MATERIALS AND METHODS

CHAPTER III
MATERIALS AND METHODS

3.0 Introduction:

Research may be defined as the systematic and objective analysis and recoding of controlled observations that may lead to the development of generalization, principles or theories resulting in prediction and possible ultimate control of events. It is concerned with the objective variation of generalization. Such a variation requires logical analysis of problems and devising of appropriate investigation for obtaining evidence. The knowledge guided by research is of highest order.

3.1 Nature of Educational Research:

Educational research refers to a systematic attempt to gain a better understanding of the educational process, generally with a view to improving its efficiency. It is an application of scientific methods to the study of educational problems. According to Travers (1958) "Educational Research represents an activity directed towards the development of an organized body of scientific   knowledge about the events with which educators are concerned. It gives the main importance on behavioral change of learners through educational process. A scientific body of knowledge about education should enable the educators to determine just what teaching and other learning educations to provide in order to produce desired aspects of learned behavior among young people who attend school".

According to International Commission on the Development of Education (UNESCO, 1972) - "Learning to Be", Education should take place at all ages of life, in all situations and circumstances of existence. Education helps everybody to be in a good economic status, social and psychological state. In this context the scope of educational researcher has a great impact.

Educational research starts with the selection of a problem, objective, careful formulation of hypothesis, and following a particular method, it involves data collection, analysis and interpretation of the data and finally report of result that leads to generalization.

From the views of the scholars, it is observed that educational research is an inquiry or investigation, which has clearly defined parameters. It is a system of critical controlled and empirical inquiry about the problem.

3.2 Methods of Educational Research:

Research methods are of utmost importance in a research process .They describe the various steps of the plan of attack to be adopted for solving a research problem such as the manner in which the problems are formulated,the definition of the terms,the choice of subjects for investigation,the validation of data gathering tools,the collection,analysis and interpretation of data and the process of inferences and generalization(Koul,2005, p.417). Most authors agree on three basic categories of research which are:

 (i) Experimental method

 (ii) Descriptive Survey method

(iii) Historical method

Practically all studies fall under one method or a combination of these types of methods.

The choice of the method of research is determined by the nature of the problem. For the present study, experimental and descriptive research methodology is used. It is because of the detailing of the methodology, apparent care and deliberate arrangement of variables and its manipulation through investigation, that the experimental method has undoubtedly been the most popular and widely used research method in education.

3.3 Experimental Method:

The experimental method of studies starts, namely with the identification and rigorous analysis of the problem. Experimental research describes what will be,

when certain variables are carefully controlled or manipulated. The focus is on variable relationships to each other. Deliberated manipulation is always a part of the experimental method. It provides for much control and, therefore establishes a systematic and logical association between manipulated factors and observed effects. The earliest assumptions of experimental method are based upon the low of the single variable. John Stuart Mill (1846) defined this law with 5 rules or canons of experimental research: (i) the method of agreement (ii) the method of difference (iii) the joint method (iv)the method of residues (v) the method of concomitant variations. These serve as guides in designing and planning of experiments.

There are 4 essential characteristics of experimental research (i) Control (ii) Manipulation (iii) Observation and (iv) Replication.

According to Van Dalen (1973) the purpose of control variables in any experiment is for (i) Achieving isolation (ii) Achieving changes in magnitude and (iii) Achieving quantitative evaluation.

3.3 (a) Steps in Experimental Research:

Lokesh Koul(1994) categorized the experimental method in the following steps:

Surveying the literature relating to the problem

Selecting and defining the problem

Stating of hypothesis

Constructing the experimental Plan.

Surveying the Literature Relating to the Problem:

For the worthwhile research based on experimentation needs to acquire up-to date information relating to the problem. The appropriate research and the procedures are helpful to acquaint the researcher with adequate related literature to complete the work.

Selecting and Defining the Problem: Experimental research starts with the selection of the problem which is amenable to experimentation. It needs a rigorous logical analysis and definition of the problem in precise forms. The variables to the studied should be defined in operational terms clearly and unambiguously. It helps the

researcher to convert the problem precisely into a hypothesis that can be verified by the experimental data.

Stating of Hypothesis: Hypothesis is the heart of experimental research. An antecedent condition i.e. independent variable is related to the occurrence of another condition i.e. dependent variable. To test a hypothesis, the researcher attempts to control all the conditions except the independent variable which he manipulates. Then he observes the effect on the dependent variable presumably because of the exposure to the independent variable. The experimental plans and statistical procedures merely help him or her in the testing of hypothesis and contribute to the development of new theories and knowledge.

Constructing the Experimental Plan : According to Van Dalen (1978) Experimental Plan represent all elements, conditions or phenomena and relation of consequences so as to: (i) identify all non-experimental variables (ii) Select a research design (iii) Select a sample of subjects to represent a given population, assign subjects to groups and assign experimental treatments to groups. (iv) Select or construct and validate instruments to measure the outcomes of the experiment (v) Outline procedures for collecting data and possibly conduct a pilot or 'trial run' test to perfect the instruments or design and (vi) State the statistical application or null hypothesis.

3.3 (b) Experimental Design:

An experimental design is to the researcher what a blueprint is to an architect. It provides the researcher an opportunity for the comparison required by the hypothesis of the experiment. And enable him/her to make a meaningful interpretation of the results of the study with the help of statistical analysis of the data. There are 3 important criteria for selecting an experimental design for conducting the experiment. These are (i) Appropriateness (ii) Adequacy of control (iii) Validity.

Appropriateness:

The 1st criterion is that the experimental design should be appropriate for testing the hypothesis of the study. It should be able to arrange objectively the experimental conditions to meet the requirements of the study.

