such as a t-test was applied in order to compare the mean difference between two groups.

From the analysis of data getting from the pre-test on an achievement test, it was found that students from both groups had the same level of knowledge on mensuration. There is no significant difference between both the experimental

group and the controlled group. On other hand, the scores obtained from the post-test were analyzed and thus had the following findings.

**Finding of the Study**

This study had been conducted between two groups. Each group contained 30/30 respondents and the raw scores were collected from the sample students. On the basis of analysis and interpretation of the data and remarkable feathers on students' classroom activities while using and manipulating the instructional materials on the experimental group and not using any manipulating materials on the controlled group, the researcher drew the following information as the finding of this study:

The mean scores of pre-test of experimental and control groups are found to be 14.76 and 14.9 respectively.

- The means obtained from both groups reveals that the average score value between experiment and control groups are almost same.
- In pre-test of achievement test, the standard deviation of experimental and control groups are found to be 2.59 and 2.106 respectively.
- Similarly, in pre-test the variance of experimental and control groups are found to be 6.7081 and 4.435 respectively.
- There is similar type of variance between the scores of experiment group and control group before conducting any treatment.
- We found the calculated t-value 0.072 which does not exceed than the critical value t=1.96 at 5 % of level of significance with degree of freedom 58.
- T-value indicated that the difference between these two group were not significant at 0.05 level of significance. Null hypothesis was accepted.
- The mean scores of post-test of experimental and control groups are found to be 24.96 and 18 respectively. The mean obtained from experimental group is greater than the mean obtained from control group by 6.96.
- In post-test of achievement test, we found that standard deviation of experimental and control groups were 2.82 and 4.11 respectively.
- The variance of experiment and control groups was found to be 6.7081 and 4.435 respectively. This shows that there was very less variance on

experimental group comparison to the variation of controlled group of research.

- We found the calculated t-value 2.96 which was exceeded than the critical value t=1.96 at 5 % of level of significance with degree of freedom 55.
- In post-test, null hypothesis was rejected and alternative hypothesis was accepted. It meant there was significance difference between the experimental and control group.
- Through post-test of an achievement test, the performance of the experimental and control group seem to be inversely related in favors of the experimental group.

**Conclusion**

This study had aimed to compare the achievement of students taught by using instructional materials and without instructional materials and to find out the effectiveness of instructional materials both physical and virtual on teaching mensuration. After analyzing the pre-test and post-test of achievement tests, the researcher found that the achievement scores of students from experimental and controlled groups were different. After conducting the pre-test, the researcher found that the obtained marks of students of both groups were as nearly as same. The researcher also found that the students were so interested and curious in the class while teaching by manipulation of instructional materials on teaching mensuration at the secondary level.

This research is one of the valuable researches in mathematics teaching. Manipulation of materials on teaching and learning helped students for conceptual learning. The use of manipulative teaching materials in learning mensuration increased overall student motivation, engagement and achievement. There was in-depth participation of students in classroom interaction and problem-solving. The students of the controlled group felt bored and lazy to learn mensuration. They were very less curious to learn mathematics without using manipulative materials on learning mensuration. It was concluded that the manipulative materials affected teaching and learning. Through analysis of the post-test of this research, we can conclude that there is significant difference between controlled and experimental groups. This shows that the students who were taught by using manipulative materials

were found more active, regular in class, participating in all activities in a class than the students who were taught without using manipulation of teaching materials on teaching mensuration at the secondary level. For better scores on achievement tests of students, teachers should use such kind of manipulative materials while teaching and learning mensuration at the secondary level.

**Implications of the Study**

Manipulation of instructional materials in teaching mathematics helps to inspire the students for the learning and improve the scores in mathematics. Observing the above study, the researcher has presented implications and recommendations which might be beneficial to the concerned authority for further improvement in mathematics teaching. So, the following points reveal the implications of this study:

- It would be worthwhile to study the opinions, attitudes of students and teachers towards the manipulation of materials in teaching mathematics.
- This study can be used by the teacher and other stakeholders to increase the achievement scores of students on teaching-learning mathematics for all levels.
- Innovative and refreshment training, orientation and supervision should be provided to the subject teacher from time to time on manipulation of materials.
- Teacher should be encouraged for making and using the teaching materials.
- This kind of research should be conducted for different levels on teaching and learning mathematics.
- Empirical study may be suggested to conduct at different levels of school.
- It may be interesting to do this kind of research in different subjects and different classes.
- This research can be usable for curriculum developer of school level to suggest possible manipulative materials on teaching mathematics.
- It can be used by teachers and students to improve in their teaching learning strategies by using physical and virtual materials in mensuration.

- It can be used to the curriculum planners and textbooks writers to organize the physical and virtual materials in the student's perspective while teaching and learning mensuration.
- This study would help to improve the teaching method adopted by mathematics teachers.
- It can be helpful to find out the effect of instructional materials in teaching mensuration at secondary level.

