Methodology
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CHAPTER III

METHODOLOGY

3.1. Introduction

The present study which aims at finding out the effectiveness of CAI with special reference to underachievers has been designed as an Experimental Design. In this chapter the details of the various steps followed in the experiment are discussed.

3.2. The Research Design

To study the effectiveness of the instruction through the Computer with and without Teacher Support System as compared to the Conventional method, the investigator adopted the three groups experimental design where the three groups were treated with three different instructional techniques assigned at random. The research design covered three phases:

i) Software development
ii) Selection of the sample
iii) Experimentation
Fig 1: RESEARCH PARADIGM

School 1
35 students

School 2
35 students

School 3
35 students

Classification of
UA-NA-OA

Elimination of Ambiguous Cases

Sample (96)
24 High IQ
42 Average IQ
30 Low IQ
Total 96

Data Collection-Study Habits
and Maths Study Attitude

Group I
8 High IQ
14 Average IQ
10 Low IQ

Group II
8 High IQ
14 Average IQ
10 Low IQ

Group III
8 High IQ
14 Average IQ
10 Low IQ

CAI with TSS

CAI without TSS

Traditional Teaching

Post-test Analysis
The software for the instruction through a PC/XT Computer was developed by the investigator in the BASIC language. The randomised block design was followed in the selection of the sample. The sample consisted of students of Std IX selected from 3 Tamilnadu State Board Schools - 1 rural & 2 urban. From each school thirty five Std IX students were selected. Using Farquhar's regression method of identifying underachievers, the selected students were classified into under-, normal- and over-achievers with respect to two different maths achievement scores. This double classification was done to eliminate the ambiguous cases. Students belonging to the same category in both the classifications alone were selected for the final study. Since IQ was the blocking variable, the size of each IQ block was further reduced to the nearest multiple of 3 by the random rejection of a few cases. Students within IQ blocks were allocated at random to three groups and thus three groups of size 32 each were formed.

The three random groups were assigned the three different treatments at random. Data on the student variables viz. Study Habit and Mathematics Study Attitude were collected before administering the treatment. The groups were tested for their achievement level at the end
Fig 2: Stages in the development of CAI software
of the treatment and statistical techniques were applied to test the hypotheses formulated for the study. The three phases of the experimental design are explained in detail in this chapter.

3.3. Development of the Software for CAI

The development of the computer assisted instructional material passed through nine stages (Figure 2). The stages suggested by Lysaught and Williams (1968) for developing programmed learning material were modified to suit the development of CAI material. The modified stages in the development of the CAI software are as follows:

i) Selection of the topic
ii) Defining entry behaviour
iii) Defining terminal behaviour
iv) Selecting a model
v) Sequencing
vi) Frame construction
vii) Editing and debugging
viii) Initial testing & Revision
ix) Validation

i) Selection of the Topic

An analysis of the tasks in terms of the stimuli required to be presented and the kinds of responses to be evoked from the learners is essential before a final decision is taken whether a particular topic can be programmed. In principle, all behaviours can be programmed. But the devices which can produce different kinds of stimuli and the devices which enable a learner to record his responses may not be available to all programmers or learners. Under these circumstances the decision regarding selection of the topic is to be taken keeping in view both task analysis and feasibility of the available devices.

Portis Leth Brooks (1991) in the study on the effect of CMI made use of cross-year comparison of grades VII and IX and found that the effect was better for Std IX. Bearing his finding in mind, the syllabus for the High School Mathematics of the Tamilnadu State Board Schools was analysed, and the content area which was found to be more apt to the attributes of the PC/XT Computer was selected. The subject experts, educationists, and senior teachers with long years of experience were interviewed to find out
the suitability of a few selected topics and accordingly the final selection was made. The topic selected is introduced in Std IX and it contains nine units:

a) Definition of a set  
b) Set notation  
c) Cardinal number  
d) Kinds of sets  
e) Equal & Equivalent sets  
f) Union & Intersection  
g) Disjoint & overlapping sets  
h) Subsets  
i) Venn diagram

ii) Defining Entry Behaviour

After the selection of the topic it is essential to state clearly the various definitions and assumptions that would be basic to learn the content. Fry, asserting the importance of previous learning, says, "Previous knowledge influences learning, even though the previous knowledge is only vaguely related to the new knowledge being required".

Since the concept of 'Sets' is introduced only in Std IX in the Tamilnadu State Board Schools, the learners had no previous knowledge on the selected topic. However, the selected topic contains 9 units and to learn any unit

effectively the thorough knowledge of the previous units is a pre-requisite. Hence, for each unit the entry behaviour in terms of behavioural objectives were defined in consultation with the subject teachers and educationists.

iii) Defining Terminal Behaviour

Framing of the Terminal Behaviour is the most important step in the construction of a software. It suggests where the learner will be at the end of the instructional process and it is the task of the program to take the learner from the 'Entry' behaviour to the 'Terminal' behaviour. Since the success of the program lies in the attainability of these behaviours, the investigator decided the specific behaviours that the learners are expected to perform at the end of each unit in consultation with the subject teachers and educationists. They are given below:

Terminal behaviour for Unit I: Definition of a Set:

The learner
- reproduces the definition of a set
- recognises the symbols ∈ and ℂ
- gives examples of sets
- discriminates between well defined collections and others
- identifies whether an element belongs to the given set
- verifies the given relationship between elements and corresponding sets
- interprets the symbolic representations involving $\in$ and $\notin$ with ease and accuracy