Adequacy of Control:

The 2nd criterion is that the design must provide 'adequate control' so that the effects of the independent variable on the dependent variable can be measured.

Validity:

The 3rd criterion is the 'validity' of the design. It is essential for the purpose of testing the particular hypothesis of the study. According to Compbell and Stanely (1963) there are two general types of validity: Internal and External.

Internal Validity:

One of the major objectives of the experimentation is to determine whether the variables that have been identified actually have a systematic effect on the dependent variable and whether the observed results were not affected by the extraneous or situational variables. The extraneous variables that affect the control of a design contribute to its internal validity.

External Validity:

The second important objective is to determine whether the systematic relationship that has been identified isolated and measured can be generalized outside the experimental setting. The extent to which this objective is attained is a measure of the external validity of the experiment. This validity is concerned with the generalize ability or representativeness of the experimental finding.

3.3 (c) Types of Experimental Design:

According to Lokesh Koul design are broadly classified as under:

Pre-Experimental Design

True Experimental Design

Factorial Experimental Design

Quasi Experimental Design

Time series Design

Pre-Experimental Design:

Pre-Experimental design provide little or no control of extraneous or situation variables. There are 2 types of pre-experimental designs.

Design-I

One Group pre-test post test Design: When an experimenter uses this design, he measures dependent variables, before the independent variables x is applied or withdrawn and takes its measurement again afterwards. The difference of dependent variable if any is computed and is taken as the amount of change as a result of the application or withdrawing of independent / treatment variable.

Design-II

Two group, static design: It utilizes two groups, only one of which is exposed to the experimental treatment . The other group which is not exposed to any experimental treatment acts as the control group and this permits the comparison that is required by a scientific investigation. The experimenter assumes that the two groups   to be equivalent in all relevant aspects at the start of the experimentation. There is no pre-test and the dependent variables measures for the two groups are then compared (post-test), to determine the effect of independent or treatment variable x. If the experimental group performs better on the post test (T_2), the experimenters are more confident that the independent variable is more responsible for the change in the dependent variable.

There are altogether 11 designs for the above mentioned categories.

For Pre-Experimental Design= 2 Design

For True Experimental Design= 5 Design

For Factorial Experimental Design= 1 Design

For Quasi Experimental Design= 2 Design

For Time series Design= 1 Design

Total= 11 Design

Depending upon the nature and purpose of the study, the pre-experimental design has been used. The design has been used to meet the requirements of the experiments.

3.4 Descriptive Survey Method:

Survey studies are conducted to collect detailed descriptions of existing phenomena with the intent of employing data to justify current conditions and practices or to make more intelligent plans for improving them. Their objective is not only to analyze, interpret, and report of the status of an institution ,group, or area in order to guide practice in the immediate future, but also to determine the adequacy of status by comparing it with established standard (Koul,2009).Surveys are confined to gather all three types of information : (i) data concerning existing status, (ii) comparison of existing status with the established status, and (iii) means of improving the existing status; while others are limited to one or two of these types. Depending upon the nature and scope of the problem, survey studies are different types. They may be broad or narrow in scope. Some surveys encompass several countries, states or regions; or may be limited to one country, region, state, district, tehsil, city, school system, or some other unit. Survey data may be collected from every unit of a population or from a representative sample. The information gathered may be concerning a large number or related factors or may be confined to a few selected items. Survey studies includes (i) school surveys,(ii) job analysis(iii) public opinion surveys ; and(iv) social surveys.

School surveys: The school survey generally is a comprehensive study of existing conditions. Its main purpose is to determine the overall effectiveness of the school programme and suggest improvement were necessary. In terms of purposes, Cooper (1946)and Reller (1942) have categorized schools surveys into three types:(a) the investigative, evaluative or status surveys which serves primarily to evaluate existing conditions;(b) the deliberative, developmental, or planning survey, which is intended primarily to make proposals for development of present circumstances; (c) the implementive survey, which not only makes suggestions for development but also attempts to create conditions in the conduct of the survey which will enhance the prospects of actually achieving survey recommendations.

According to Good (1966, p.207), the comprehensive school survey usually covers the following aspects of school system:

1. Aims, outcomes, pupil achievement, curriculum, method ,and instructional aids.
2. Administrative problems and procedures of the schools.
3. Financial policies and procedures.
4. Pupil transportation.
6. Staff and personnel.
7. School plant and related factors.

Schools surveys may be conducted at the local , state, regional or national level. They may be undertaken at various levels of instruction – elementary, secondary or higher. Achievement testing surveys are conducted not just to collect some figures but to provide necessary information for educational administrators and teachers for taking decisions and actions to improve instructional process. In India the first step towards a comprehensive study was undertaken by National council of educational research and training ,New Delhi(Kulkarni et.al.,1968).The survey was confined to mathematics achievement and conducted at the three levels of education – primary, middle and high school level respectively ,in all the states of India (except Bihar and Tamilnadu) . Many other organizations like university teaching departments of education, state institutes of education, etc. are constructing achievement tests for the purpose of achievement testing surveys.

3.5 Experimental Tools and Techniques:

Inquiry forms are one of the most important data gathering tool or technique.

Each of the tests should keep the validity, reliability & usability. Teachers make use of their own made tests in classroom situation to assess achievement of students in different schools subjects.

Test of Attainment or Achievement:

Test of attainments/achievements have been constructed to measure present performance in relation to a skill or knowledge which have been required as a result of training. Beggs and Lewis (1975) have indicated that such tests are found to be as

good for predicting success as aptitude tests. Achievement tests may be classified as traditional or essay type and new or objective type tests. Objective type tests include alternate response, completion, matching, and multiple-choice types.