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# Appendices

Appendix A

Specification grid for pre-test

| Content | Knowledge level | Skill Level | Application level |
|---|---|---|---|
| Perimeter and Area of plane figure | 8 | 6 | 6 |

Specification grid for post test

| Contents | 1 mark questions | | | 2 marks questions | | | 4 marks questions | | |
|---|---|---|---|---|---|---|---|---|---|
| Level | K | S | A | K | S | A | K | S | A |
| Area & Volume of triangular prism | 2 | 1 | | 1 | | | | | |
| Area & Volume of square based pyramid | 2 | 1 | | | 1 | | | | 1 |
| Area & Volume of Cone | 1 | 1 | | 1 | | | | | |
| Area & Volume of Cylinder | 1 | 1 | | | | | | | |
| Combined Solid | | | | | 1 | | | | 2 |
| Total | 10× 1= 10 marks | | | $4\times 2 = 8\ marks$ | | | $3\times 4 = 12\ marks$ | | |
| K=Knowledge level, S=Skill level and A = Application level | | | | | | | | | |

Appendix B

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

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

Appendix C

Pre-test for achievement test

Tick the best answer from the given alternatives.

1. What is the formula to find the area of ΔABC having base (AB), height (CA)?
   i) AB× $CA$ ii) $\frac{1}{2} \times AB \times CA$ ii) $2 \times AB \times CA$ iv) None of above
2. Which one of the following is the formula to find the area of circle?
   i) $\pi r^2$ ii) $\pi r$ iii) $2\pi r$ iv) $\frac{1}{2} \times \pi r^2$
3. What is the area of crossing path inside a rectangular field?
   i) A=$2d(l + b + 2d)$ ii) $A = 2d(l + b - 2d)$ iii) $A = d(l + b - d)$ iv) None of above
4. Which is the formula to find the area of an equilateral triangle having side *a?*
   i) 3a ii) $\frac{\sqrt{3}}{4} \times a^2$ iii) $\frac{\sqrt{3}}{2} \times a^2$ iii) $\frac{1}{2} \times a^2$
5. If s is a semi-perimeter of a triangle whose sides are a, b and c; what is its area?
   i) $\sqrt{(s-a)(s-b)(s-c)}$ ii) $\frac{1}{2}\sqrt{(s-a)(s-b)(s-c)}$

iii)$\sqrt{(s^2-a)(s-b)(s-c)}$ iv)$\sqrt{s(s-a)(s-b)(s-c)}$

6. How many faces are there in triangular base prism?
   i) 3 ii) 4 iii) 5 iv) 2
7. What is the relationship between base (b), perpendicular (p) and hypotenuse (h) in right angled triangle?
   i) $h^2 = p^2 - b^2$ ii) $h^2 = b^2 - p^2$ iii) $p^2 = h^2 + b^2$ iv) $h^2 = p^2 + b^2$
8. If the cross section area of solid figure is A, height of solid is h and perimeter of base is p, which formula is used to find volume of solid?
   i) $P \times h$ ii) $A \times P$ iii) $A \times h$ iv) None of above
9. Which one of the following is the area of square having length 5 cm?
   i) 20 $cm^2$ ii) 25 $cm^2$ iii) 15 $cm^2$ iv) 20 cm
10. If the base area of cuboid is $30cm^2$ and height 5 cm, which one is volume of cuboid?
    i) 35 $cm^3$ ii) $6cm^3$ iii) 150 $cm^3$ iv) None of above
11. If a triangle has three sides 4cm, 5cm and 3 cm respectively, what is the area of triangle?

i) 12 $cm^2$ ii) 17 $cm^2$ iii) 18 $cm^2$ iv) 19 $cm^2$

12. If the cost of painting the four walls is Rs.5000 at the rate of Rs.50 per $m^2$, what is the area of four walls?

    i) 50 $m^2$ ii) 75 $m^2$ iii) 100 $m^2$ iv) 125 $m^2$

13. If the area of equilateral triangle is $36\sqrt{3}\ cm^2, what\ is\ its\ perimeter?$

    i) 36 cm ii) 40 cm iii) 42 cm iv) 45 cm

14. The surface area of a cube whose edge equals to 3cm is…

    i) 62 $\boldsymbol{cm^2}$ ii)$\boldsymbol{30\ cm^2}$ iii) 54 $\boldsymbol{cm^2}$ iv) 90 $\boldsymbol{cm^2}$

