CHAPTER 4

METHODOLOGY

1.0 Introduction
2.0 Method Adopted
3.0 Design Selected
4.0 Sample Selected for the Study
5.0 Tools and Materials used for Collection of Data
6.0 Data Collection Procedures
7.0 Statistical Techniques used for Analysis
METHODOLOGY

1.0 Introduction

Methodology includes the description of the techniques or methods and the tools the researcher has used for collecting, organizing, analysing and interpreting data. It gives a detailed description of the research variables and procedures. Here it has been described under the following major heads.

2.0 Method adopted

3.0 Design selected

4.0 Sample selected for the study

5.0 Tools and materials used for collection of data

6.0 Data collection procedures

7.0 Statistical techniques used for analysis

2.0 Method Adopted

The major objective of the present study was to compare the effectiveness of mastery learning strategy with the conventional textbook approach. Experimental method is a systematic and logical method of hypothesis testing under carefully controlled conditions. It helps to find out whether one method of teaching is
more effective than the other or not. Hence, experimental method, the most important from the strictly scientific point of view was found to be most appropriate for the study and was adopted to compare the effectiveness of mastery learning strategy with the conventional textbook approach.

3.0 Design Selected

In the experimental method, the investigator has to follow an experimental design. This is the blue print of the procedures that enable the researcher to test hypotheses. In the present study the pretest-posttest non-equivalent groups design was used. This design is often used in classroom experiments when experimental and control groups are such naturally assembled groups as intact classes, which may be similar (Best, 1999). Hence, without disturbing the natural settings of the classrooms, intact class groups, which are normally non-equated, were selected for the study. These non-equivalent class groups were later statistically equated by applying appropriate statistical techniques.

3.1 Variables of the Study

The independent, dependent and controlled variables involved in the study are given in table 1.
### TABLE 1

**VARIABLES OF THE STUDY**

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Dependent variables</th>
<th>Controlled variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastery learning</td>
<td>Achievement</td>
<td>Subject Taught</td>
</tr>
<tr>
<td>Strategy</td>
<td>Retention power</td>
<td>Standard</td>
</tr>
<tr>
<td>Conventional</td>
<td>Science Interest</td>
<td>Intelligence</td>
</tr>
<tr>
<td>textbook approach</td>
<td>Scientific Attitude</td>
<td>S.E.S</td>
</tr>
<tr>
<td></td>
<td>Achievement</td>
<td>Teacher</td>
</tr>
<tr>
<td></td>
<td>Motivation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self Concept</td>
<td></td>
</tr>
</tbody>
</table>

### 4.0 Sample Selected for the Study

The population consisted of secondary school pupils of the government and private schools following state syllabus of Kerala. The investigator decided to adopt purposive sampling keeping in view the experimental nature of the study and its demands and limitations. Two IX standard classes each from St. Johns Higher Secondary School, Kavalangadu, Ernakulam and Government Higher Secondary School, Akanadu, Ernakulam were selected for the study. Among the four classes selected, one each from both the schools was selected as experimental groups and the other two as control groups. The sample selected was purposive but representative of the population. A group of 172 pupils from the four classes was treated as sample. By adopting the weeding out technique in the socio economic status and intelligence test scores
and also by removing the absentees either in pretests or in the posttests, the sample size was reduced to 156.

5.0 Tools and Materials used for Collection of Data

The tools and materials employed for the present study were the following:

(I) Pre-requisite test

(II) Formative evaluation tests

(III) Summative evaluation test (Achievement test)

(IV) Non-verbal test of intelligence

(V) Socio economic status scale

(VI) Science interest inventory

(VII) Scientific attitude scale

(VIII) Achievement motivation scale

(IX) Self concept scale

(X) Lesson transcripts based on the selected units.

(XI) Strategies and study materials used for corrective and enrichment purpose
5.1 Description of the Tools and Materials

(I) Prerequisite Test

The investigator prepared and administered a test to assess the entry behaviour of the students prior to the initiation of the treatment phase. Attempt was made to find out the important pre-requisites unattained by the pupils. Two major chapters Heat and Sound, selected for the study, were subjected to a thorough analysis and the pre-requisites that are essentially needed for learning the new content were determined. Experts scrutinized the results of the analysis and necessary modifications were made. Then items to test these pre-requisites were developed and expert teachers scrutinized them. Since the test was prepared after thorough analysis and scrutiny the content validity of the test was assured.

The final pre-requisite test thus prepared by the investigator consisted of 25 objective test items having one score each for correct response. Compensatory learning programme was carried out in order to help the pupils attain all the necessary pre-requisites. The test and its response sheet are given in appendix II.
(II) Formative Evaluation Tests

In the present study, formative evaluation was designed as an integral part of the teaching learning process. The formative test administered at the close of a unit served two main purposes, such as to find out how much the pupils have not learned in the specific unit and also to assess whether instruction has been properly designed and conducted or not.

1. Steps followed in the Construction of Formative Tests

(i) Analysis of the Learning Units

In the present study two major chapters Heat and Sound of standard IX curriculum were divided into five sequentially ordered learning units. These short units of learning were analysed with the aim of identifying not only the objectives to be attained but also the relationships between the objectives.

(ii) Preparation of Table of Specifications

Table of specifications for each learning unit was prepared based on the guidelines suggested by Bloom (1971) through his book 'Handbook on formative and summative evaluation of student learning'. In all the learning units some things were to be memorized, others were to be understood so that the student can
express them in his own words; still others were to be utilized in solving new and unfamiliar problems. Each element of content was analysed in terms of the cognitive operations, the student was expected to perform for the attainment of mastery. Thus the two dimensional table was prepared with the content and behaviour. On one axis of this table, major behaviour categories have been placed and under each of these the investigator listed the appropriate subject matter elements or details. A frame of the table of specifications prepared for the first learning unit is given in table 2.
### TABLE 2

**TABLE OF SPECIFICATIONS FOR UNIT I - HEAT AND ITS EFFECTS ON SOLIDS**

<table>
<thead>
<tr>
<th>Content</th>
<th>Behaviour</th>
<th>Knowledge and Comprehension</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Knowledge of scientific</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>terminology</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge of concepts of</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>science</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge of conventions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge of trends and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>sequences</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge of scientific</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>principles and laws</td>
<td></td>
</tr>
<tr>
<td>Heat and Temperature</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Unit of heat</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Measurement of temperature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat capacity and</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>specific heat capacity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Principle of method of</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>mixtures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change of state</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Latent heat of fusion</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

The table presented is an illustration of the analysis of the content and the behaviours. On the same guidelines tables of specifications were prepared for all the other four learning units. Tables of specifications for the other four units are presented as appendix III.
(iii) Construction and Finalisation of Formative Tests

After the unit is analysed into content and behaviour every content behaviour is not tested as Bloom (1971) says, “the constructor of the test must determine which elements in the unit are important or essential, and which are unimportant or useful only as a background for the essential material. Such specific facts may be included in the specification but dropped at the time of testing”. The point is that everything included in the specifications is not of equal importance and the test maker must apply some judgement to determine what is essential in the unit and what may be omitted without impairing the student’s mastery of the unit. In the present study, by following the general principle of formative evaluation, the test items included in the formative tests represented all the important instructional objectives of a unit, as detailed by the specifications.