3.5 (a) Questionnaire:

According to Good and Hatt (1952) in general the word 'questionnaire' refers to a device for serving answers to a series of questions by using a form which the respondent fills in himself. Questionnaire is a popular means of collecting all kinds of data in research. It is used in research to obtained information about certain conditions and practices, and to inquire into opinions and attitudes of an individual or a group. It saves the time and money. A good questionnaire must serve two major purposes. First it must translate the objectives of the investigation into specific statements of questions. Secondly it must motivate the respondents to communicate the required information. It may be the closed form or the open form.

The Closed Form: Questionnaires that calls for short, check responses (yes/no) are known as the restricted or closed form type.

The Open Form: The open form or unrestricted, type of questionnaire call for a free response in the respondent's own words or views.

3.5 (b) The Interview Schedule:

The interview schedule is process of communication in which the subject or interviewee gives the needed information verbally in face to face situation. It may be used to test hypothesis/ solve the problems of any type of research. This type of interview is called 'research interview'. It may be for an individual or for a group.There are some other technique like opennaire, rating scale and schedule etc.

3.5 (c) Method of Summated Rating:

The method of summated rating was introduced by Likert (1932).It is simpler, easier and less laborious than Thurstone's method. It has been found that the time required to construct an equal- appearing interval scale is approximately twice that required by the method of summated ratings. In terms of this advantage, the method of summated

ratings tends to be used more frequently by the researchers in opinion research. The following steps are involved in the construction of Likert-type scale:

1. **Collecting and editing of statement.** A large number of statements which express an opinion or a feeling towards the psychological object are collected. It is important that they express definite favorableness or unfavourableness to the psychological object. The number of favorable and unfavourable statements should be approximately equal. After the statements have been gathered, they are edited keeping in view the criteria mentioned earlier.

2. **The try out.** The preliminary draft of the scale is administered to a sample of 200 subjects who are selected from the population for which the scale has to be constructed. Each item, or statement, in the attitude scale is following by five response, one of which is checked by the subject. The responses, indicating degree of strength of attitude are:

    Strongly Agree   (SA)

    Agree   (A)

     Undecided   (U)

    Disagree   (D)

    Strongly Disagree   (SD)

<div align="center">Or</div>

In some situations, 'approve'- 'disapprove' are used in place of 'agree'- 'disagree'. Arbitrary scoring weights of 5, 4, 3, 2 and 1 are used for SA, A, U, D, and SD for the statements favouring a point of view. On the other hand, the scoring weights of 1, 2, 3, 4 and 5 are used for the statement opposing this point of view. An individual's score on a particular attitude scale is the sum of his ratings on all items.

3. Selection of items and preparation of the final draft. In the method of equal-appearing intervals, the items are selected on the basis of Q and scale values. As basis for selecting statements in the method of summated rating, use is made of some form of item analysis. On the basis of scores based upon the responses to all statements, 25 per cent of the subject with the highest total scores and 25 per cent of the subjects

with the lowest total scores are taken. According to Edwards (1957, p. 152) these two groups provide criterion groups in items of which to evaluate the individual statement. In evaluating the responses of high and low groups to the individual statement, a ratio of 't' is found out. The value of 't' is a measure of the extent to which a given statement differentiates between the high and low groups. A t-value equal to or greater than 1.75 indicates that the average response of the high and low groups to a statement differs significantly. Finally, 20 to 25 statements with the largest t-values (t $\geq$ 1.75) are selected for the final draft of the attitude scale.

4. Reliability and validity. The reliability of Likert-type of attitude scale is computed by split-half method. Attempts have been made to validate these type of scale by comparing them with older scales and also by correlating the results with actual behavior.

Analysis and Interpretation of Attitude Scores:

The attitude score of an individual is taken as the mean or median of the scale values of the statements with which he agrees. If this score falls in the middle range of the middle range of the psychological continuum, the attitude of the individual is described as 'neutral'. If it falls towards the favourable end of the continuum, it described as 'favourable' and if it towards the unfavaurable ends, it can be described as 'unfavourable'. In an equal-appearing interval type of scale, the interpretation of an attitude scores is made independently of the distribution of scores for a particular group of individuals. On the other hand, the interpretation of an attitude score on a summated-rating scale cannot be made independently of the distribution of some defined or norm group. This is because the summated-rating score corresponding to the 'zero' or 'neutral' point on a favourable-unfavourable continuum is not known as it is in the case of equal-appearing interval scores. The interpretation of the scores is done with the help of the mean of the norm group.

3.6 Methodology of the present study:

The present study is concerned with experimental and survey methods. The objectives of the present study are to investigate the effectiveness of different methods in teaching science at secondary level.

1) **Experimental Method:** For verification of the objectives nos.1, 2, 3 ,4 and 5 experimental method(Koul,1994) is used .

2) **Descriptive Survey Method:** Survey method is used for objective no.6

3.6.1 Design of the present study:

The design of the present study is selected, keeping in view the specific objectives of the study. General Science is taught as a compulsory subject in secondary schools. What is to be taught is predetermined, but how it is to be taught still remains a problem. A number of methods are use by teachers for teaching science, but it is necessary to examine which method will be more effective for teaching science in secondary schools. Here, the investigator attempts to elucidate her methods (3) and procedures for evolving the design of the present study on "A comparative study on the Effectiveness of Lecture-cum Demonstration Method, Inquiry Method and Laboratory Method for Teaching General Science in Secondary Schools."