Terminal behaviour for Unit II: Set Notation

The learner
- defines the list form and set builder form of set notation
- recognises the given set notation
- gives illustrations for both the forms of set notation
- translates verbal statements into symbolic ones
- translates symbolic statements into verbal ones
- converts one form of set representation into the other
- reads the set notation with ease and accuracy
- appreciates the development of brevity and exactness in the Language of Sets

Terminal behaviour for Unit III: Cardinal Number:

The learner
- reproduces the definition for the cardinal of a set
- gives illustrations for sets of the given cardinal number
- detects errors in the given relationships and corrects them
- finds out the cardinal number of the given set
- computes the cardinal number with ease and accuracy

Terminal behaviour for Unit IV: Kinds of Sets:
The learner
- reproduces the definition of finite, infinite, singleton, empty, universal and complementary sets
- identifies the kind of sets
- gives illustrations of the given kind of sets
- justifies the classification of the given set
- discriminates between sets with ease and accuracy
- appreciates the exactness in the Language of Sets

Terminal behaviour for Unit V: Equal & Equivalent sets
The learner
- defines equal and equivalent sets
- identifies the kind of sets
- gives examples of equal and equivalent sets
- discriminates between equal and equivalent sets
- classifies the sets with ease and accuracy
- appreciates the brevity in the Language of Sets
Terminal behaviour for Unit VI: Union & Intersection of sets

The learner
- defines union and intersection of sets
- gives illustrations of union and intersection
- translates verbal statements into symbolic ones and vice-versa
- solves related problems with ease and accuracy
- appreciates the exactness and brevity developed in the Language of Sets

Terminal behaviour for Unit VII: Overlapping & Disjoint sets

The learner
- defines overlapping and disjoint sets
- gives illustrations for the given kind of sets
- discriminates between overlapping and disjoint sets
- justifies the classification of the given sets
- solves related problems with ease and accuracy

Terminal behaviour for Unit VIII: Subsets

The learner
- defines a subset and a superset
- gives illustrations of subsets and supersets
- discriminates between a subset and a superset
- justifies the classification of the given sets
- translates verbal statements into symbolic ones and vice-versa
- solves related problems with ease and accuracy

**Terminal behaviour for Unit IX: Venn Diagram**

The learner

- reproduces the definition of venn diagram
- detects errors and corrects them in the venn diagram
- translates the given statements into venn diagrams
- estimates the result using venn diagram
- draws venn diagrams with ease and accuracy
- appreciates the exactness and brevity developed through the Language of Sets

iv) Selecting a Model

The next task is the choice of the Model - a paradigm to be followed, as the program is constructed. The paradigm supplies the basic conceptual framework through which individual items are connected. Many research studies have proved (Lin-cheng Andrew, 1991; Purushothaman and Stella, 1992) the supremacy of the non-linear approach over the linear approach in CAI with reference to both learning and retention. The investigator selected the non-linear approach.
Fig 3(a): Option to Learners (The Menu)

Fig 3(b) Paradigm Showing Branching in CAI with remedial loop
In the non-linear approach or Branching Model, the learner has to face questions at various places of the material. The questions may be asked to serve two purposes - either to route the learner according to his option or to check the learner's understanding of what had already been presented to the learner.

Figure 3(a) explains the path through which a learner will be taken based on the learner option. Figure 3(b) explains the path through which a learner will be taken based on the learner response to a test item. If the learner response is correct, the learner would be taken to the next concept. A wrong response would lead to the remedial loop where the learner's mistakes would be corrected. After the remedial loop, if the learner succeeds in giving the correct answer, he would be taken back to the main line of instruction. If the learner fails to succeed even after the remedial loop he will be taken to the beginning of the teaching frames corresponding to that concept.

v) Sequencing

There is no doubt that a logically sequenced content matter can produce the expected learner-response to
Objects present in a set are its members.

Fig 4: Sample frame - Screen lay-out
realise the objectives. The concepts were presented in a logical order according to their increasing order of complexity.

vi) Frame Construction

A frame in the computer software is a single item or step or screen which represents a single idea with suitable visuals. Each concept was resolved into a number of small steps with suitable visuals. The frames were constructed bearing in mind that the maximum number of characters per line that can be represented on the screen was 80 and the maximum number of lines per screen that could be fed was 24. To make the frames uncluttered and readable it was decided to give double line spacing and the width of the screen was altered to be 40 characters per line. Figure 4 shows a sample frame.

Each frame with the verbals and visuals was translated into its BASIC version. For the development of the package, the investigator learnt commands of the BASIC and QUICK-BASIC languages viz., how to generate random numbers, sequential data files, print question and alternatives on the VDU, comparison of responses of the students with the correct response, function confirming answers of the
Fig 5: Graphics used often
student, use of time etc. The rules of BASTC were followed for writing the program. Efforts were made to make the program as user friendly as possible. That is to say, the students were not required to know much about computers except switching the computer on and placing the diskette into the disk drive.

The questions were mostly of the multiple choice. The number of alternatives ranged from 3 to 6. The student was to select one of the alternatives. There were some questions like fill in the blanks also. In case of fill in the blanks, the answers were checked only in the capital form. For this the instructions were displayed whenever necessary. In the unit tests, if the student entered correct answer then the score was one else zero and it was displayed immediately on the screen. One after another the student attempted the questions and the scores were stored in a sequential data file, item wise and cumulative at the end. Question number, individual marks for each question, total marks and time taken were displayed by the program itself on the top of the VDU. So, there was the scope for self evaluation and motivation. The visuals which were to be presented many times were grouped together. Figure 5 gives a few graphics that were used many times.
v) Editing and debugging

At this stage the investigator obtained the feedback from mathematics teachers and educationists. Incorporating their suggestions, the investigator proceeded with editing each frame, word by word till the experts were convinced of the effectiveness of the program. The prime concern of the investigator here was whether the learning material would get across the student in order that the student would be able to demonstrate the specified behavioural output as a result of learning experience. In this connection the investigator examined all the examples and analogies in terms of their pertinence and relevance.