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Figure 3 Block diagram showing the relationship between formative evaluation and mastery learning procedure
On the basis of the guidelines discussed above, formative tests, which are criterion referenced, were constructed. The first formative test for each unit was designated as formative diagnostic test (FDT). These tests were diagnostic in nature and administered after the completion of each unit and were the main source of feedback. The formative diagnostic test (FDT) developed for each learning unit consisted of 20 test items. It was not possible to undertake item analysis for paucity of time but the items were edited with respect to (a) match with instructional objectives (b) content accuracy (c) language accuracy and (d) other technical features of tests. Expert opinions were also obtained and necessary modifications were made. Scoring key was prepared to score each formative diagnostic test. Sample FDTs are given as appendix IV.

Having administered and scored the first formative test (FDT), an error chart was prepared based on the table of specifications. The error chart was utilized for the construction of formative remedial test (FRT). Formative remedial test was administered only after the corrective instruction based on the error chart. The main difference between FDT and FRT is that FDT is based on the table of specifications and FRT on the error chart developed on the basis of the table of specifications. After adopting corrective procedures FRT₁ and FRT₂ were administered based on the mastery attainment of the pupils.
**(III) Summative Evaluation Test (Achievement Test)**

The investigator developed and standardized an achievement test in Physics for standard IX. In the present study the achievement test was constructed to,

- judge the pupils' mastery of the specified objectives
- evaluate the instructional methods adopted
- grade the pupils in terms of their achievement
- assess entry behaviour and criterion behaviour by treating achievement test as pre test and posttest respectively.

In the preparation and standardization of the achievement test, the following sequence was adopted.

**(i) Choosing the Course Content**

Two major chapters Heat and Sound from the physics curriculum of standard IX were selected. They were divided into five teaching units as given below.

Unit 1: Heat and its effects on solids

Unit 2: Effects of heat on liquids and gases
Unit 3: Introduction to sound
Unit 4: Wave motion
Unit 5: Characteristics and pollution of sound

(ii) Deciding the Teaching Objectives

This test was constructed keeping in view the objectives, knowledge, comprehension and application in the cognitive domain (Bloom, 1968).

(iii) Preparation of Table of Specifications

In order to ensure content validity of the test, the investigator prepared a two dimensional table of specifications and discussed with six teachers teaching physics and four teacher educators. Bloom (1968) pointed out that several cells in the matrix might well be empty as the specific behaviour for that particular content is not an objective of the course. Generally, it is not possible to evaluate the students on the total matrix in one summative test. The table could assist in the formulation of appropriate instructional objectives.
(iv) Preparation of Test Items for Draft Test

Objective type test items are more economical, time saving, reusable and tend to possess higher score reliability and content validity. Keeping this in view the investigator selected objective type test items only. Since the test preparation demanded vast experience in the field, the help of experts and experienced
teachers was sought. With their support and help the investigator was able to prepare multiple-choice items in the subject area. The items were arranged according to their increasing order of difficulty. A question paper consisting of 80 multiple-choice items was prepared with necessary directions on the first page. A copy of the draft test is provided as appendix VI.

(v) Try out of the Draft Test

The try out of the draft test for item analysis was conducted on a sample of 185 pupils of standard IX. Enough time was given so as to enable all the students to complete the test. The scoring was done according to the scoring key prepared for this purpose. Sample split up for the try out is given in table 4.

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>School</th>
<th>No. of pupils</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Govt. H.S.S. for Girls, Perumbavoor</td>
<td>38</td>
</tr>
<tr>
<td>2.</td>
<td>Govt. H.S.S. for Boys, Perumbavoor</td>
<td>36</td>
</tr>
<tr>
<td>3.</td>
<td>Govt. H.S.S., Akanadu</td>
<td>37</td>
</tr>
<tr>
<td>4.</td>
<td>Asramam H.S.S., Iringole</td>
<td>40</td>
</tr>
<tr>
<td>5.</td>
<td>St. John’s H.S.S., Kavalangadu</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>185</td>
</tr>
</tbody>
</table>
(vi) Item Analysis

The process of item analysis helped to identify items with high discriminating power and optimum difficulty level. The quality of each item was determined by analysing two important characteristics of the items such as difficulty index and discriminating power. Kelly’s method (Kelly, 1939) was used to calculate the difficulty index and discriminating power. Based on the scores obtained, response sheets of the students were arranged in descending order from highest to the lowest. The responses of the top scoring 27 percent of sheets and the bottom scoring 27 percent were used for item analysis. Items having difficulty index between 0.20 and 0.80 and discriminating power above 0.20 were selected for the final test. The details regarding the difficulty index and discriminating power of each item are given as appendix VII.

(vii) Preparation of the Final Test

The final test was prepared based on a blue print by giving due weightage to content, objectives and difficulty level.

Weightage to Content

Mehren and Lehmann (1973) clearly stated that ‘there is no hard and fast rule that can be prescribed for the teacher to use in
determining the weights to be assigned to the various cells in the table of specifications, experience is his best resource'. The breakup is provided in the table 5.

**TABLE 5**

**WEIGHTAGE TO CONTENT**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Content</th>
<th>No. of Questions</th>
<th>Marks</th>
<th>Percentage of marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Heat and its effects on solids</td>
<td>6</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>2.</td>
<td>Effects of heat on liquids and gases</td>
<td>12</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>3.</td>
<td>Introduction to sound</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>4.</td>
<td>Wave Motion</td>
<td>14</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>5.</td>
<td>Characteristics and pollution of sound</td>
<td>8</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>50</strong></td>
<td><strong>50</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Weightage to Objectives**

The weightage given to the instructional objectives is represented in table 6.