The investigator had adopted both experimental and descriptive survey research methodology for the study. The basic nature of experimental research is to explain Cause-Effect relationship between variables under the controlled conditions. In the case of physical research experiments are conducted in laboratory settings. In case of educational research, which mainly deals with variables concerning human behavior in educational settings, experimental method is adopted with a lot of considerations of human and social factors by providing control of the factors intervening between the independent and dependent variables. As Good & Hatt (1952) states that "In experimentation the investigator controls i.e., manipulates or changes certain independent variables and observes the changes which takes place in the dependent variables". Here, in the present study independent variables are teaching methods namely, Lecture-cum Demonstration, Inquiry Method and Laboratory Method. The

outcome of the method of teaching, i.e., learner's achievement in terms of test scores is the dependent variable. The objectives of the present study is to investigate the effectiveness of different methods (traditional and modern) in teaching science at secondary level, comparison of methods problems faced by the teachers and pupils and to make science teaching an effective one at secondary level.

3.6.2 Variables:-In the present study Academic Achievement of the Students (scores) are dependent variables and all the three methods are independent variables. Along with these variables following independent variables are taken into account for the present study.

1) Location of the schools: urban and rural 2) The type of school on the basis of management: government and private 3) School under the board/certificate: SEBA, CBSE and ICSE.

Thus target population, students and teachers for the study are as follows:

3.6.3 Population: A population refers to any collection of specific group of human beings or non –human entities such as objects, educationist, institution, geographical areas ,prices of wheat, salaries drawn by individuals etc.

 The population of the present study comprised of all students and teachers of government and private Assamese, English and Bengali medium secondary schools of Kamrup (metro and rural)

3.6.4 Sampling procedure and sample:-

A sample is asmall portion of the population .The samples for the present study has taken from different secondary schools of Kamrup district of Assam. A total number of 60 schools have been selected for this purpose. Sampling depends upon certain conditions of population. Proportionate and stratified random sampling procedure has been applied to select the sample. This method involves purposive or deliberate section of the units of the population for constitution of the sample which represents the population.

 Stratified Random Sampling: First of all the schools were stratified on the basis of nature of management and thus 60 government and private schools were randomly

selected. In the second stage schools were classified on the basis of locality and 33 schools from urban area while 27 from rural area were selected. In the third stage schools were stratified on the basis of controlling authority (academic) board or certificate and thus 52 under SEBA, 07 CBSE and 01 under ICSE.

DIAGRAMATIC REPRESENTATION OF SAMPLE SCHOOLS
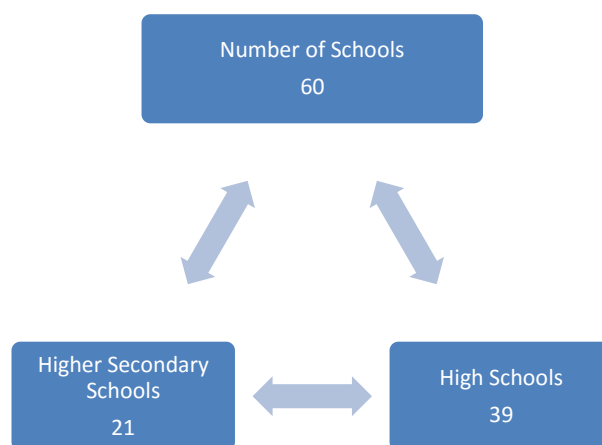
Figure:2 Number of Schools Included In The Study

In selecting schools for the present study certain criteria have considered:

      a) The school must have adequate number of teachers to teach science,

      b) The teacher must be trained teacher,

      c) The school must have a laboratory and

   d) The schools must have at least some teaching aids for teaching science.

Only those schools which have satisfied the above mentioned conditions were selected to maintain homogeneity .The samples were assumed to be homogeneous in order to get optimum results.

Total Sample: A total number of 3069 students of class x were selected as sample for the present study. For conducting the experiment the sample students were divided into three groups. Each group was consisted of 1023 students. Students' achievement level was taken into consideration from their scores of annual

examination of class IX standard. The investigator tried to include students having almost same achievement level to maintain the homogeneity.

All the trained science teachers teaching general science in class X of the selected secondary schools were included as sample in the study and the number of teacher is 76. The list of schools are shown in table 2.

DISTRIBUTION OF SAMPLE STUDENTS
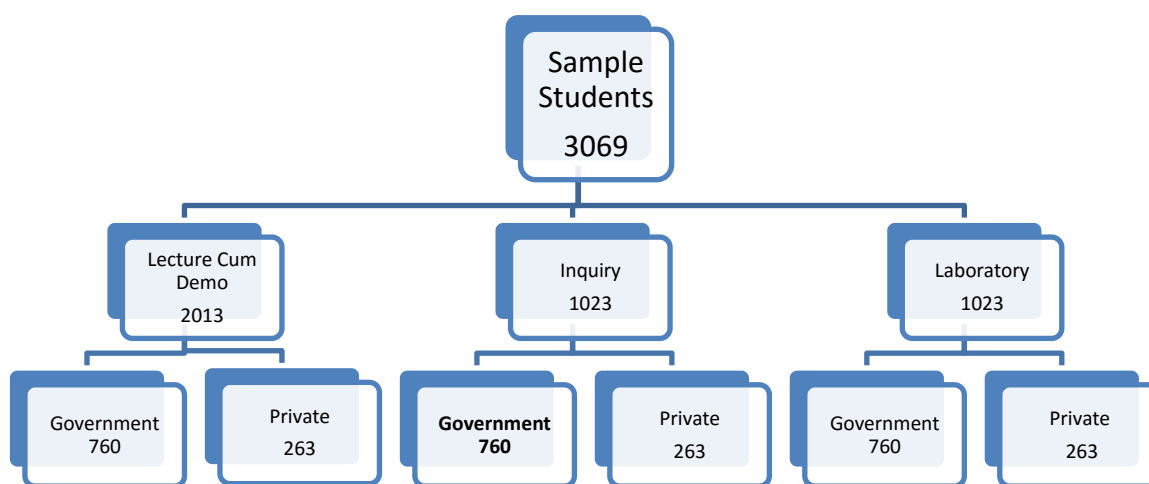
Figure: 3 Sample Students In The Study Under The Three Methods