Debugging refers to the method of error detection and correction. The syntax errors which arise when the basic rules are violated (e.g.) spelling mistakes or missing commas, the execution error which makes it impossible to execute the program and the logical error which arises due to the mistakes done in the development of the program, were detected and correction was applied. The above procedure was repeated till the program was run satisfactorily showing the expected output for the various possible responses.
viii) Initial testing & Revision

**Individual Try-out:**

An average achiever was exposed to the CAI material. His mistakes were noted and the frames where he made wrong responses were modified suitably. The modification was done based on the type of error committed by the student. Some frames were deleted, some more frames were added in order to present the concepts in simpler steps and a few phrases were reworded.

**Small Group try-out:**

A set of 4 below average pupils of both sexes - 2 boys and 2 girls, were exposed to the computer software. The immediate achievement of the pupils were assessed. It was found that 75% of the students scored 78% average.

Based on the learners' responses, many changes were introduced. The word order of some of the frames were changed. A few frames of extra length were broken down into smaller and simpler ones. The sequencing of frames were changed. Some of the frames were omitted as they were considered as redundant due to repetition of ideas. More visuals were added to some of the frames. New frames were added wherever necessary inorder to bridge the gap
Are you ready to take the test?

Here are some guidelines for the test!

1. Most of the questions have 3 choice
2. Choose the correct alternative & type the number/alphabet of your choice
3. Type the number in the numeric form
4. For some questions you have to type one or two words
5. Type the words only in capitals
6. The questions will be displayed one after the other.
7. After answering a question press "ENTER" key

PRESS SPACE BAR WHEN YOU ARE READY

Fig 6: Sample frame - Instruction to take the test
resulting in a better form of logical sequencing and a smooth flow of ideas from one frame to the next. Certain techniques like flickering of key concepts, and motivational sound were made use of, to make the lesson more effective.

ix) Validation

After these revisions, another set of four pupils were exposed to the revised lesson. The criterion level of learner achievement for validating the lesson was fixed as 75% of the sample scoring above 85% average. The achievement of the pupils were found satisfactory with reference to the criterion level, since 75% of the pupils scored above 86%.

3.4. Description of the Computer Software

The concepts given in the nine units of the selected topic are covered by the computer software. The program has built-in branching and remediation. At the end of each unit, the learner's understanding is checked through a test (Figure 6). If the learner performance is found satisfactory (ie) if the student scores 80% or more which is the mastery level criteria fixed for CAI, then the
You have Scored 35%

I am sure you will do better
after redoing the unit.

Would you like to start right now?

PRESS "Y" FOR YES AND "N" FOR NO

Fig 7: Sample frame - Feed back on learner's performance in the unit test (KRO)

Your answer is wrong

The given sets have the same
Cardinal number. Hence they are
Equivalent sets.

PRESS SPACE BAR TO CONTINUE

Fig 8: Sample frame - KCR feedback
computer would allow the learner to the next unit (Figure 7). Otherwise the same unit should be repeated by the learner till he/she reaches the mastery level criteria.

Within each unit, there are questions posed at various stages of the program. If given the right answer the next concept would be presented. A wrong answer would lead to the remedial loop where the learner's mistakes would be explained. After the remedial loop the learner would be taken back to the main line of instruction. For the feedback mechanism three levels were set with varying degrees of elaboration.

Level 1: KRO - Knowledge of Result Only
Level 2: KCR - Knowledge of Correct Response
Level 3: KRE - Knowledge of Result with Elaboration

Jay (1986) compared these three feedback strategies and found that the learners using the KCR feedback achieved significantly higher than the KRO group. Jeffries Michael Greene (1989) in his research on the effect of these three feedback levels has proved the supremacy of both KCR and KRE over KRO. Though KCR and KRE did not differ significantly in their effect on achievement, KRE did lead to slightly higher mean scores. In the CAI software
Your answer is wrong

The given sets are not disjoint sets
They are overlapping sets
For more explanation PRESS SPACE BAR

Fig 9: Sample frame - KRE feedback

Here is your progress report!

** Name:..............................:
** Roll Number:......................:
** Score:..............................:
** Time taken to complete the unit:..............:
** Time taken for the test:............:
** Correct responses in the first attempt:............:
** Total Number of errors:............:

PRESS SPACE BAR TO CONTINUE

Fig 10: Data on learner's performance
developed by the investigator the three feedback levels have been incorporated as follows:

- **KRO** for unit tests
- **KCR** for simple questions at various stages of the program
- **KRE** for the questions that precede a new concept. They are meant to route the learner to remedial loops, if necessary. All KRE feedbacks have the choice of branching to the remedial loops. Figure 7 is an example of KRO feedback. Figures 8 and 9 give sample frames of the other two feedback levels.

The learner responses for the questions are recorded in a sequential file. The time taken by the learners to reach every testing station is also recorded. These data would be helpful to the teacher to analyse the learning sequence of the learners so that suitable teacher support could be planned. Figure 10 gives the data a teacher could get about the learner's performance. A simple command giving the learner's code number would give these details.