**TABLE 6**

**WEIGHTAGE TO OBJECTIVES**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Objectives</th>
<th>Number of questions</th>
<th>Marks</th>
<th>Percentage of marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Knowledge</td>
<td>12</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>2.</td>
<td>Comprehension</td>
<td>25</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>3.</td>
<td>Application</td>
<td>13</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>50</strong></td>
<td><strong>50</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Weightage to Type of Questions

The investigator selected objective type test items only. The purpose of the test was to assess pupils’ factual knowledge, their understanding of principles as an ability to interpret and apply. For this purpose objective type tests are most suited. Besides, they are more economical and tend to possess higher score reliability and content validity. One of the purposes of the test was ‘grading’. Objective tests are useful for that purpose because they provide scope for greater sampling of content and more objective scoring. They are time saving and reusable also. Thus keeping all these plus points 50 multiple choice type items were selected.

Weightage to Difficulty Level

The difficulty levels of the questions are given in table 7.

**TABLE 7**

WEIGHTAGE TO DIFFICULTY LEVEL

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Difficulty level</th>
<th>Number of questions</th>
<th>Marks</th>
<th>Percentage of marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Easy</td>
<td>14</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>2.</td>
<td>Average</td>
<td>26</td>
<td>26</td>
<td>52</td>
</tr>
<tr>
<td>3.</td>
<td>Difficult</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>
Then the Blue print was prepared with weightage given to content subunits, objectives and type of questions. It is given as in table 8.

### TABLE 8

#### BLUE PRINT

<table>
<thead>
<tr>
<th>Type of questions (Content)</th>
<th>Knowledge</th>
<th>Comprehension</th>
<th>Application</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat and its effects on solids</td>
<td>1 (1)</td>
<td>3 (1)</td>
<td>2 (1)</td>
<td>6</td>
</tr>
<tr>
<td>Effects of heat on liquids and gases</td>
<td>2 (1)</td>
<td>5 (1)</td>
<td>5 (1)</td>
<td>12</td>
</tr>
<tr>
<td>Introduction to sound</td>
<td>6 (1)</td>
<td>3 (1)</td>
<td>1 (1)</td>
<td>10</td>
</tr>
<tr>
<td>Wave motion</td>
<td>1 (1)</td>
<td>10 (1)</td>
<td>3 (1)</td>
<td>14</td>
</tr>
<tr>
<td>Characteristics and pollution of sound</td>
<td>2 (1)</td>
<td>4 (1)</td>
<td>2 (1)</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>25</td>
<td>13</td>
<td>50</td>
</tr>
</tbody>
</table>

- The number outside the bracket indicates number of questions.
- The number inside the bracket indicates marks.

Based on the highest discriminating power and optimum difficulty index, best 50 items were selected from the draft test. The final test consisted of 50 objective type test items carrying one mark each. The items were analysed in the order of difficulty level as per Frisbie’s (1971) suggestion. The time duration of the test
was decided to be 65 minutes. Frisbie has suggested that four/five response multiple-choice items can be responded in about 75 seconds. A copy of the achievement test and its response sheet are given in appendix IX.

(viii) **Reliability and Validity of the Achievement Test**

The reliability and validity of the achievement test was assessed before it was used in the final data collection.

**Reliability of the Test**

The reliability of the test was established by using split-half method. A sample of 80 pupils studying in two divisions of standard IX was used for the purpose. Here the odd numbered items were treated as one half of the test and scored separately and all the even numbered items were treated as another half and scored. The scores of the halves were correlated and the reliability of the test was found to be 0.78.

**Content Validity**

The test was conducted keeping in view the weightages given for content area and objectives on one hand and experts' comments and opinions on the other, it was treated as a valid test
Empirical or Statistical Validity

The empirical validity of the test was calculated by correlating the scores of the test with marks of a recently conducted test obtained from the school (Ebel, 1991). The coefficient of correlation obtained was 0.68. This value ensures the empirical validity of the test.

(IV) The Kerala Non-verbal Group Test of Intelligence

This is an important and popular non-verbal test of intelligence standardized for use with Kerala Secondary School children (1968). The test consists of four subtests. The details of the components; the number of items in each and time allotted for each sub-test are given in table 9.

<table>
<thead>
<tr>
<th>TABLE 9</th>
<th>THE KERALA NON-VERBAL GROUP TEST OF INTELLIGENCE TEST COMPONENTS AND OTHER DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI.No.</td>
<td>Test Component</td>
</tr>
<tr>
<td>1.</td>
<td>Figure classification</td>
</tr>
<tr>
<td>2.</td>
<td>Figure series</td>
</tr>
<tr>
<td>3.</td>
<td>Figure analogies</td>
</tr>
<tr>
<td>4.</td>
<td>Figure matrices</td>
</tr>
</tbody>
</table>
Description of the Test

(i) Figure Classification

Each of the 20 items consists of five abstract figures four of which belong to the same group on the basis of some order, rule, principle, but one figure will stand out as not belonging to the group. The subjects have to identify the figure, which does not go into the group. The answer has to be selected from a list of five abstract figures given. An example is given in figure 4.

![Figures A, B, C, D, E](image)

**Figure 4 Illustrative example of Figure Classification**

(ii) Figure Series

Each item in this subtest contains a sequence of five abstract figures, the first four of which are given with the last one missing. The correct answer has to be chosen from among the four alternative abstract figures given. The illustrative example is given in figure 5.
(iii) Figure Analogy

Each item in the subtest contains three abstract figures of which the first two figures are related to each other in a particular way. Applying the relationship that exist between the first two figures, the subject has to find out the fourth figure (from among the four alternatives given) so that the third and fourth bear the same relationship as the one between the first and the second. An illustrative example is given in figure 6.
(iv) Figure Matrices

This contains nine abstract figures arranged in three rows and three columns. The figure that is to come in the bottom right hand corner is missing. By examining the first two rows or columns, the subject has to discover the principle which connect the figures in the first two rows or columns and then use the relationship to find out the missing figure. An example is given in figure 7.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>W W W</td>
<td>M ≥ ≤ W</td>
</tr>
<tr>
<td>≥ ≥ ≥</td>
<td>A B C D</td>
</tr>
<tr>
<td>M M</td>
<td></td>
</tr>
</tbody>
</table>

Figure 7 Illustrative example of Figure Matrices

Reliability

The test retest reliability coefficient of the test has been calculated at different intervals. For a three-month interval, the reliability was 0.76 (N=246) for a one-month interval the reliability was 0.75 (N=124) and for one-week interval reliability was 0.8 (N=121).
Corrected split half coefficients of reliability for the whole test battery and for the component tests are given in \textit{table 10}.