15. If the perimeter of one of the faces of a cube is 40 cm, then its volume is:

    i) 6000 $cm^3$ ii) 1600 $cm^3$ iii) 1000 $cm^3$ iv) 600 $cm^3$

16. The total surface area of a cube is 96 $cm^2$. The volume of the cube is….

    i) 8 $cm^3$ ii) 512 $cm^3$ iii) 64 $cm^3$ iv) 27 $cm^3$

17. The length, breadth and height of a room is 5m, 4m and 3m. The cost of white washing its four walls at the rate Rs.7.50 per $m^2$ is……

    i) Rs.110 ii) Rs.109 iii) Rs.220 iv) Rs.105

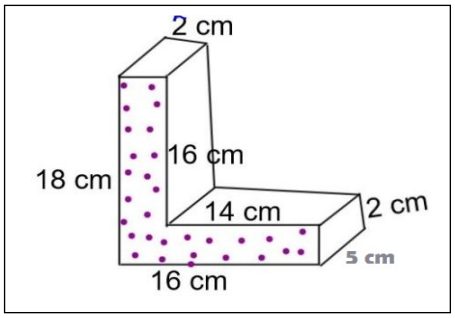
18. If 1000 bricks having dimensions $30cm \times 20cm \times 10cm$ are required to build a wall, the volume of wall should be……

    i) 10 $m^3$ ii) 8 $m^3$ iii) 6 $m^3$ iii) 4 $m^3$

19. If the volume of a wall is 5,85,00,000 cubic cm and volume of a brick is 4,500 cubic cm, find the required number of bricks.

    i) 12,000 ii) 13,000 iii) 14,000 iv) 15,000

20. What is the lateral surface area of given solid figure?



Appendix D

Achievement scores of students in pre-test and their analysis

| **Marks on Pre-test** | | |
|---|---|---|
| | | F.M: 20 |
| Roll no: | Experimental Group | Controlled Group |
| 1 | 13 | 12 |
| 2 | 14 | 19 |
| 3 | 17 | 15 |
| 4 | 18 | 16 |
| 5 | 16 | 17 |
| 6 | 14 | 18 |
| 7 | 15 | 13 |
| 8 | 18 | 15 |
| 9 | 13 | 14 |
| 10 | 10 | 16 |
| 11 | 11 | 18 |
| 12 | 9 | 14 |
| 13 | 18 | 15 |
| 14 | 19 | 18 |
| 15 | 16 | 18 |
| 16 | 15 | 11 |
| 17 | 14 | 14 |
| 18 | 13 | 16 |
| 19 | 12 | 14 |
| 20 | 12 | 15 |
| 21 | 12 | 13 |
| 22 | 15 | 14 |
| 23 | 16 | 14 |
| 24 | 19 | 17 |
| 25 | 18 | 15 |
| 26 | 15 | 12 |

| | | |
|---|---|---|
| 27 | 14 | 12 |
| 28 | 16 | 16 |
| 29 | 16 | 13 |
| 30 | 15 | 13 |
| **Sum** | **443** | **447** |
| **Mean** | **14.76666667** | **14.9** |
| **s.d** | **2.59** | **2.106** |
| **variance** | **6.7081** | **4.435** |

Appendix E

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

| | **Roll No. of Students** | | | | | | | | | | | | **R** | **P-value** | D-Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **S.N** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | | | |
| **Qn** | | | | | | | | | | | | | | | |
| 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | **5** | **41.66666667** | 0 |
| 2 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | **9** | **75** | 0.666666667 |
| 3 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | **6** | **50** | 0.333333333 |
| 4 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | **5** | **41.66666667** | 0 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | **8** | **66.66666667** | 0.333333333 |
| 6 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | **5** | **41.66666667** | 0 |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **12** | **100** | 0 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | **10** | **83.33333333** | 0.333333333 |
| 9 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **3** | **25** | 1 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | **8** | **66.66666667** | 0.666666667 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | **10** | **83.33333333** | 0.333333333 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | **10** | **83.33333333** | 0.333333333 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | **8** | **66.66666667** | 0.666666667 |
| 14 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | **5** | **41.66666667** | 0 |
| 15 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | **8** | **66.66666667** | 0.333333333 |
| 16 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | **7** | **58.33333333** | 0.333333333 |
| 17 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **12** | **100** | 0 |
| 18 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | **8** | **66.66666667** | 0.333333333 |
| 19 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | **8** | **66.66666667** | 0.333333333 |
| 20 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **3** | **25** | 0.666666667 |
| 21 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | **6** | **50** | 0.333333333 |
| 22 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | **10** | **83.33333333** | 0.666666667 |
| 23 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | **9** | **75** | 0.333333333 |
| 24 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | **7** | **58.33333333** | 0.333333333 |
| 25 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | **10** | **83.33333333** | 0.333333333 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | **8** | **66.66666667** | 0.666666667 |
| 27 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | **8** | **66.66666667** | 0.666666667 |
| 28 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | **5** | **41.66666667** | 0.333333333 |
| 29 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **12** | **100** | 0 |
| 30 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | **8** | **66.66666667** | 0.333333333 |
| 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | 0 |
| 32 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **4** | **33.33333333** | 0.333333333 |
| 33 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | **8** | **66.66666667** | 0.666666667 |
| 34 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | **8** | **66.66666667** | 0.333333333 |
| 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** | **0** | 0 |
| | 25 | 29 | 29 | 20 | 28 | 28 | 16 | 14 | 17 | 6 | 12 | 29 | | 0 | |
| | | | | | | | | | | Where, R=No. of Correct answer | | | | | |
| Q.no. 7, 17, 29, 31 and 35 are eliminated. | | | | | | | | | | | | | | | |

Appendix F

Post-test for achievement test

Attempt all questions:

Group: A [ $10 \times 1 = 10$]

Tick the best answer from the given alternatives.