### 3.5. Achievement test preparation

The objective of the administration of the pre-test focuses on the assessment of entering behaviour of the pupils. The entering behaviour of the learner refers to
his/her previous knowledge of the content. Since the investigator selected the pre- and post-test experimental design where the topic selected has not been introduced to the sample earlier, the same test was used as pre- and post-tests. The weightage for each unit was decided in consultation with the senior teachers of mathematics and experienced educationists. Accordingly the post-test items were prepared. There were 60 objective type questions and the total marks allotted was 60.

T - 1: Data on weightage to content in the post-test

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Content</th>
<th>No. of Items</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit I</td>
<td>Definition of a Set</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Unit II</td>
<td>Set Notation</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Unit III</td>
<td>Cardinal Number</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Unit IV</td>
<td>Kinds of Sets</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Unit V</td>
<td>Equal &amp; Equivalent Sets</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Unit VI</td>
<td>Union &amp; Intersection of Sets</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Unit VII</td>
<td>Overlapping &amp; Disjoint Sets</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Unit VIII</td>
<td>Subsets</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Unit IX</td>
<td>Venn Diagram</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>
The items thus prepared were further scrutinised by evaluation experts and subject matter specialists of the Department of Educational Technology, Bharathidasan University and the teachers with long experience in teaching the subject at the high school level.

3.5.1. The Pilot Test

After detailed discussions with the research guide and the other experts, necessary modifications were made in certain items before the actual tryout was done. Specific instructions for the learners, mentioning time limit, method of answering etc., were inserted. The required type of answer sheets were also prepared for the test so constructed. The test so constructed was tried out on a sample of 67 students of both sexes. The sample for the pilot study was selected carefully to represent the sample for the final study and the sample size was also adequate. It is a mixed school, located in a semi-urban area and the Tamilnadu State Board syllabus is followed there. This test was conducted after ascertaining that the prescribed units in "Sets" have been taught. The time taken by the students to answer the test ranged from 45 to 70 minutes.
3.5.2. Scoring the Answer Sheets

After rejecting the incomplete answer sheets there were 63 answer sheets which were complete. The number was further reduced to 60 by random rejection of three answer sheets. This was done to make further analysis much easier. Using the 60 completed and scored answer sheets, item-wise analysis was done.

3.5.3. Item Analysis

Item analysis consists of two parts. They are: i) Difficulty level and ii) Discriminative Index. It was done by following the procedure suggested by Ebel.

**Index of Item Difficulty**

\[
\text{Index of Item Difficulty} = \frac{(U + L)}{2N} \times 100
\]

**Index of Discrimination**

\[
\text{Index of Discrimination} = \frac{(U - L)}{N}
\]

Where:
- \( U \) = Number of correct responses in the Upper 25 percent group
- \( L \) = Number of correct responses in the Lower 25 percent group.
- \( N \) = Number of answer sheets in the Upper or Lower group

The valued answer sheets were arranged in the decreasing order of scores. After the arrangement it was divided into three groups viz., the upper 25 percent, the lower 25 percent and the middle 50 percent. In this study N = 15 i.e. 25 percent of 60.

Items with difficulty level ranging from 30% to 80% and discrimination index ranging from 0.3 to 0.8 were selected. The total number of the selected items in the final test was 50 and the time allowed was fixed as 1 hour.

The analysis of the test for its reliability and validity were checked next where reliability means the consistency and validity means the truthfulness of the test. Since a good test should measure the truth consistently, both reliability and validity were calculated for the post-test.

3.5.4. Estimating the reliability of the test

The reliability of the test was calculated by the split-half method. In the split-half method, the test was divided into two equivalent 'halves' by odd-even method and the correlation was found for these half-test scores. The reliability coefficient for the half-test was 0.78.
The self correlation for the whole test was 0.88 as estimated by the Spearman Brown prophecy formula:

\[ r = \frac{2r}{1 + r} \]

where \( r \) = reliability coefficient of the whole test
\( r \) = reliability coefficient of the half test found experimentally

\[ r = 0.78 \]

\[ r = \frac{2 \times 0.78}{1 + 0.78} = 0.876 \]

The index of reliability = \( \sqrt{r} \) = 0.936

3.5.5. Estimation of Validity

The content validity of the test was determined by finding the correlation between the scores in the post-test and the students' average achievement scores. The scores of all the 60 students were used and the co-efficient of validity was found to be 0.61.

The internal validity of the test was ensured through item analysis and selection. The coefficients of reliability and validity indicate that the test is a reasonably dependable measure of achievement. The test is given as Appendix I.

3.6. Selection of the sample

Randomised block design was followed to select the sample. In randomised block design, the sample is divided into blocks and the items belonging to a particular block are allocated to the different experimental groups at random. Since the study deals with the effectiveness of CAT on underachievers and IQ is the important criteria that enables the identification of underachievers, IQ was selected as the blocking variable.

Three high schools of the Tamilnadu State Board – one rural & two urban, were selected. Availability of a computer and co-operation from the school are important in the conduct of the research. Hence the schools were selected keeping in view the criteria mentioned above. From

each school, 35 students of Std IX were selected at random.
Since IQ is the blocking variable, the students had to be
classified into groups on the basis of their IQ level.