3.6.5 Tools of the study:

1. Pre- test for testing previous knowledge of the students.

2. Post-test for determining the academic achievement score.

3. Structured Interview schedule for the teachers;

3.6.6 CONSTRUCTION OF THE TOOLS:

i) Question-Paper for Pre-test: A Question Paper with simple items on General Science   covering specific chapters with full marks 20 for class X was prepared. i.e. for pre test which is the control group.

ii) Question-Paper for Post-test: A Question Paper with different items on General Science   covering same chapter with full marks 20 for class X was prepared, i.e. for post- test which is the experimental group. It was planned to prepare a question paper of 20 marks with 12 test items for final test (post-test). Same question paper was used for the three methods. There was 08 numbers of very short answer type questions carrying 1 mark each, 03 numbers of short answer type questions carrying 3 marks for two questions and 2 marks for one question and 01 number of essay   type question carrying 4 marks. Thus the full weightage of the test score was 20. Same pattern was used for pre-test.The syllabus of science subject for class x contained four units. Out of the four units the unit entitled 'Light' was selected for teaching and the achievement test. The question paper was a balanced one, with proper objectives, type of questions and content where   each of the test items reflected learning outcome of the students (Kour, 2013). The blue print of the achievement test was prepared and the question papers are shown in the appendix I and II.

The teachers were asked to teach the chapter using the three methods namely, Lecture Cum Demonstration, Inquiry and Laboratory. After teaching them by using three different methods a post test was conducted to test the acquired knowledge, understanding, application and skills i.e., post test, which is experimental group. A careful planning was made to develop   a valid instrument for evaluating the achievement of sample class x students, while planning due consideration was given to different aspects like length of the test, weightage to different units and preparing the blue print of the question paper.

 The achievement scores i.e. data are analyzed by using t-test, F-test and post hoc test (ANOVA).

3.6.7 Structured Interview Schedule for the teachers: To know the opinions of teachers a structured interview schedule was constructed following Likert - scale. A careful planning was made to develop   a valid instrument for evaluating the opinion of sample teachers teaching in   class X. While planning, due consideration was given to different aspects like length of the test, equal weightage to different methods and

giving freedom for the answer. There were 30 questions in total out of which 28 were closed ended and 02 were open ended. After completion of the experiment the teachers responded all the questions according to their choice and convenience. There were all together 76 trained science teachers in the selected 60 schools.

The data were analyzed by using χ^2- test (chi-square test).The Structured Interview Schedule for the teachers is attached in Appendix III.

3.6.8 Procedure of Data Collection: At first the investigator personally visited I.S. office of Kamrup district and collected the permission from both rural and metro, for the investigation. Then the investigator personally visited the sample schools and took permission of all the headmasters/principals to meet the teachers for experiments and collection of data. For collection of data there were two types of Question-Paper one for the pre –test and another for the Post-test. Both are used for students of class x under the experimental method. An interview schedule for science teachers of total numbers of selected schools was used to find out the problems for   science teaching existed. It was completed following survey method.

Before starting the experiment the investigator discussed with the all science teacher about the experiment and evaluation. And also requested to find out the previous knowledge of the students with the annual exam report, and take the pre-test for the selected units. The investigator distributed the Question-Paper to all the science teachers to take the pre- test. Periodically all the science teacher took the pre- test and collected data from the students and handedover the investigator. Investigator collected all the performing data of the scores and prepared the respective tables. (Pre-test scores)

After that the investigator personally requested all   the science teachers to take classes taking lessons from the chapter on Light for required time. The teaching system comprised of three methods- Lecture cum Demonstration,   inquiry and Laboratory methods. All the science teacher taught in proper manner in all the three methods as per the guidance of the investigator in all 60 schools of kamrup district during 2012-2015.The science teacher took the classes in six weeks and applied all

the three methods i.e. Lecture-cum Demonstration , Inquiry and Laboratory method. After completion of the topics the investigator requested to arrange for the post- test for achievement scores of the students of different schools. After arrangement, the investigator distributed the question paper to respective science teacher for conduction of post-test. The science teacher of different schools held the post-test and collected data from the students' performance and prepared a list of their achievement scores or filled up the supplied mark sheet by scores.

A total sample of 3069 students was selected from class X standard. All the students were divided into three groups, on the basis of their academic achievements. The groups were A, B, and C containing 1023 number of students in each group. To test their previous knowledge and experience a pre-test was administered before the experiment .These groups were the control groups.

After teaching them by using the three methods viz., Lecture-cum Demonstration ,Inquiry and Laboratory method, a post test was conducted .The same units from science text book was used for both the tests (pre & post).On the basis of 'blue print' the content, different objectives and types of questions were prepared and administered. The achievement scores of post test were the dependent variables whereas the methods of teaching were the independent variables. The post test was conducted to compare the effectiveness of one method over the other.

After specific period the investigator visited the schools and collected all the mark sheets from the science teachers of selected schools (post-test scores).