The use of rational equivalence method gave a reliability of 0.84 (N=100).

\begin{table}
\centering
\caption{SPLIT HALF RELIABILITY COEFFICIENTS FOR THE KERALA UNIVERSITY NON-VERBAL GROUP (K.U.N.V.G) TEST OF INTELLIGENCE}
\begin{tabular}{|c|c|c|}
\hline
Sl.No. & Test & Corrected value of reliability coefficients \\
\hline
1 & Figure classification & 0.92 \\
2 & Figure series & 0.90 \\
3 & Figure analogies & 0.88 \\
4 & Figure matrices & 0.81 \\
5 & Whole test (N=237) & 0.91 \\
\hline
\end{tabular}
\end{table}

\textbf{Validity}

The validity of the test has been established using different tests as external criterion. The test manual provides data regarding the validity of the tests. The following correlation has been reported for the external criteria noted in \textit{table 11}. 
TABLE 11

VALIDITY OF THE KERALA UNIVERSITY NON-VERBAL GROUP (K.U.N.V.G) TEST OF INTELLIGENCE

<table>
<thead>
<tr>
<th>External Criteria</th>
<th>Correlation coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>With P.M.T</td>
<td>( r = 0.7840 ) (N=256)</td>
</tr>
<tr>
<td>With K.U.V.G.T</td>
<td>( r = 0.7340 ) (N=256)</td>
</tr>
<tr>
<td>With Teacher ratings</td>
<td>( r = 0.5200 ) (N=504)</td>
</tr>
<tr>
<td>S.S.L.C English</td>
<td>( r = 0.2636 ) (N=324)</td>
</tr>
<tr>
<td>S.S.L.C Malayalam</td>
<td>( r = 0.2082 ) (N=324)</td>
</tr>
<tr>
<td>S.S.L.C Hindi</td>
<td>( r = 0.2285 ) (N=324)</td>
</tr>
<tr>
<td>S.S.L.C Social Science</td>
<td>( r = 0.4327 ) (N=324)</td>
</tr>
<tr>
<td>S.S.L.C Mathematics</td>
<td>( r = 0.4286 ) (N=324)</td>
</tr>
<tr>
<td>S.S.L.C School Marks</td>
<td>( r = 0.5370 ) (N=324)</td>
</tr>
</tbody>
</table>

Factor analysis of the battery with the PMT and KUVGT as reference tests revealed presence of a major factor in all the tests of the battery, which is a close approximation to Spearman's 'g' factor of intelligence. Another less important common factor of the nature of a space-perception factor was also detected.

The reliability and validity coefficients reproduced above show that the test is both a reliable and valid tool for measuring intelligence suitable for use with Secondary School students of Kerala, on which it has been standardized. A copy of the test is given as appendix XV.
(V) The Kerala Socio-Economic Scale

The tool developed by Nair (1976) is a popular research tool, which measures socio-economic status. It measures the individual’s Father’s education level, Father’s occupation level and Father’s income level. An equal weightage is given for Mother’s education level, Mother’s occupation level and Mother’s income level.

The income levels were slightly modified, with respect to the responses collected, according to the latest income ratings.

The tool is in the form of a questionnaire, which in addition to obtaining data for quantifying socio-economic status, is also of help in obtaining personal information relating to each subject.

Parent’s education level, parent’s occupation level, parent’s income level, and hence socio-economic status has been determined by quantifying the data, giving weightages as described in the table 12.
## TABLE 12

### SCORING SCHEME OF THE KERALA SOCIO-ECONOMIC SCALE

<table>
<thead>
<tr>
<th>Variables</th>
<th>Categories</th>
<th>Weightage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. B.A/B.Sc/B.Com/ Diploma in Engg. Etc</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>3. Pre-university/ Pre-degree/T.T.C/I.T.I etc</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>4. Standard VIII to X</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>5. Standard I to VII</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>6. Illiterates</td>
<td>0</td>
</tr>
<tr>
<td><strong>Parent's Occupation Level</strong></td>
<td>1. High professional</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>2. Semi professional</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>3. Skilled</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>4. Semi skilled</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>5. Unskilled</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>6. Unemployed</td>
<td>0</td>
</tr>
<tr>
<td><strong>Parent's Income Level</strong></td>
<td>1. Above Rs.5000 per month</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>2. Rs.3001 to Rs.5000 per month</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3. Rs.1501 to Rs.3000 per month</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4. Rs.501 to Rs.1500 per month</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>5. Up to Rs.500 per month</td>
<td>1</td>
</tr>
</tbody>
</table>
The procedure of quantifying ‘Father’s Occupation level’ is given below.

**High Professionals:** Ministers, Judges, Bank executives and officials, Doctors, Engineers, Lawyers, University teachers, Heads of research organizations, Heads of Government departments, Secretaries of Government, Big landlords, Business executives etc., belong to this category and a 10 point score was allotted to this category.

**Semi-Professionals:** Chemists, Druggists, Qualified nurses, Managers, Superintendent of offices, Small scale business man, Contractors, Small landlords, Sub Inspectors of Police, Sub-registrars, Assistant education officers, Block development officers, Officers of sub district level, Public health workers, High School and Higher Secondary school teachers etc come under this category and they were assigned a 9 point score.

**Skilled:** Mechanics, Fitters, Electricians, Drivers, Photographers, Laboratory assistants, Carpenters, Document Workers, Clerks, Head Constables, Primary school teachers, Factory machine operators, Village Officers etc fall under this category and they were assigned a 8 point score.
Semi-Skilled: Farmers, small-scale merchants, library attenders, police constables, etc belong to this category and they were assigned a 5 point score.

Unskilled: Coolies, Ordinary labours, Watchmen, Peons etc are from unskilled groups. A 3 point score was assigned to this group.

Unemployed: Those who have no work at all. No weightage was assigned to this category (zero score).