3.7. Measurement of Intelligence

3.7.1 Tool used

To measure the intelligence of the selected students,
Culture Fair Intelligence Test - Scale 2 - Form B designed
by R B Cattell and A K S Cattell was used. The test has
been proved to be effective for the following reasons:
1. Highest possible test validity
2. Freedom from contamination by over a wide range of
cultural and social differences
3. Adequate reliability
4. Proper balance to primary abilities

The real basis of validity of an intelligence test is
its correlation with the 'construct' or concept of
intelligence in the general ability factor (g). In aiming
at this general ability factor, the Cattell C.F. test
measures 'g' through comparable, uniform tests for children
and adults over the whole age and ability range. Scale 2
with four sub-tests operates over 8 through 14 years.
Since the sample consisted of students who had just entered
3.7.2. Description of the tool

There are four subtests in the tool. Details of those sub-tests are presented below:

Table 2: Data on Scale 2 - Form B

<table>
<thead>
<tr>
<th>Sub-test</th>
<th>Number of items</th>
<th>Time Allotted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1: Series</td>
<td>12</td>
<td>3 mins</td>
</tr>
<tr>
<td>Test 2: Classifications</td>
<td>14</td>
<td>4 mins</td>
</tr>
<tr>
<td>Test 3: Matrices</td>
<td>12</td>
<td>3 mins</td>
</tr>
<tr>
<td>Test 4: Conditions</td>
<td>8</td>
<td>2 1/2 mins</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>46 items</strong></td>
<td><strong>12 1/2 mins</strong></td>
</tr>
</tbody>
</table>

3.7.3. Reliability and Validity of the tool

According to the original published researches and others since the correlations with "g" of the four types of sub-test range through .53, .68, .89 and .99 - the last obviously raised and the first probably dropped by sampling error. Another study in France, by the Centre de Psychologic Appliquee, on a very ample sample, found all "g" correlations of these culture free sub-tests to range
between .78 and .83, which is a very gratifying level for
tests of such brevity. The reliability has been estimated
to range from 0.70 to 0.92 on different samples.

3.7.4. Data collection

The above mentioned validities and reliabilities show
that the test is a dependable instrument to measure
intelligence. The instructions given in the test manual
were followed and the scoring was done accordingly. The
test is included as Appendix - II.

Using the IQ measures the students were classified into
three groups - High, Average and Low IQ categories.

High IQ group : IQ scores > Mean + One o--

Average IQ group : IQ scores between Mean + o--

Low IQ group : IQ scores < Mean - One o--

T - 3 : Classification of the students with respect to IQ

<table>
<thead>
<tr>
<th>S.No.</th>
<th>School</th>
<th>High</th>
<th>IQ level</th>
<th>Low</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Average</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>S1</td>
<td>8</td>
<td>17</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td>2</td>
<td>S2</td>
<td>7</td>
<td>17</td>
<td>11</td>
<td>35</td>
</tr>
<tr>
<td>3</td>
<td>S3</td>
<td>10</td>
<td>14</td>
<td>11</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>25</td>
<td>48</td>
<td>32</td>
<td>105</td>
</tr>
</tbody>
</table>
3.8. Classification of UA, NA and OA

The sample of 105 students had to be classified into three achievement levels - Underachievement, Normal achievement and Overachievement. The classification was done in terms of two criteria. The first criterion was the students' average achievement in mathematics in Std VIII and the second criterion was students' average maths test scores in Std IX. Classification was done separately for each criterion making use of the Regression method as explained below.

The percentage scores were obtained after the administration of the test of intelligence. The average achievement in Std IX mathematics was calculated by taking the average of the students' scores in two monthly tests - First monthly test and Second monthly test. Product moment correlation coefficient was worked out for intelligence scores and Std VIII average achievement and also for intelligence and Std IX average maths achievement scores. Each correlation coefficient was used to obtain regression equation with intelligence score as the independent variable (X) and achievement score as the dependent variable (Y). Thus two different regression equations were
formed. In one regression equation, the Std IX average achievement in mathematics was the dependent variable. The other regression equation was formed with Std VIII average maths score as the dependent variable. The regression equations were obtained as suggested by Garret:

\[
(Y - \bar{Y}) = r \frac{\sigma_y}{\sigma_x} (X - \bar{X})
\]

3.8.1. Regression Equation with respect to Std VIII average achievement in Mathematics

The mean, standard deviation and correlation coefficient of average achievement scores and intelligence test scores were calculated. The obtained values were:

\[
\begin{align*}
X & = \text{Intelligence Scores} \\
Y & = \% \text{Average achievement Scores} \\
\bar{X} & = 104.21 \quad \bar{Y} = 67.32 \quad r = 0.66 \\
\sigma_x & = 5.413 \quad \sigma_y = 6.342
\end{align*}
\]

where \( \bar{X} \) = Mean of intelligence scores

\( \bar{Y} \) = Mean of Std VIII average achievement scores

\( \sigma_x \) = Standard deviation of intelligence scores

\( \sigma_y \) = Standard deviation of average achievement scores

\( r \) = Product moment correlation coefficient between intelligence and average achievement scores

The above values were used to develop the regression equation. The regression equation is given by:

\[
\begin{align*}
(Y - \bar{Y}) &= r \frac{y}{x} (X - \bar{X}) \\
Y &= r \frac{y}{x} (X - \bar{X}) + \bar{Y} \\
&= 0.66 \left( \frac{6.342}{5.413} \right) (X - 104.21) + 67.32 \\
&= 0.77X - 13.26
\end{align*}
\]