1. How many rectangular surfaces are there on triangular prism?
   i) 3 ii) 4 iii) 2 iv)1
2. Which formula is used to calculate the total surface area of prism?
   i) TSA = $Ph + A$ ii) TSA = $Ph + 2A$
   iii) TSA= $Ah + A$ iv) TSA= $Ah + 2A$
3. Which formula is used to calculate the curve surface area of cone?
   i) $2\pi rh$ ii) $2\pi r(r + h)$ iii) $\pi rl$ iv) $\pi r(r + l)$
4. The formula use to find the volume of cone is……..
   i) $2\pi r^2 h$ ii) $\pi r^2 h$ iii) $\frac{1}{3}\pi r^2 h$ iv) $\pi r^3$
5. Which one of the given statement is true in square based pyramid?
   i) 'h' is the real height of pyramid.
   ii) 'h' is not real height of pyramid.
   iii) $l$ is a real height of pyramid.
   iv)All of the above
6. If $l, h$ $and$ $a$ represent slant height, vertical height and length of base of square based pyramid respectively, which one of the following is true?
   i) $l^2 = h^2 + a^2$
   ii) $l^2 = h^2 - a^2$
   iii) $l^2 = h^2 - (\frac{a}{2})^2$
   iv) $l^2 = h^2 + (\frac{a}{2})^2$
7. A triangular prism with volume 200 $cm^3$ has length 20 cm, what is its base area?
   i) 20 $cm^2$ ii) 200$cm^2$ iii) 10$cm^2$ iv) No one of above
8. If length of side of base($a$), vertical height($h$) of square based pyramid are 10 cm and 12 cm respectively, what is its slant height($l$)?
   i) 12 cm ii) 14 cm iii) 13 cm iv) None of above

9. In a cylinder, the circumference of the base is 60 cm. If the sum of its radius and height is 25 cm, then the total surface area of cylinder is……

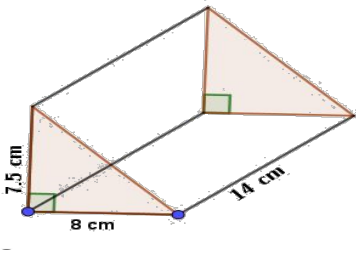
   i) 150 $cm^2$ ii) 15000 $cm^2$ iii) 1000 $cm^2$ iv)None of above

10. If the volume of cone is 770 $cm^3$ and its height is 15cm. What is the radius of the base?

    i) 7 cm ii) 14 cm iii) 21 cm iv) 10 cm

Group: B $[4 \times 2 = 8]$

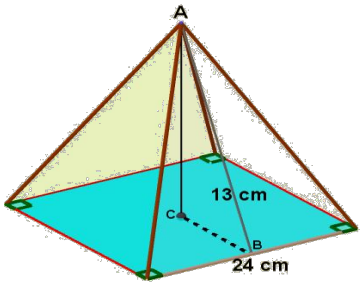
11. Find the volume of given triangular prism.




12. The total surface area of a cylinder is 1188 $cm^2$. Its h
    ratio of 4:3, find its height.

13. A cone whose radius of the base is 7 cm has a volume of 1232 $cm^3$. Find the height of the cone.

14. Find the lateral surface area of square based pyramid.



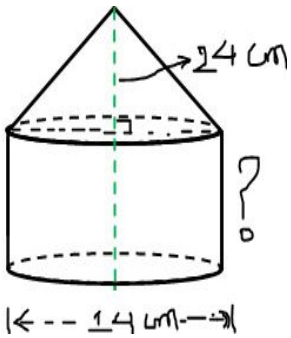

Group: C [4×3=12]

15. The total surface area of square based pyramid is 672$cm^2$. If the side of base of pyramid is 16 cm, find its slant height and volume.

16. In the figure given alongside, if the total surface area of solid is 2464 $cm^2$, find

    i) Length of cylindrical part

    ii) Volume of whole solid




17. A test is of the shape of right circular cylinder up to a height of 3 m with 14 m and then becomes a right circular cone. If the area of the base of the cylinder is 125 $m^2$ and the volume of whole tent is 625 $m^3$, find the height of tent.