Summated score for parent’s education level, parent’s occupation level; parent’s income level (with equal weightage given for both) is taken as the score for ‘socio-economic status’ of an individual. A copy of the scale is given as appendix XVI.

(VI) Science Interest Inventory

The variable ‘Science Interest’ was measured using a standard tool available. The Kerala university science interest inventory (developed by Nair and Jacob Thomas, 1971) was utilized for the study. This inventory contains 56 items patterned on the Kuder Interest Inventory. Each item consists of a set of three items representing different interests, out of which one indicates interest in science. The three statements in an item are in the form of possible activities in which subject is free to engage him. Assuming
all the three activities are within the means of the subject, and that he is required to make a selection of one activity, which appeals most of him. If the selected statement (activity) represents interest for science, the subject receives one score. If any other item is selected a zero score is assigned. The test is what may be described as a ‘forced-choice’ inventory of 56 items of trials. Representative items of the scale are given below.

(i)  A. to converse with scientists.
     B. to converse with political leaders.
     C. to converse with ecclesiastical leaders.

(ii) A. visit places of historical importance
     B. visit places of scientific importance.
     C. visit holy places.

*Note:* For the test item choice ‘A’ represents interest in science. Similarly for the second item choice ‘B’ represents the science interest.

**Reliability and Validity**

The test manual gives the test-retest reliability coefficient as 0.68 (N=32). Validity of the test is 0.53 (with teacher ratings of
science interest as external criterion). Specimen inventory is given in appendix XVII.

**(VII) Scientific Attitude Scale**

Scientific attitude was measured using the Kerala Test of Scientific Attitude, developed by Nair and Sobhana Devi (1978). This is a standardized test developed for measuring the scientific attitude of Secondary School pupils and other equivalent population in Kerala. The test is Likert type attitude scale, developed using the conventional procedures laid down for the purpose. There are 25 items in the scale with 11 positive and 14 negative items. The subjects are expected to respond to the items by indicating their degree of endorsement of the idea by taking in one of the five categories. Representative items are presented below.

(i) It is possible to assess the intelligence of a person through his appearance.

(ii) Religious leaders have succeeded in obtaining rain in draught affected areas through mass prayers.

The five response categories used are:

A – Highly Agree
B – Agree
C – Undecided
D – Disagree
E – Highly Disagree

For positive item (item accepting the concept of scientific attitude) highest degree will get highest score of 5, the other entries getting 4,3,2 and 1 respectively. Negative scoring will be adopted for negative items, i.e., given score 1,2,3,4, and 5 for the each categories A, B, C, D and E. The sum of the scores for all the items for an individual will represent his score for ‘scientific attitude’.

Reliability and Validity

The test manual provides evidence of the test’s reliability and validity. The reliability of the test has been established by the split-half method. The split-half reliability coefficient for the scale as reported in the test manual is 0.84 (N=100). The coefficients quoted above indicate that the scale is a reasonably valid and reliable tool.

The test claims both content and empirical validity. Content validity of the test has been ensured through the choice of items and the scale construction procedures. The empirical validity of the test has been established by correlating the test scores obtained from other suitable external scores. The test correlated 0.41 with
science achievement (N=45). A copy of the test is given in appendix XVIII.

(VIII) Achievement Motivation Scale

The Kerala scale of achievement motivation developed by Nair (1976) has 60 items in the form of statements and is standardised to measure the level of achievement motivation among Secondary School pupils of Kerala.

The subjects are to respond to the items by marking either 'Y' (yes), 'U' (undecided) or 'N' (no) on the response sheet supplied. Each 'Y' response carries one credit. There is no time limit for the test. Two illustrative items are:

(i) What others think of me won't be an obstacle to my success in life.

(ii) I feel tired when I have to perform very important things.

Reliability and Validity

The test–retest reliability of the scale is 0.73 (N=56) and the split-half reliability coefficient for the scale is 0.82. The test has been validated against the total achievement of students of
Secondary School classes as external criterion. Details of validity are:

With school marks of standard VIII as external criterion, validity is 0.33 (N=47).

With school marks of standard IX as external criterion, validity is 0.44 (N=38).

With school marks of standard X as external criterion, validity is 0.39 (N=42).

A copy of the test is given as appendix XIX.

**IX Self Concept Scale**

The variable was measured using the Kerala self concept scale, standardized by Nair (1976). This scale, a self report inventory, standardized for cultural samples from South India. The test contains sixty items grouped in pairs and divided into two sections A and B. For each item in section A, there is an equivalent item in section B. The subjects are asked to enter their responses by marking against any one of its five entries marked ‘A’, ‘B’, ‘C’, ‘D’ or ‘E’ in the response sheet. Here ‘A’ stands for ‘Strongly agree’, ‘B’ stands for ‘Agree’, ‘C’ stands for ‘Neutral’, ‘D’ stands for ‘Disagree’ and ‘E’ for ‘Strongly disagree’. The score for each item in section A
is compared with score in section B. The difference is computed using appropriate procedures.

Each item in section A represents an individual’s perception of ideal self. Two examples are given below from section A.

**(i)** I wish, if my parents had been the most influential people in our locality.

**(ii)** I wish, if I could be the most popular student in my class.

The matching items in section B for these two items are the following:

**(i)** My parents are the most influential people in our locality.

**(ii)** I am the most popular student in my class.

Item ‘1’ in section A represents the ideal concept of the individual with respect to the influence that his parents can wield in the locality. Item ‘1’ in section B represents the actual concept of the individual about actual influence that his parents wield in the locality. The individual by ticking in one of the five response categories (A,B,C,D,E) is getting a score for his perception of the ideal self and real self. The responses for each item can be scored according to the scheme given below.
Theoretically the score for the 'ideal self' cannot exceed the score for the 'real self'. When the difference is small, it represents a higher self concept as compared with larger difference. The maximum possible difference is 4. This represents the lowest score of an item with respect to self concept. Each difference is subtracted from four (the maximum possible difference) to obtain a positive self concept score for each item. This procedure helps to express a higher self concept in terms of higher scores and vice versa.

All the item scores are summated to obtain the total score of the whole test.

**Reliability and Validity**

The test manual provides evidence of the test’s reliability and validity. The reliability of the scale has been established in two methods the split-half reliability coefficient for the scale, as reported in the test manual, is $0.74(N=100)$. The test-retest reliability coefficient for the scale is $0.83(N=56)$. The coefficient
quoted above indicates that the scale is a reasonably valid and reliable instrument for measuring the self concept.