3.6.9 Statistical Technique used for this study: In this study both experimental and survey methods are used. In analyzing and interpreting the data the following technique are used- (i) Tabular presentation (ii) t-test (iii) F-test (ANOVA)   (iv) Chi-Square test (v) Graphical Presentation.

For conducting the investigation the following structure have been taken:

Experimental Details:

Table-1: Abstract information table of the investigations

Serial No.	Title of the investigation	Year of Expt.	Name of the institutions
Investigation 1.**Pre-test** Investigation 2 .**post-test**	A Comparative Study on the Effectiveness of Lecture Cum Demonstration method, Inquiry method and Laboratory method for teaching General Science in Secondary Schools.	2012-2015	60 schools (List Enclosed)

In this investigation (1 and 2), same method was used for the above-mentioned title i.e. for pre- test and post-test.

3.5.9 (a)   Statistical Techniques Used for the Analysis of Data:

In the present investigation, the data have been analyzed statistically. For analyzing and interpreting data the following methods have been used for testing hypotheses:

(i) Tabular presentation   (ii) Method of analysis of variance (ANOVA) or F -test

(iii) t-test, (iv) Post Hoc Test, (v) chi-square test (χ^2),

(vi) Graphical presentation

 (i) Table: A table is systematic method of presenting statistical data, according to classification of subject matter or topic. Tables enables one to comprehend and interpret masses of (all) the data rapidly, systematically and to group significant details and relationship at a glance. Hence tables for pre-test and post-test are shown separately for each section of investigation (class X).

(ii) F-test or Method of analysis of variance (ANOVA):

It is an extremely useful technique relating to researches in the field of education, Zoology, Botany, Psychology, Economics etc. The technique is used when multiple sample cases are involved. The essence of ANOVA is that the total amount of variation in a set of data is broken down into two types, that amount which can be attributed to specified cases. There may be variation between samples and also within sample items.

The basic principle of ANOVA (Fisher, 1944) is to test for differences among the means of the populations by examining the amount of variation between the samples. The F-test measures whether the sample means differ from one another (between group variance) to a greater extent than the test scores differ from their own sample means (within groups variance) using the ratio.

$$F = \frac{Variance\ Between\ Groups}{Variance\ Within\ Groups}$$

The significant of F-ratio is determined from its significance value.

(iii) t-test: The test of significance of the difference between two means is made by t-test for testing the hypotheses. It requires the calculation of the ratio between experimental variance (observed differences between two sample means) and error variance (sampling error factor) to analyze whether two groups differ significantly in mean performance. The formula uncorrelated large group is given below.

$$t = M_1 - M_2 \ / \sqrt{\sigma_1^2/N_1} + \sqrt{\sigma_2^2/N_2}$$

Where, M_1 is the mean of the 1st group

M_2 is the mean of the 2nd group

N_1 is the number of cases of 1st group

N_2 is the number of cases of 2nd group

O_1 is sd of the 1st group

O_2 is sd of the 2nd group

(iv) Post Hoc Test: Post hoc tests are designed for situations in which the researcher has already obtained significant omnibus F-test with a factor that consists of three or

more means and additional exploration of the differences among means is needed to provide specific information on which means are significantly different from each other. The first post hoc, the LSD test: The original solution to this problem, developed by Fisher, was to explore all possible pair-wise comparisons of means comprising a factor using the equivalent of multiple t-tests. This procedure was named the Least Significant Difference (LSD) test. The least significant difference between two means is calculated by:

$$LSD = t \sqrt{2MSE/n*}$$

Where t is the critical, tabled value of the t- distribution with the df(degree of freedom) associated with MSE(Mean Square Error), the denominator of the F statistic and n* is the number of scores used to calculate the means of interest. In this study table 6 represents Post Hoc Test where the investigator tried to find out differences between lecture- cum demonstration method and inquiry method, lecture-cum demonstration method and laboratory method, inquiry method and laboratory method.

(v) χ^2- test (chi-square test):

χ^2 -test is an approximate test for large values of 'n' i.e. the sample size. For the validity of χ^2-test following conditions must be satisfied:

1. The sample observations should be independent.
2. Constraints on the cell frequencies, if any, should be linear,

   i.e. $\sum 0i = \sum Ei$ the total frequency should be reasonably large, say, greater than 30.
3. No theoretical cell frequency should be less than 5; otherwise it cannot maintain its character of continuity. Under such situation some modification is necessary.
4. $\chi 2$- test depends only on the set of observed and expected frequencies and on degrees of freedom (d.f.) It does not make any assumption regarding the parent population from which the observations are taken. The formula for computing - test is given by :

   $$\chi 2 = \sum [(f_o - f_e)^2/f_e]$$

Where, f_o = obtained frequencies on some experiment

f_e = expected frequencies on hypothesis

(vi) Graphical Representation:

Graphical presentation facilitates good understanding of a set of data (scores) because these devices helps the research to find out the errors even when the most careful array of statistical evidence fails to attract notice. It translates numerical facts often abstract and difficult of interpretation in to concrete and understandable form. It helps to compare or relate the results of a group with another and in conclusion.

a) Histogram and Bar diagram: Histogram focuses how the scores in the group are distributed whether they are piled up at the low end of the scale or are even by and regularly distributed over the scale when the test is well suited to the abilities of the groups; scores will be around the mean, a few individuals scoring quite high or low. A bar diagram represent each value in a range with a bar of varying heights. There may be single range bar graph which compares values in one set of data, to each other, or multiple range bar graphs which displays comparable values from up to 4 sets of data at each point along with the x-axis. A variety of shadings or columns can be used to identify the bars. 3-dimentional type is easily understandable and attractive.