# Appendix G

Achievement scores of students in post-test and their analysis

| Roll no. | Experimental group | Controlled Group |
|---|---|---|
| 1 | 22 | 19 |
| 2 | 25 | 20 |
| 3 | 23 | 18 |
| 4 | 29 | 17 |
| 5 | 28 | 16 |
| 6 | 26 | 22 |
| 7 | 21 | 18 |
| 8 | 25 | 14 |
| 9 | 20 | 12 |
| 10 | 24 | 22 |
| 11 | 26 | 26 |
| 12 | 28 | 20 |
| 13 | 27 | 17 |
| 14 | 26 | 12 |
| 15 | 27 | 18 |
| 16 | 22 | 14 |
| 17 | 23 | 17 |
| 18 | 26 | 16 |
| 19 | 24 | 19 |
| 20 | 28 | 20 |
| 21 | 29 | 20 |
| 22 | 27 | 10 |
| 23 | 25 | 23 |
| 24 | 27 | 24 |
| 25 | 22 | 17 |
| 26 | 27 | 11 |
| 27 | 19 | 24 |

| | | |
|---|---|---|
| 28 | 20 | 0 |
| 29 | 25 | 0 |
| 30 | 28 | 0 |
| **Sum** | **749** | **486** |
| **Mean** | **24.96666667** | **16.2** |
| **s.d** | **2.82** | **4.11** |
| **variance** | **6.7081** | **16.8921** |

Appendix H

Comparison of student's achievement on pre-test

| Group Type | Sample | Mean | S.D. | Variance | Calculated t-value | Decision |
|---|---|---|---|---|---|---|
| Experimental | 30 | 14.76 | 2.59 | 6.7081 | 0.072 | There is no significance difference |
| Control | 30 | 14.9 | 2.106 | 4.435 | | |

Comparison of students' achievement on post-test

| Group Type | Sample | Mean | S.D. | Variance | Calculated t-value | Decision |
|---|---|---|---|---|---|---|
| Control | 30 | 18 | 4.11 | 6.7081 | 2.96 | There is significance difference. |
| Experimental | 27 | 24.96 | 2.82 | 16.8921 | | |

Appendix I

**Lesson plans**

**Lesson Plan 1**

Subject: Compulsory Mathematics Date: 2077/12/1

Topic: Mensuration (Review: perimeter and area of plane figures) Class: X

1. Specific objectives: At the end of end of class, students will be able to:
    - Recognize the formula to find the perimeter of plane figures,
    - Tell the formula to find area of plane figures.
2. Instructional Materials
    a) Daily use materials
    b) Manipulative materials: Chart of formulae
3. Teaching learning process
    - Teacher will ask some questions about plane figures which can draw in plane surface.
    - Teacher will describe the formulae of perimeter of different plane figures with the geometrical meaning of perimeter.
    - Teacher will ask the definition of area to the students and will justify about it more.
    - Teacher will describe about the areas of different plane figures such as triangles ( Equilateral, Isosceles, Scalene, right-angled triangle), Quadrilaterals (Parallelogram, rectangle, square, rhombus, kite, trapezium)
    - Teacher will discuss about area of plane figures with their unique property.
4. Evaluation
    - What is the formula to find area of rhombus?
    - Tell the formula to find area of trapezium.
    - Find the area of equilateral triangle having side 7 cm.
5. Homework
    - Teacher will provide some questions from textbook as homework.

## Lesson Plan 2

Subject: Compulsory Mathematics Date: 2077/12/2

Topic: Mensuration (Area of triangular Prism) Class: X

1. Specific objectives: At the end of end of class, students will be able to:
    - Identify prisms on the basis of its base,
    - Generate the formulae to find L.S.A and T.S.A.
2. Instructional Materials
    a) Daily use materials
    b) Manipulative materials: Dynamic GeoGebra file of prism, Solid prism having different bases: Triangles, square, rectangle
3. Teaching learning process
    - Teacher will concentrate to the students towards teaching learning activities by asking the pre-required knowledge of topic.
    - Teacher will ask about prism and describe about it by showing the physical materials.
    - Teacher will provide an opportunity to touch and manipulate the materials to understand about the area of triangular based prism.
    - Similar opportunity will be provided by teacher to manipulation of virtual material made by GeoGebra.
    - By observing on the manipulative materials of triangular based prism, teacher will instruct to the students to derivate the formula to find the area of triangular based prism.
    - Teacher will play the role as a facilitator on teaching and learning activities.
    - After derivation of area's formula of triangular based prism, teacher will ask to the students about the derivation of rectangular and squared based prism.
4. Evaluation
    - Teacher will ask oral questions relating to triangular based prism.
5. Homework
    - Teacher will provide some work from text book.

## Lesson Plan 3

Subject: Compulsory Mathematics Date: 2077/12/3

Topic: Mensuration (Volume of triangular prism) Class: X

1. Specific objectives: At the end of end of class, students will be able to:
    - Identify the different parts of prism,
    - Generate formula to find the volume of triangular based prism.
2. Instructional Materials
    a) Daily use materials
    b) Manipulative materials: Dynamic GeoGebra file of prism, Solid prism having different bases: Triangles, square, rectangle

3.Teaching learning process

- At the first, teacher will concentrate to the students by asking the questions relating to the prism and taught on previous day.
- Teacher will describe about the different parts of triangular prism with the help of virtual and physical materials.
- Teacher will ask about the definition of volume of any prism to the students.
- Teacher will discuss about the general formula to find the volume of any prism.

  i.e.Volume of prism (V)= A x h

  where, A= base area/cross section area and h=height of prism.
- Teacher will derive the formula to calculate volume of triangular base prism with help of manipulation of teaching materials.