The standard error of a Y score predicted from an X score was worked out using the following formula:

\[
\hat{\sigma}_Y = \frac{\sigma_y}{\sqrt{1 - r^2}}
\]

where \(\hat{\sigma}_Y\) = The standard error of Y scores

\(\sigma_y\) = The standard deviation of the Y distribution

\(r\) = The coefficient of correlation between X and Y

\[
\begin{align*}
\sigma_y &= 6.342 \\
r &= 0.66 \\
\hat{\sigma}_Y &= \frac{6.342 \times \sqrt{1 - (0.66 \times 0.66)}}{1 - (0.66 \times 0.66)} \\
&= 4.76
\end{align*}
\]

3.9.2. Regression Equation with respect to Std IX Average Maths Scores

The percentages of Std IX average Maths scores and the intelligence scores were used to develop the regression equation by the same method as the one used for average achievement in Std IX. The steps involved in the calculation are as follows:

\[ X = \text{Intelligence scores} \]
\[ Y = \% \text{Std IX Average Achievement score in Maths} \]

\[ \bar{X} = 104.21 \quad \bar{Y} = 71.91 \]
\[ \sigma_x = 5.413 \quad \sigma_y = 6.72 \]
\[ r = 0.59 \]

where

\[ \bar{X} = \text{Mean of intelligence scores} \]
\[ \bar{Y} = \text{Mean of Std IX average achievement scores in Maths} \]
\[ \sigma_x = \text{Standard deviation of intelligence scores} \]
\[ \sigma_y = \text{Standard deviation of Std IX Average Acht. scores} \]
\[ r = \text{Correlation coefficient between intelligence and Std IX average achievement scores} \]

The regression equation is given by

\[ (Y - \bar{Y}) = r \frac{\sigma_y}{\sigma_x} (X - \bar{X}) \]

The regression equation is thus \[ Y = 0.73 \, X - 4.42 \]
The standard error of a Y score predicted from an X score was worked out using the formula

\[ \sigma_{est Y} = \sigma_y \sqrt{\frac{1 - r^2}{1 - r}} \]

where \( \sigma_{est Y} \) = The standard error of Y scores

\( \sigma_y \) = The standard deviation of the Y distribution

\( r \) = The coefficient of correlation between X and Y

\[ \sigma_y = 6.72 \quad r = 0.59 \]

\[ \sigma_{est Y} = 6.72 \times \sqrt{\frac{1 - (0.59 \times 0.59)}{1 - (0.59 \times 0.59)}} \]

\[ \sigma_{est Y} = 5.43 \]

3.9.3. The Regression Method of Classification of Underachievers, Normalachievers and Overachievers

Using the two regression equations developed above and their standard errors of Y, classification of underachievers, normalachievers and overachievers was done by regression method developed by Farquhar. Farquhar's method is explained in the following pages.

The regression line connecting Intelligence scores as independent variable (X) and achievement scores as dependent variable (Y) is graphically plotted.

The standard error of Y scores predicted from X scores is predicted using the equation,

\[ o_{\text{est}\ Y} = o_{\text{y}} \sqrt{1 - r^2} \]

Two parallel lines with a perpendicular distance of \( o_{\text{est}\ Y} \) are drawn on either side of the regression line plotted.

The region in the first quadrant which falls in between the two parallel lines on either side of the regression line is marked as the zone of normal achievers.

The zone in the first quadrant, which falls above the region for normal achievers represent the region for overachievers.

Region for underachievers is marked as the zone in the first quadrant which falls below the zone for normal achievers. The Figure XI illustrates the method of classification.
Fig XI  Farquhar's method of Classification of Overachievers Normalachievers and Underachievers

X = INTELLIGENCE

Regression line of Y on X
Using Figure XI, all the 105 students were classified into categories of overachievers, normalachievers, and underachievers by the method given below:

Let $X$ denote the intelligence score and $Y$ denote the achievement score of a student. The student can be assigned in a graphical representation, a point denoted by the ordered pair $(X,Y)$ where $(X,Y)$ form the co-ordinates of the point. The zone in which this co-ordinate of the point falls in the space of the first quadrant of the graph classifies the student in one of the three achievement categories.

If the point $(X,Y)$ falls into the zone assigned for normalachievers (between two parallel lines on either side of the regression line) the student is classified as a normalachiever.

If the point $(X,Y)$ falls above this zone of normalachievers, the student is classified as an overachiever and if the point falls below the zone for normalachievers, the student is an underachiever. Each student of the sample will have to be classified in this manner, making use of the achievement score and intelligence score of the student.
Achievement Levels - w.r.t. Std VIII
Average Achievement score in Maths

Regression line: \( Y = 0.77x - 13.6 \)
Fig XIII Regression Equation used for Identifying Achievement Levels - w.r.t. Std IX Average Achievement score in Maths

Regression line $Y = 0.73X - 4.42$

OVERACHIEVERS

UNDERACHIEVERS
Figures XII and XIII give regression diagrams used for the classification of 105 students by the two criteria.

Table 4 presents the distribution of the three categories of learners - both school wise and IQ wise, with respect to the criterion Std VIII average achievement of the learners in mathematics.

### T-4: Sample classified into Three Achievement Levels:

(Criterion: Std VIII Average achievement in maths)

<table>
<thead>
<tr>
<th>School</th>
<th>TQ level</th>
<th>Achievement level</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>UA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>S1</td>
<td>Average</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>S2</td>
<td>Average</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>12</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>S3</td>
<td>Average</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>36</td>
<td>58</td>
</tr>
</tbody>
</table>
Similarly, Table 5 presents the distribution of the sample with respect to the criterion Std IX scores.