The validity of the scale has been estimated against a ‘semantic differential scale’ of self concept (translated version of the Osgood model developed for another research study) as external criterion. The resulting correlation was 0.48 (N=56), showing that the scale is a reasonably valid measure of self concept. Sample test is given in appendix XX.

**Lesson Transcripts**

The investigator prepared lesson transcripts for mastery learning by following the steps proposed by Bloom (1956). Two major chapters Heat and Sound in Physics in standard IX were selected. These topics were divided into five units in a sequential manner and objectives were identified. Thirty lesson transcripts were developed from the five units.

The investigator designed an enlarged plan of initial teaching well in advance, in order to carry out the instructional activities in a sequentially assigned order. The steps followed in the preparation of lesson transcripts were the following.
(i) In depth analysis of the content. Terms, facts, concepts, principles etc were identified.

(ii) The content was divided into lessons to be handled in one period of 40 minutes duration.

(iii) Objectives were cited in behavioural terms

(iv) Teaching aids needed for each lesson such as models, charts, pictures etc were prepared

(v) The structure and content of the lesson transcripts were discussed with the teachers teaching physical science and teacher educators. The suggestions of the teachers and teacher educators were utilized in the finalisation of lesson format.

In each lesson transcript objectives in specific behavioural terms were stated. Pre requisites needed for establishing the objectives were specified and given provision for the achievement of the prerequisites. In the first phase pupils were prepared for receiving the new concept. In the second phase various learning activities were provided. Here models and charts were used and real pupil involved activities were included for internalizing the concepts. In the last phase provision was given for review of the path they followed in the achievement of the objectives.
Assignments were also included in this phase. A model lesson transcript is given in appendix X.

**(XI) Learning Materials and Strategies used for Corrective and Enrichment Purpose**

For the promotion of students' learning to the fullest extent, the diagnostic information provided by formative evaluation was made use of in providing remedial instruction and enrichment activities. The investigator had used the following strategies and materials for the corrective and enrichment activities.

**1. Structured Peer Tutoring**

The students who mastered the unit were expected to answer a set of questions given to them by the investigator. The masters who had completed this assignment were paired with a member from the non-mastered group. They were engaged in discussion and doubt clearance. Pupils then change their pairs and prepare more questions based on the unit and conduct quiz programme. The answers for the prepared questions were entered in their notebooks and submitted before the investigator for correction. The investigator utilized this technique for each unit
after the administration of the first formative test. A model of the structured peer tutoring is given as appendix XI.

![Figure 8 Block diagram of Peer Tutoring](image)

**(ii) Small Group Study Session**

Investigator divided the class into small groups comprising of five to six pupils. Here the pupils discussed among themselves and expressed their remarkable ability to cooperatively correct each other's learning errors. Based on their discussions pupil completed the workbooks provided to them and checked the answers with the answer sheets provided to them in the later stage. The investigator then conducted a quiz programme to evaluate their attainment and all the pupils were given chance to answer questions representing their respective group. This was repeated for all the five units. This technique was adopted after...
the administration of second formative test. A model of small group study session is given as *appendix XII*.

![Block diagram of Small Group study session](image)

**Figure 9** Block diagram of Small Group study session

**(iii) Individual Tutoring**

This is the most efficient and effective strategy for correcting individual learning problems. The investigator identified pupils who need individual help after the formative test and taught them. The investigator in teaching of all the five units utilized this.

**(iv) Re-teaching**

This was employed in those cases where large number of students failed to learn particular content. Investigator adopted this technique in the attainment of some objectives of the first, second and fourth units. Re-teaching was adopted in the out of class hours only for those pupils who were non-masters of the unit.
(v) Individualised Instructional Module

This is a self contained and self sufficient unit of instruction for the learners to achieve a set of objectives. A module is broken into several sub units called capsules. Each capsule is framed based on one/two objectives. Its structure includes a brief introduction with a figure or a picture, observation, findings, conclusion and self-check exercise. Answers to the self-check exercise are given at the end of the module. In the present study three self-instructional modules were developed based on the pre-requisites needed for the learning of the chapters Heat and Sound of standard IX physics curriculum. ‘Heat and Expansion’, Modes of Heat Transfer’ and ‘Reflection of Sound’ were the three modules developed for the study. These modules were adopted mainly for providing compensatory instruction after the pre-requisite test. The investigator gave each module to the class and provided enough time for them to master the content. Then discussions and small group study sessions were conducted. Formative tests were administered after each module and ensured mastery of the pre requisites before starting the treatment phase. A copy of the module ‘Modes of Heat Transfer’ is given as appendix XIII.
(vi) Workbook

The workbook is a supplement to classroom learning. It has been developed by the investigator to enable student to test his knowledge of facts, confirm understandings of basic concepts developed and gain practice in the skills of solving problems and also to apply the understanding to everyday situations. The tests in the workbook also furnish the investigator with an instrument of measuring individual pupil differences in capacity and achievement and the status of the class as a whole, while a critical survey of the scores attained by the tests reveal the efficiency of the method of instruction. The content of the workbook was arranged according to the order of the five units selected for the study based on the major chapters Heat and Sound. Investigator developed two workbooks one on Heat and other on Sound. A copy of workbook on 'Sound' is attached as appendix XIV.

(vii) Audio-Visual Material

The investigator made use of models, charts, pictures, classroom demonstrations and instructional illustrations to provide pupils a clear and concrete idea of the material they were expected to learn.
5.2 Validity of the Instructional Module and Workbook

The investigator strictly following the scientific principles of module development prepared the modular lessons. Each module consisted of objectives cited in behavioural terms, learning activities to achieve these objectives and self check exercises to evaluate the attainment of the objectives.

The workbooks on the chapters 'Heat' and 'Sound' were also developed after thorough analysis of the contents based on the specific objectives.