4.Evaluation

- Teacher will ask different oral questions relating to the volume of prism.

5.Homework

- Questions will be provided from text book.

## Lesson Plan 4

Subject: Compulsory Mathematics Date: 2077/12/4

Topic: Mensuration (Problem solution: Prism) Class: X

1. Specific objectives: At the end of end of class, students will be able to
    - Find the L.S.A and T.S.A of triangular based prism.
    - Solve the problem relating to the volume of prism.
2. Instructional Materials
    a) Daily use materials
    b) Manipulative materials : Dynamic GeoGebra file of prism, Solid prism having different bases: Triangles, square, rectangle
3. Teaching learning process
    - At the first, teacher will ask the pre-requisite knowledge from area and volume of triangular based prism.
    - Teacher will ask about the formula to calculate lateral surface area and total surface area and volume of triangular based prism.
    - Teacher will solve one problem from L.S.A, T.S.A of triangular based prism and provide one question as a classwork.
    - Similarly, teacher will solve one question from volume of triangular based prism.
    - Teacher will provide one question from volume of triangular based prism as a classwork.
4. Evaluation
    - Teacher will ask different oral questions relating to the area and volume of prism.

5. Homework
    - Questions will be provided from text book.

## Lesson Plan 5

Subject: Compulsory Mathematics Date: 2077/12/5

Topic: Mensuration (Area of square based pyramid) Class: X

1.Specific objectives: At the end of end of class, students will be able to

- Identify the different parts of square based pyramid,
- Derive the formula to find the area of square based pyramid.

2.Instructional Materials

a) Daily use materials
b) Manipulative materials: Ggb file of different base pyramid, solid squared based pyramid made by wooden

3.Teaching learning process

- At first teacher will concentrate students towards their study by asking questions related to previous class's content,
- Teacher will ask about pyramid by showing some solid examples of pyramids.
- With the help manipulative materials, teacher will describe about the different parts of square based pyramid.
- Teacher will provide an opportunity to touch and play with manipulative materials and ask to them to identify the different parts of pyramid.
- Teacher will guide to the students to derive the formula to find the area of square based pyramid. As well as teacher will justify about the formula with different context.

4. Evaluation

- Teacher will ask oral and written questions related to area of square based pyramid.

5. Homework

- Teacher will provide some questions from text book.

## Lesson Plan 6

Subject: Compulsory Mathematics Date: 2077/12/6

Topic: Mensuration (Volume of square based pyramid) Class: X

1.Specific objectives: At the end of end of class, students will be able to:

- Derive the formula to find the volume of square based pyramid,
- Define the relationship between the volumes of square based pyramid and prism.

2.Instructional Materials

a) Daily use materials
b) Manipulative materials: Ggb file of square based prism and pyramid, Square based wooden pyramid and prism.

3.Teaching learning process

- Teacher will start the class by asking about the pre-concept of prism and pyramid.
- Teacher will ask about the different parts of square based pyramid and focus on the parts which are needed to generate the formula of value of pyramid.
- Teacher will generate the formula to find the volume of square based pyramid with active participation of students.
- Teacher will discuss and explain about the relationship between the volume of prism and pyramid having same height and based.
- Students will be directed to experiment the relation between the volume of square based pyramid and prism with the help of manipulative materials.
- Finally, teacher will tell to students to come on conclusion of the class.

4. Evaluation

- Teacher will ask oral and written questions related to volume of square based pyramid.

5. Homework

- Some questions will be provided by teacher from text book.

## Lesson Plan 7

Subject: Compulsory Mathematics Date: 2077/12/8

Topic: Mensuration (Problem solution: square based pyramid) Class: X

1. Specific objectives: At the end of end of class, students will be able to:
    - Find LSA and TSA of square based pyramid,
    - Find the volume of square based pyramid.

2.Instructional Materials

c) Daily use materials

d) Manipulative materials: Ggb file of square based prism and pyramid, Square based wooden pyramid and prism.

3.Teaching learning process

- At the first, teacher will ask the pre-requisite knowledge from area and volume of square based pyramid.
- Teacher will ask about the formula to calculate lateral surface area and total surface area and volume of volume of square based pyramid.
- Teacher will solve one problem from LSA, TSA of square based pyramid and provide one question as a classwork.
- Similarly, teacher will solve one question from volume of square based pyramid.
- Teacher will provide one question from volume of square based pyramid as a classwork.