**T-5: Sample Classified into Three Achievement Levels:**

*(Criterion: Std IX Average Acht. Score in maths)*

<table>
<thead>
<tr>
<th>School</th>
<th>TQ level</th>
<th>Achievement level</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>UA</td>
<td>NA</td>
</tr>
<tr>
<td>High</td>
<td>5</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Average</td>
<td>3</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Low</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>High</td>
<td>4</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Average</td>
<td>2</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Low</td>
<td>6</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>19</td>
<td>4</td>
</tr>
<tr>
<td>High</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Average</td>
<td>3</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Low</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>54</td>
<td>14</td>
</tr>
</tbody>
</table>

As indicated above, the double classification of achievement levels led to the possibility of the same individual being classified into different achievement levels. Such indiscriminating data were rejected. Only those students who fall into the same achievement levels by
both methods of classification were selected for final analysis. After this classification and elimination of the ambiguous cases, the original sample of 105 was further reduced to 99 and classified into the three achievement levels as given in the Table - 6.

T-6: Sample belonging to the same achievement level with respect to both Criteria

<table>
<thead>
<tr>
<th>School</th>
<th>TQ Level</th>
<th>Achievement Level</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>UA</td>
<td>NA</td>
</tr>
<tr>
<td>S1</td>
<td>High</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>S2</td>
<td>High</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>S3</td>
<td>High</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>36</td>
<td>53</td>
</tr>
</tbody>
</table>

Out of the 99 students there were 25 high achievers, 44 average achievers and 30 low achievers. Since the students should be allocated to the three groups at random
with IQ as the blocking variable, it was decided to make the number of students in each IQ block a multiple of three. Hence, from the high achieving group one student was omitted by random rejection. He happened to be a normalachiever in School 3. Similarly, from the average achieving group two were omitted by random rejection. Among those two, one of them was a normalachiever from School 3 and the other one was an underachiever from School 1. After the rejection, there were 24 high achievers, 42 average achievers and 30 low achievers left for the study.

T-7: Table showing the distribution of the final sample

<table>
<thead>
<tr>
<th>School</th>
<th>IQ level</th>
<th>Achievement level</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>UA</td>
<td>NA</td>
</tr>
<tr>
<td>S1</td>
<td>High</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>S2</td>
<td>High</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>S3</td>
<td>High</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>36</td>
<td>53</td>
</tr>
</tbody>
</table>
In the sample selected for the final study, there were 24 high achievers, 42 average achievers and 30 low achievers. Only those who belonged to the same classification with respect to both the criteria were selected for the study to avoid ambiguous cases.

The Randomised Block Design was selected to constitute the three groups for the study. According to the randomised block design, students belonging to each of these blocks were allocated to three groups at random. Thus three groups of size 32 each, with 8 high IQ, 14 average IQ and 10 low IQ in each group were formed. The distribution of students in those groups with respect to the under-, normal- and over-achievement category are given below in Tables 8, 9 and 10.

T - 8 : Distribution of UA, NA and OA in Group I

<table>
<thead>
<tr>
<th>Achievement level</th>
<th>High</th>
<th>IQ level Average</th>
<th>Low</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underachievement</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Normalachievement</td>
<td>3</td>
<td>9</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>Overachievement</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>14</strong></td>
<td><strong>10</strong></td>
<td><strong>32</strong></td>
</tr>
</tbody>
</table>

131
T - 9 : Distribution of UA, NA and OA in Group II

<table>
<thead>
<tr>
<th>Achievement level</th>
<th>High</th>
<th>IQ level</th>
<th>Low</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Average</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underachievement</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Normal achievement</td>
<td>4</td>
<td>9</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>Oversocialisation</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>14</td>
<td>10</td>
<td>32</td>
</tr>
</tbody>
</table>

T - 10 : Distribution of UA, NA and OA in Group III

<table>
<thead>
<tr>
<th>Achievement level</th>
<th>High</th>
<th>IQ level</th>
<th>Low</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Average</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underachievement</td>
<td>5</td>
<td>1</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Normal achievement</td>
<td>3</td>
<td>11</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>Oversocialisation</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>14</td>
<td>10</td>
<td>32</td>
</tr>
</tbody>
</table>

3.9. Data on Study Habits

3.9.1. The tool used

To find out the Study Habit of the students, the Study Habits Inventory constructed and standardised by Dr. B. V. Patel was used.
3.9.2. Description of the tool

The inventory consists of 45 statements that fall into the following seven areas:

1. Home environment and planning of work
2. Reading and note taking
3. Planning of subject
4. Habits of concentration
5. Preparation for examination
6. General habits and attitudes
7. School environment

Each statement can be marked on a five point scale - Always, Often, Sometimes, Hardly, Never. In case of the item depicting good study habits the student is to be given five marks if he puts a tick (\/) in the column of Always. Four, three, two and one marks are to be given if he puts the tick mark in the column of Often, Sometimes, Hardly and Never respectively.

In the case of the statement depicting bad study habits, the score is to be assigned in reverse order, that is, Always - One mark, Often - 2 marks, Sometimes - 3 marks, Hardly - 4 marks and Never - 5 marks. Thus the high score will indicate good study habit and vice-versa.
3.9.3. Reliability and Validity the tool

The reliability and validity of the inventory have been established by the author. The reliability established by test-retest method and split-half method were found to be .79 and .82 respectively. The validity was established by using external criteria. Here scores on the study habits inventory were correlated with the teachers' opinion and examination marks. The co-efficient of correlation with examination mark was 0.50, which is sufficiently high. With teachers' opinion, the co-efficient of correlation was 0.40. The sample used for studying these properties of the standardised tool was 430 students taken from rural as well as urban areas. It included boys as well as girls. Thus the inventory used for the study is sufficiently reliable and valid.