The modules and workbooks were then subjected to a try out. The try out was made to a group of 10 students representing below average, average and above average categories of standard IX in Govt. Higher Secondary School, Akanadu. Their difficulties were analysed. The modules and workbooks were modified according to the suggestions and comments of the pupils, the observations made by the investigator and suggestions given by the experts, teachers and colleagues. Thus based on the procedures adopted in the development and try out of the modules and workbook, content and construct validity of the materials were ensured.
6.0 Data Collection Procedures

After finalizing the sample and tools to be used, the investigator approached the authority of the schools to seek the permission for conducting the study. The investigator met the heads of the schools and class teachers and had discussions with them; their co-operation was hence assured. The teaching and testing commenced from October 1998 and finished by the end of February 1999. The data collection was carried out through three phases namely,

i. Pre-testing
ii. Treatment
iii. Post-testing

6.1 Phases of the Study

The study included three phases. Pre testing was the first phase. In this phase pre requisites, intelligence, socio economic status, achievement, science interest, scientific attitude, achievement motivation and self concept of pupils were tested. The second phase was the treatment phase. The experimental and control groups were taught five units of standard IX physics. Post testing was the third phase. In this phase the students were tested on achievement, science interest, scientific attitude, achievement
motivation and self concept. A retention test was given after a period of two weeks of post achievement test. The three phases of the study are summarized in the *table 13.*

### TABLE 13

**PHASES OF THE STUDY**

<table>
<thead>
<tr>
<th>Phase</th>
<th>Experimental Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Pre test</td>
<td>1. Pre requisites</td>
<td>1. Pre requisites</td>
</tr>
<tr>
<td></td>
<td>2. Intelligence</td>
<td>2. Intelligence</td>
</tr>
<tr>
<td></td>
<td>3. Socio economic status</td>
<td>3. Socio economic status</td>
</tr>
<tr>
<td></td>
<td>4. Achievement</td>
<td>4. Achievement</td>
</tr>
<tr>
<td></td>
<td>5. Science Interest</td>
<td>5. Science Interest</td>
</tr>
<tr>
<td></td>
<td>7. Achievement motivation</td>
<td>7. Achievement motivation</td>
</tr>
<tr>
<td></td>
<td>8. Self concept</td>
<td>8. Self concept</td>
</tr>
<tr>
<td>II. Treatment</td>
<td>Teaching the units based on MLS</td>
<td>Teaching the units based on CTA</td>
</tr>
<tr>
<td>III. Post test</td>
<td>1. Achievement</td>
<td>1. Achievement</td>
</tr>
<tr>
<td></td>
<td>2. Science Interest</td>
<td>2. Science Interest</td>
</tr>
<tr>
<td></td>
<td>4. Achievement motivation</td>
<td>4. Achievement motivation</td>
</tr>
<tr>
<td></td>
<td>5. Self concept</td>
<td>5. Self concept</td>
</tr>
<tr>
<td></td>
<td>6. Retention</td>
<td>6. Retention</td>
</tr>
</tbody>
</table>

A flow chart showing the data collection procedure is given in *figure 10.*
Chapter 4 Methodology

Figure 10 Data Collection Procedure

Start

Pre-testing phase
1. Intelligence
2. SES
3. Achievement
4. Science Interest
5. Scientific Attitude
6. Achievement Motivation
7. Self-concept

Testing the entry behaviour through pre-requisite test

Compensatory learning programme

Unit-wise presentation of pre-determined objectives

Unit wise teaching

Formative diagnostic test

Mastery attained? (80%)

No

Corrective instruction

Yes

Enrichment activities

More than 80% students attained mastery

No

Mastery attained? (80%)

Yes

Formative Remedial test

No

All units covered

Post testing phase
1. Achievement
2. Science interest
3. Scientific Attitude
4. Achievement motivation
5. Self concept
6. Retention

End
6.1.1 Collection of Data During Pre-testing Phase

The investigator studied the basic literature relating to the selected psychological tests, contained in the test manuals and other references and acquainted herself with the testing procedures, possible eventualities, etc., before commencing actual testing. She then obtained copies of the test booklets and the answer sheets in the final form in adequate numbers.

Except the intelligence and SES, all the other tests were administered before and after the treatment stage as pre and post-tests. The intelligence and SES tests were administered initially only for control purpose. In the pre-testing phase data were collected for two types of variables namely, data relating to ‘control variables’ such as intelligence and socio-economic status and data relating to ‘dependent variables’ such as academic achievement, science interest, scientific attitude, achievement motivation, self concept and retention.

The investigator gave a short explanation of the aim and scope of the study to the subjects and appealed to their conscious participation and co-operation. The tasks implied in answering each test was explained before each test was given. The rules and
procedures prescribed for the different type of tests in the manuals were strictly followed.

The following steps were invariably followed for administering tests.

(i) Distribution of the test booklets to the subjects together with printed instructions regarding the test.

(ii) Explaining the general directions in the booklet.

(iii) Distribution of the answer sheets with instructions for filling up.

(iv) Making students familiar with the answer sheet, mode of entering responses etc.

(v) Clearing the doubts of subjects, giving instructions regarding time limit, methods of dealing with eventualities etc.

(vi) Strict adherence to the time limit in the case of speed test, directions not to disfigure the booklets etc.

(vii) Collecting back the test booklets and response sheets.

The investigator took five days to administer all the tests.
Pre-requisite Testing and Compensatory Learning Programme

In the pre-testing phase a pre-requisite test was also administered in order to assess the entry behaviour of the pupils. A compensatory learning programme was carried out to ensure the attainment of all the pre-requisites needed for learning the topics 'Heat' and 'Sound' by the pupils of the experimental group before the onset of treatment phase. The investigator provided self-instructional modules such as 'Heat and Expansion', 'modes of Heat Transfer' and 'Reflection of Sound' to the pupils and gave enough time to master the content. Discussions, small group study sessions and formative tests were conducted in the classroom based on each instructional module. Before starting the treatment phase the investigator confirmed the mastery of all the pre-requisites by the pupils of the experimental group.

6.1.2 Treatment Phase

(i) Utilisation of Time

The experiment was conducted in normal classroom setting. Thirty lesson plans were developed and taught through each method. Teaching period of 40 minutes duration was utilized. The table 14 shows the time devoted for original instructions among experimental and control groups and time devoted to corrective
procedures including formative tests in mastery learning strategy. While the experimental group undergone through corrective instruction the control group members engaged in supervised and self-study.