4. Evaluation
    - Teacher will ask oral and written questions related to LSA, TSA and volume of square based pyramid.

5. Homework
    - Some questions will be provided by teacher from text book.

## Lesson Plan 8

Subject: Compulsory Mathematics Date: 2077/12/9

Topic: Mensuration (Area of cone: CSA) Class: X

1. Specific objectives: At the end of end of class, students will be able to
   - Identify the different parts of right-circular cone,
   - Derive the formula to find the curve surface area of cone.
2. Instructional Materials
   a) Daily use materials
   b) Manipulative materials: Ggb file of cone by presenting curve surface area and total surface area , solid cone made by wooden
3. Teaching learning process
   - At first teacher will concentrate students towards their study by asking questions related to previous class's content.
   - Teacher will ask about real life related examples of cone and will list out the examples given by students.
   - With the help of examples given by students, teacher will try to generalize the different parts of cone.
   - With the help manipulative wooden materials, teacher will describe about the different parts of cone.
   - Teacher will provide an opportunity to touch and play with manipulative materials and ask to them to identify the different parts of cone.
   - Teacher will guide to the students to derive the formula to find the curve surface area of cone. As well as teacher will justify about the formula with different context.
4. Evaluation
   - Teacher will ask oral and written questions related to identification of cone and curve surface area of cone.
5. Homework
   - Teacher will provide some questions from text book.

## Lesson Plan 9

Subject: Compulsory Mathematics Date: 2077/12/10

Topic: Mensuration (Cone: TSA and Volume) Class: X

1. Specific objectives: At the end of end of class, students will be able to:
    - Derive the formula to find total surface area of cone,
    - Derive and know the formula to find the formula to find volume of cone.
2. Instructional Materials
    a) Daily use materials
    b) Manipulative materials: Ggb file relating to area and volume of cone, Solid wooden cone.

3.Teaching learning process

- Teacher will start the class by asking about the pre-concept of cone.
- Teacher will describe about meaning of total surface area of cone by using wooden solid cone with the active participation of students.
- Teacher will derive the formula to find the total surface area of cone with active participation of students.
- Teacher will generate the formula to find the volume of cone.
- Teacher will provide an opportunity to play with materials and make concept on total surface area and volume of cone.
- Finally, teacher will tell to students to come on conclusion of the class.

4. Evaluation
    - Teacher will ask oral and written questions related to TSA and volume of cone.
5. Homework
    - Some questions will be provided by teacher from text book.

## Lesson Plan 10

Subject: Compulsory Mathematics Date: 2077/12/11

Topic: Mensuration (Problem solution: cone) Class: X

6. Specific objectives: At the end of end of class, students will be able to:
    - Find CSA and TSA of cone,
    - Find the volume of cone.

7.Instructional Materials

e) Daily use materials

f) Manipulative materials: Ggb file of relating to area and volume of cone, solid wooden cone.

8.Teaching learning process

- At the first, teacher will ask the pre-requisite knowledge from area and volume of cone.
- Teacher will ask about the formula to calculate cone surface area and total surface area and volume of cone.
- Teacher will solve one problem from CSA, TSA of cone and provide one question as a classwork.
- Similarly, teacher will solve one question from volume of cone.
- Teacher will provide one question from volume of cone as a classwork.

9. Evaluation
    - Teacher will ask oral and written questions related to LSA, TSA and volume of cone.

10. Homework
    - Some questions will be provided by teacher from text book.

## Lesson Plan 11

Subject: Compulsory Mathematics Date: 2077/12/12

Topic: Mensuration (Area of cylinder: CSA) Class: X

1. Specific objectives: At the end of end of class, students will be able to
    - Ientify the different parts of right-circular cylinder,
    - Derive the formula to find the curve surface area of cylinder.
2. Instructional Materials
    a) Daily use materials
    b) Manipulative materials: Ggb file of cylinder by presenting curve surface area and total surface area, solid cylinder made by wooden, Hollow Pipe, etc.
3. Teaching learning process
    - At first teacher will concentrate students towards their study by asking questions related to previous class's content.
    - Teacher will ask about real life related examples of cylinder and will list out the examples given by students.
    - With the help of examples given by students, teacher will try to generalize the different parts of cylinder.
    - With the help manipulative wooden materials, teacher will describe about the different parts of cylinder.
    - Teacher will provide an opportunity to touch and play with manipulative materials and ask to them to identify the different parts of cylinder.
    - Teacher will guide to the students to derive the formula to find the curve surface area of cylinder. As well as teacher will justify about the formula with different context.
4. Evaluation
    - Teacher will ask oral and written questions related to identification of cylinder and curve surface area of cylinder.
5. Homework
    - Teacher will provide some questions from text book.

## Lesson Plan 12

Subject: Compulsory Mathematics Date: 2077/12/13

Topic: Mensuration (Cylinder: TSA and Volume) Class: X

- Specific objectives: At the end of end of class, students will be able to:
    - Derive the formula to find total surface area of cylinder,
    - Derive and know the formula to find the formula to find volume of cylinder.
- Instructional Materials
    a) Daily use materials
    b) Manipulative materials: Ggb file relating to area and volume of cylinder, Solid wooden cylinder.
- Teaching learning process
    - Teacher will start the class by asking about the pre-concept of cylinder.
    - Teacher will describe about meaning of total surface area of cylinder by using wooden solid cylinder with the active participation of students.
    - Teacher will derive the formula to find the total surface area of cylinder with active participation of students.
    - Teacher will generate the formula to find the volume of cylinder.
    - Teacher will provide an opportunity to play with materials and make concept on total surface area and volume of cylinder.
    - Finally, teacher will tell to students to come on conclusion of the class.