3.9.4. Administering the tool

The following instructions were given before distributing the study habits inventory to the sample:

"This is not a test. There is no right or wrong answer of each item. So the copying from your neighbour will not help you in any way. It will be in your interest to be honest in answering the items. Be honest feel and
free to answer the items. Your answers will be kept secret. It will not be communicated to others."

The method of filling up the inventory was explained to the students as suggested in the manual. There was no time limit. The completed inventories were collected.

3.9.5. Scoring

The inventory consists of 45 statements. Out of these 45 statements some of them depict good habits while some of them depict poor habits of study. In case of the item depicting good study habits the student is to be given one, two, three, four and five marks if he puts a tick (\/) in the column of Never, Hardly, Sometimes, Often, and Always respectively. In case of the statement depicting bad study habits, the score is to be assigned in reverse order. The maximum possible score would be 225 and the least possible score would be 45. Table A and Table B giving the Scoring Key and Grade Norms respectively of the inventory were used to classify the students on the basis of the total score made on the inventory. The Study Habits Inventory along with the Scoring Key and Grade Norms are appended as Appendix - III.
3.10. Data on Attitude Towards the Study of Mathematics

3.10.1. Tool used

Since attitude has been found to be one of the important correlations of achievement (Chopra, 1982; Sundararajan and Srinivasan, 1990; Sundararajan and Dhandapani, 1991) in Mathematics, the investigator collected data on the sample's Attitude Towards the Study of Mathematics. A Scale for measuring the Higher Secondary Students' Attitude towards the Study of Mathematics, constructed and standardised by Sundararajan and Srinivasan in 1990 was used.

3.10.2. Description of the tool

This scaling is of the Likert type and it has as many as 24 statements of which 12 are favourable and 12 are unfavourable towards the study of Mathematics. The usual weights are given for the five alternatives against each statement depending on the nature of the statement, favourable or unfavourable. The score range in this scale is from 0 to 96 in terms of unfavourableness to favourableness. A student with a favourable attitude can get a maximum of 96. Therefore any one who gets a score of
48 and above can be said to have a favourable attitude towards the study of Mathematics and any one who gets a scoring less than 48 may be said to have an unfavourable attitude towards its study. An individual's score is the sum of scores for all the 24 statements. The attitude scale is appended as Appendix - IV.

3.10.3. Reliability & Validity of the tool

Its content validity has been checked by the evaluation experts and its reliability has been established to be 0.874 by the split-half method by using the Spearman Brown Prophecy Formula.

3.10.4. Data Collection

As in the case of administering the Study Habits Inventory, students were made to feel comfortable and the score sheets were collected from the students. The Attitude scores for all the 96 students were calculated. Based on the individual's score the classification was done as follows:

Score 48 and above : Favourable Attitude
Score below 48 : Unfavourable Attitude

There were 59 and 37 students respectively in those categories.
3.11. The treatment

The three groups were assigned different treatments at random. Group III was assigned the traditional teaching method. Group II was assigned the CAI without Teacher Support System and Group I, the CAI with Teacher Support System.

Group I : CAT with Teacher Support System
Group II : CAI without Teacher Support System
Group III : Traditional Method

3.11.1. Treatment of Group I

Whenever Group III had traditional teaching of the topic, Group I was taken to the computer room for the CAT with teacher support system treatment. The maths teachers of the selected schools were given orientation on the support system expected of them. Since only eight terminals were available which had to be used for both the Groups I & II, Group I was divided into convenient batches and the groups co-operated whole heartedly by coming early in the morning, staying after regular school hours and coming during week-ends. This became unavoidable due to
lack of adequate computer facilities. For Group II, learning the topic with in-between check points was through the CAI material. The test at the end of each unit was evaluated by the teacher and feedback and guidance as to whether students can goto the next unit or should repeat the same unit, was by the teacher. The remediation if progress is found not satisfactory at the end of a unit was also guided by the teacher.

3.11.2. Treatment of Group II

Group II was given CAT without teacher support system. Learning, testing and guidance were through the CAI software. At the end of each unit there was a computer based test. Based on the learner's performance in the test, the information flow was controlled by the program. After the departure of the students the teacher could get the print-out giving the data on the students progress. A simple command with the student's code number was enough to get the data sheet. Figure 10 gives a sample data sheet.

3.11.3. Treatment of Group III

Group III received instruction through traditional method. Lesson plans were written by the investigator in

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consultation with the subject teachers and educationists and the maths teachers of the three selected schools were requested to follow the lesson plan and make the class effective. Fifteen periods, each of forty five minutes duration, were allotted for the topic. Three charts and black board were the aids used.

3.12. Post-test/post-treatment administration

All the three groups completed the topic at the end of the second week. The groups were exposed to the post-test. Though the computer groups had taken the unit tests in the computer, the comprehensive post-test was given as a paper-pen test for all the three groups. The test papers were scored objectively and recorded in data sheets.

3.13. Conclusion

Thus the research design covered three phases, namely,
(i) developing the software and test items,
(ii) matching the three groups and
(iii) the treatment.

The data collected on the variables under study at both entry level and terminal level were analysed using
suitable statistical techniques and based on the analysis, interpretations were drawn and generalisations were arrived at. A detailed discussion on the various statistical techniques applied and the inferences drawn are given in the following chapter.