Bar diagram has been presented for the different tables.

b) Line graph: Data showing the changes attributable to growth, practice and learning may often be most clearly presented by line graph. The graph represents changes in logical memory or achievement of students for a connected passage of prose or content. Here, methods are represented on the horizontal or X axis and mean value of post- test of different methods is placed on the vertical or Y axis.

c) Pie diagram: The construction of this pie diagram is quite simple.There are 360 degrees in the circle. Hence 59% of 360^0 or 35% of 360^0 are counted off as shown in the diagram (Fig.6); this sector represents the proportion of lecture cum demonstration or laboratory method.

The pie diagram is useful when one wishes to picture proportions of the total in a striking way.Numbers of degrees may be measured off ''by eye'' or more accurately with a protractor (Garrett, 1981).

   3.5.9 (b) Statistical Analysis of Data: In this teaching-learning process of science teaching, the data collected from both the experiment conducted during the pre and post-test were statistically analysed for greater reliance of finding. Fisher's method of analysis of variance was employed to analyse the data (marks obtained). The investigations were conducted separately in the different groups of the same class. Combine statistical analysis of all the pupils of pre and post-test were performance for the convenience of their comparison of the relative teaching performance in this investigation.

At first the analysis was done accordingly to three different methods such as lecture-cum demonstration, inquiry and laboratory. Under each method there were 3 different groups, and experiment was conducted by one   or more   science teachers of 60 different schools.

Again each group (A, B and C) was conducted by the respective teacher under two tests i.e. pre-test and post-test. And sample of pre-test serves as control group for each group of the respective schools.

Thus there were 1023 treatment combinations made up of 3 groups (A/B / C) of 60 schools.

That is 1023 x 1 =1023 for lecture cum demonstration method

      1023 x 1 = 1023 for inquiry method

       1023 x 1 = 1023 for laboratory method

 Total, 1023 x 3 = 3069 samples for all groups.

Thus, 1023 treatment combinations for group A i.e. for lecture cum demonstration method,

 1023   treatment combinations for group B i.e.for inquiry method.

 1023 treatment combinations for group C i.e.for laboratory method.

 1023 treatment combinations for each group i.e. A, B and C.

Total 1023x3 = 3069 samples used for this investigation of science teaching.

 There were 3069 samples of 60 secondary schools have been selected from Kamrup district of Assam. It is a large sample. The numbers of groups are more than two hence Anova and F ratio is convenient and reliant for statistical analysis and to interpret the effectiveness of the different methods.

A skeleton of the ANOVA table is given below:

Sources of Variation	Degree of Freedom
Method types	2
Groups	2
Error	1018
Total	**1022**

Besides this, analysis was also done to bring out the overall effects of method are used in teaching process. This was done to know the overall effect of this method along with techniques and skills irrespective of the actual classroom teaching involved. A skeleton of the ANOVA table for methods and groups:

Sources of Variation	Degree of Freedom
Method types	2
Groups	2
Error	1018
Total	**1022**

A skeleton of the ANOVA table for methods and schools:

Sources of Variation	Degree of Freedom
Method types	2
Schools	59
Error	963
Total	**1022**

We used SPSS softwere for   analysis of data.

Table:2 List of Sample Schools

	Sl. No.	Name of School	Location	Medium	Date of Experiment
Central Kamrup	1	Guwahati Madrassa High School	Paltanbazar	Assamese	05/08/2013
	2	St.Marry's H.S.School	Guwahati Club	English	05/03/2014
	3	Panbazar Girls'H.S.School	Panbazar	Assamese	13/03/2014
	4	Uzanbazar Govt.GirlsH.School	Uzanbazar	Assamese	27/03/2014
	5	T.C.Govt.Girls'H.S.&M.P.School	GuwahatiClub	Assamese	22/04/2014
	6	Don Bosco Senior S..School	Panbazar	English	20/07/2014
	7	CottonCollegiateBoysGovt.H.S.School	Panbazar	Assamese	20/11/2014
East Kamrup	8	Geetanagari High.School	Noonmati	Assamese	05/08/2013
	9	Noonmati High.School	Noonmati	Assamese	05/08/2013
	10	Pub Guwahati Girls H.School	Chandmari	Assamese	12/03/2014
	11	Rajgarh Girls' H.School	Rajgarh	Assamese	12/03/2014
	12	Rupnagar Vidyapith H.School	Rupnagar	Assamese	12/03/2014
	13	Ulubari H.S. School	Ulubari	Assamese	12/03/2014
	14	BhaskarVidyapith H.S. School	Bhaskarnagar	Assamese	13/03/2014
	15	Chandrapur H .School	Chandrapur	Assamese	19/04/2014
	16	PachimMayong H. School	Chandrapur	Assamese	19/04/2014
	17	Happy Child H. School	Rehabari	English	26/04/2014
	18	Delhi Public School	Guwahati	English	28/04/2014
	19	Maharishi VidyaMandir	Lalmati	English	28/04/2014
	20	Sanskriti the Gurukul	Guwahati	English	28/04/2014
	21	Khetri Girls' H.School	Khetri	Assamese	16/05/2014
	22	Nahargurighat H.S.School	GandhiNagar	Assamese	16/05/2014
	23	Pub-Dimoria H.School	Dimoria	Assamese	16/05/2014
	24	Sri Satya Sai Girls' H.School	Ulani	Assamese	16/05/2014
	25	Montfort Senior Secondary School	Guwahati	English	18/05/2014