**TABLE 14**

**UTILIZATION OF TIME IN MASTERY LEARNING STRATEGY AND CONVENTIONAL TEXTBOOK APPROACH**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Mastery Learning Strategy (MLS)</th>
<th>Conventional Textbook Approach (CTA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial teaching with formative tests</td>
<td>Corrective sessions with formative tests</td>
</tr>
<tr>
<td></td>
<td>No. of periods</td>
<td>No. of periods</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>35</strong></td>
<td><strong>19</strong></td>
</tr>
</tbody>
</table>

(ii) **Criteria for Mastery and Grading**

The criterion for mastery was fixed at 80% mastery of the objectives pre determined in each unit. Table 15 shows the grouping and grading of students.
TABLE 15

GROUPING AND GRADING OF ACHIEVEMENT

<table>
<thead>
<tr>
<th>Mastery learning Strategy</th>
<th>Criteria decided</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>On Formative tests</strong></td>
<td></td>
</tr>
<tr>
<td>Mastery Group (G)</td>
<td>80% and above</td>
</tr>
<tr>
<td>Group G₁</td>
<td>60% to 79%</td>
</tr>
<tr>
<td>Group G₂</td>
<td>40% to 59%</td>
</tr>
<tr>
<td>Group G₃</td>
<td>Below 40%</td>
</tr>
<tr>
<td><strong>On Summative tests</strong></td>
<td></td>
</tr>
<tr>
<td>For M.L.S &amp; C.T.A</td>
<td>Criteria decided</td>
</tr>
<tr>
<td>Grade A</td>
<td>80% and above</td>
</tr>
<tr>
<td>Grade B</td>
<td>70% to 79%</td>
</tr>
<tr>
<td>Grade C</td>
<td>60% to 69%</td>
</tr>
<tr>
<td>Grade D</td>
<td>50% to 59%</td>
</tr>
<tr>
<td>Grade E</td>
<td>40% to 49%</td>
</tr>
<tr>
<td>Grade F</td>
<td>Below 40%</td>
</tr>
</tbody>
</table>

(iii) **Various Stages of Treatment Phase**

**Stage 1: Orientation for Mastery Learning**

Since the strategy was new to the teachers and pupils, they were given detailed information regarding mastery level, corrective procedures, formative diagnostic and remedial tests, grading of summative tests etc. Since the pupils were not accustomed to learning for mastery, the investigator oriented them to the procedures to be used and to the nature of the content they had to learn. They were also given an idea about how to learn the subject matter and the level of mastery to be attained by them.
Stage 2: Initial Teaching

The investigator herself taught the experimental and control groups based on the lesson transcripts prepared for each unit. The topics selected and the specific objectives for each learning unit were the same for both experimental and control groups. The control group was taught following lecture method and illustrations were made with the help of the physics textbook prescribed for state syllabus.

Stage 3: Formative Test

Formative diagnostic tests were administered to all the groups after the completion of each unit. After scoring the test (FDT), the teacher identified the students achieving mastery level (80% and above) in the mastery group (G). Students who scored 60% to 79% were grouped as G1, those who scored from 40% to 59% as group G2 and those below 40% as G3.

Stage 4: Corrective and Enrichment Activities

Corrective procedures for mastery were used for students in groups G1, G2 and G3. Enrichment activities were utilized for masters in group G. The procedures adopted were
• Individual guidance:- in light of the error(s) committed by the non-masters.

• Peer tutoring:- the students of group G were engaged in enrichment activities for group G1, G2 and G3. A model for the structured peer tutoring is given in appendix XI.

• Small group study session:- the students of group G, G1, G2 and G3 were divided into small groups. Each group generally had five students having representation from groups G, G1, G2 and G3. Verbal guidance was given by the teacher to eliminate the errors. A method used for this is given in appendix XII.

• Re-teaching:- the teacher taught the whole unit to the non-masters in out of class hours keeping in view the nature and type of errors committed by the students.

• Individualized tutorial:- identified pupils who needed individual help and taught them

• Textbooks and workbooks

• Quiz

• Assignments

A sample of workbook is given as appendix XIV.
Stage 5: Remedial Tests

Revaluation of students of group $G_1$, $G_2$ and $G_3$ was done with the administration of remedial test. The students who achieved the expected level of mastery formed group $G$. The remaining students who failed to achieve mastery level were again classified into $G_1$, $G_2$ and $G_3$ groups as in stage three and treatment was repeated as in stage four. Revaluation was again done with the help of formative remedial test.

Stage 6: Organization of Tutorial

The teacher and students from $G$ as per need engaged the students who failed to achieve the decided level of learning after remedial tests. Student’s individual difficulties were searched out and solved accordingly till they achieved the mastery level of the unit.

The teacher repeated this cycle of stage four to six till the mastery level of learning by the students was achieved for the unit. Similarly all the units were treated and completed one by one.

Stage 7: Proceeding to the Next Unit

As soon as all or almost all students on one unit achieved the mastery level next unit was taken up for teaching. In the similar manner all the units were taught.
6.1.3 Post Testing Phase

At this stage pupils were post tested and scored on achievement, science interest, scientific attitude, achievement motivation, self concept and retention.

One of the methods of measuring retention is to test students at the end of a learning experience and then retest them after a period of time. In the present study in order to compare the 'Retention Score' of the two groups the following procedure was adopted. The achievement test, which was administered after the experiment, was re-administered to the groups after a gap of two weeks and scores of each individual student was determined. Thus every student got a pair of scores. From this 'retention score' was arrived at for each student using the formula

\[
\text{Retention Score} = \left( \frac{\text{Scores obtained in the 2nd test}}{\text{Scores obtained in the 1st test}} \right) \times 100
\]

7.0 Statistical Techniques used for Analysis

The pre-test scores and the post-test scores of the experimental and control groups were consolidated for statistical analysis. The intelligence test scores and SES scores were utilized for equating the control and experimental groups in terms of the variables intelligence and SES. The mean and the standard
deviation of the scores for each test were found out and ensured the equivalence of the two groups by adopting critical ratio test. A preliminary analysis was done using the method of critical ratio and test of significance to compare the performance of experimental and control groups.

The experiments were done using intact, previously non-equated class groups. Even though the control and experimental groups were equated in terms of intelligence and SES, many other intervening variables could not be controlled. Analysis of Covariance (ANCOVA) is a method that enables the researcher to equate the pre experimental status of the groups in terms of relevant known variables. Difference in the initial status of the groups can be removed statistically so that they can be compared as though their initial status had been equated (Best, 1996). Thus in the present study the researcher decided to adopt the technique of ANCOVA for sharper experimental comparison of performance between experimental and control groups. The details of the analysis of data using relevant statistical methods have been compiled in the next chapter.