- Evaluation
    - Teacher will ask oral and written questions related to TSA and volume of cylinder.
- Homework
    - questions will be provided by teacher from text book.

## Lesson Plan 13

Subject: Compulsory Mathematics Date: 2077/12/17

Topic: Mensuration (Problem solution: Cylinder) Class: X

1. Specific objectives: At the end of end of class, students will be able to:
    - Find CSA and TSA of cylinder
    - Find the volume of cylinder.
2. Instructional Materials
    a) Daily use materials
    b) Manipulative materials: Ggb file of relating to area and volume of cylinder, solid wooden cylinder.

3.Teaching learning process

- At the first, teacher will ask the pre-requisite knowledge from area and volume of cylinder.
- Teacher will ask about the formula to calculate cylinder surface area and total surface area and volume of cylinder.
- Teacher will solve one problem from CSA, TSA of cylinder and provide one question as a classwork.
- Similarly, teacher will solve one question from volume of cylinder.
- Teacher will provide one question from volume of cylinder as a classwork.

4. Evaluation
    - Teacher will ask oral and written questions related to CSA, TSA and volume of cylinder.

5. Homework
    - Some questions will be provided by teacher from text book.

## Lesson Plan 14

Subject: Compulsory Mathematics Date: 2077/12/18

Topic: Mensuration (Combined Solid: Cylinder and cone I) Class: X

1. Specific objectives: At the end of end of class, students will be able to:
    - Find CSA and TSA of combined solid made by cylinder and cone,
2. Instructional Materials
    a) Daily use materials
    b) Manipulative materials: Ggb file of relating to area of cylinder and cone, solid wooden cylinder and cone.
3. Teaching learning process
    - At the first, teacher will ask the pre-requisite knowledge from area of cylinder and cone.
    - To find the curve surface area of combined solid made by cylinder and cone, teacher will facilitate students to generate its formula. Teacher will give an instruction to find CSA of cone and CSA of cylinder and add to them.
      Finally, CSA of combined solid made by cylinder and cone is given by:
      CSA= $2\pi rh + \pi rl = \pi r(2h + l)$
    - Similarly Teacher will help to the students to find the total surface area of combined solid made by cylinder and cone as:
      Total surface area of combined solid made by cone and cylinder is given by:
      TSA= CSA of combined solid + Base area of cylinder
      i.e. TSA = $2\Pi rh + \Pi rl + \Pi r^2 = \Pi r(2h + l + r)$
    - Teacher will solve one problem from CSA, TSA of combined solid made by cone and cylinder.
    - Teacher will provide one similar question from combined solid made by cylinder and cone.
4. Evaluation
    - Teacher will ask oral and written questions related to CSA, TSA of cylinder and cone with its combined solid.
5. Homework
    - Some questions will be provided by teacher from text book.

# Lesson Plan 15

Subject: Compulsory Mathematics Date: 2077/12/19

Topic: Mensuration (Combined Solid: Cylinder and cone II) Class: X

1. Specific objectives: At the end of end of class, students will be able to:
    - Find volume of combined solid made by cylinder and cone,
2. Instructional Materials
    a) Daily use materials
    b) Manipulative materials: Ggb file of relating to area and volume of cylinder and cone, solid wooden cylinder and cone.
3. Teaching learning process
    - At the first, teacher will ask the pre-requisite knowledge from area of cylinder and cone.
    - To find the volume of combined solid made by cylinder and cone, teacher will facilitate students to generate its formula. Teacher will give an instruction to find volume of cone and volume of cylinder by using following formulae:
      Volume of Cylinder $(v_1)$= $\pi r^2 h_1$
      Volume of Cone $(v_2)$ = $\frac{1}{3}\pi r^2 h_2$
    - After finding the volume of cone and cylinder individually, teacher will tell to students to add both formula to find the volume of both solids:
      i.e. Volume of combined solid (V)= $v_1 + v_2$
      Or, Volume (V) = $\pi r^2 h_1 + \frac{1}{3}\pi r^2 h_2$
      Or, volume (V) = $\pi r^2 (h_1 + h_2)$
      Where, $h_1 = height\ of\ cylinder$
      And $h_2 = height\ of\ cone$
    - Teacher will solve one problem from volume of combined solid made by cone and cylinder.
    - Teacher will provide one similar question from combined solid made by cylinder and cone.

4. Evaluation
    - Teacher will ask oral and written questions related to volume of cylinder and cone with its combined solid.

5. Homework
    - Some questions will be provided by teacher from text book.