		Cont. Table:1			
	26	Bidyamandir H.S.School	Pandu	Bengali	02/04/2015
	27	Assam Jatiya Vidyalaya	Noonmati	Assamese	04/07/2015
	28	Narengi High School	Narengi	Assamese	08/10/2015
	29	Satgaon High School	Noonmati	Assamese	08/10/2015
	30	G.N.T.Chinmaya Vidyalaya	Rukminigaon	English	30/10/2015
West Kamrup	31	C.P.B.Girls H. School	Azara	Assamese	05/08/2013
	32	Jalukbari Girls' H. School	Jalukbari	Assamese	13/02/2014
	33	Baramboi H.S.School	Hajo	Assamese	07/04/2014
	34	Damdama H.S.School	Hajo	Assamese	07/04/2014
	35	Pachgaon H.S.School	Hajo	Assamese	07/04/2014
	36	B.A.S.Madrassa H.S.School	Hajo	Assamese	07/08/2014
	37	Barni High School	Hajo	Assamese	07/08/2014
	38	Bullut Anchalik jatiya Vidyalaya	Hajo	Assamese	07/08/2014
	39	Doloitola Shaukat Ali H.School	Hajo	Assamese	07/08/2014
	40	Gyanjyoti Jatiya Vidyalaya	Hajo	Assamese	07/08/2014
	41	Khopanikuchi Anchalik H,School	Hajo	Assamese	07/08/2014
	42	R.B.K.Anchalik H.School	Hajo	Assamese	07/08/2014
North Kamrup	43	Premada Sivanath Vidyapith	Rangia	Assamese	08/04/2014
	44	Railway H.School	Rangia	Assamese	08/04/2014
	45	Bezera H.S.School	Bezera	Assamese	19/05/2014
	46	Dumunichowki H.School	Dumunichowki	Assamese	19/05/2014
	47	Pub-Kamrup H.School	Rangia	Assamese	19/05/2014
	48	Titkuchi H.School	Titkuchi	Assamese	19/05/2014
	49	Borka Girls' H.School	Kamalpur	Assamese	20/05/2014
	50	Jawaharlal Nehru H.School	Kamalpur	Assamese	20/05/2014
	51	Udayan Santi Niketan	Bezera	Assamese	27/11/2015

		Cont. Table:1			
South Kamrup	52	Nagarbera H.S.School	Boko	Assamese	11/02/2014
	53	Sankardev H.School	Boko	Assamese	11/02/2014
	54	Boko H.School	Boko	Assamese	09/04/2014
	55	Boko Girls' H. School	Boko	Assamese	09/04/2014
	56	Kaliprasad Das Girls' H.School	Chhaygaon	Assamese	09/04/2014
	57	Palashbari Boys H.School	Palashbari	Assamese	09/04/2014
	58	Rampur H.S.School	Palashbari	Assamese	09/04/2014
	59	Chhaygaon ChampakNagar Girls' H.S.	Chhaygaon	Assamese	12/07/2014
	60	Chhaygaon H.S. School	Chhaygaon	Assamese	13/10/2014

Figure: 4 Map showing the number of selected schools
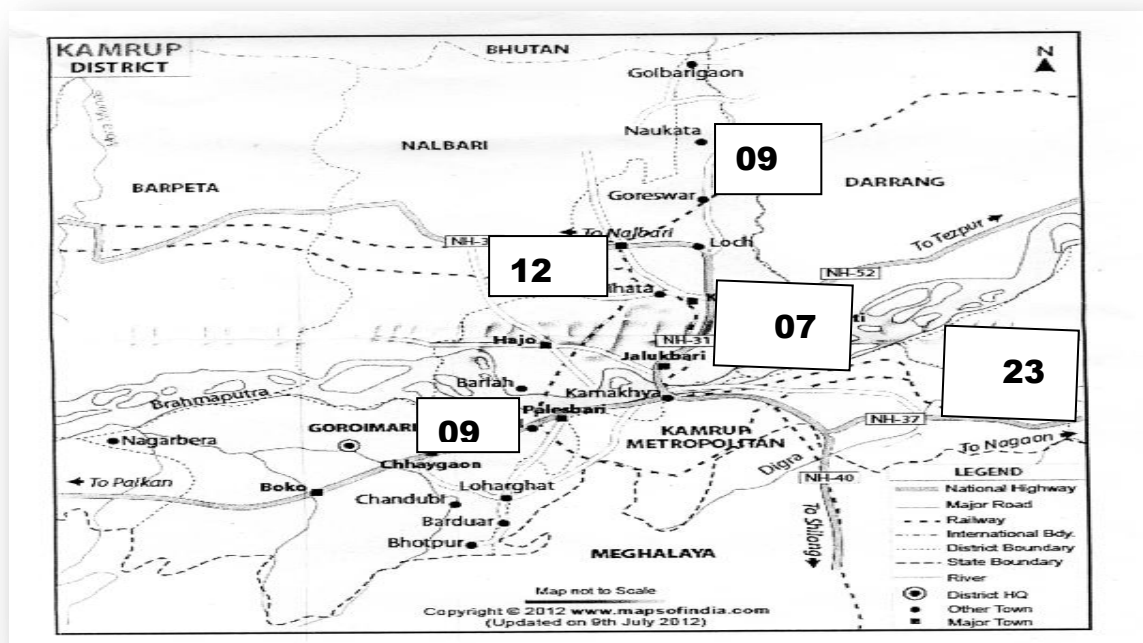
Central part of kamrup=07 schools, East part of kamrup=23 schools,

West part of kamrup=12 schools, North part of kamrup=09 schools and

South part of kamrup=09 schools.