CHAPTER III

RESEARCH DESIGN AND METHODS

3:1 INTRODUCTION

This chapter reflects the thinking that has been at the background of the hypotheses framed in relation to the determinants of achievement in Mathematics of pupils who hail from low socio-economic stratum of the society. Further, it throws light on designing the instruments and tests and selecting the appropriate sample of subjects, besides explaining the research procedure followed in this investigation.

3:2 HYPOTHESES

3:2:01 Learning Styles and Achievement in Mathematics

Many studies such as that of Philip John (1989), Faith Ann (1993) reported the influence of learning style preference (abstract conceptualization, concrete experience, active experimentation and reflective observation) on course - performance of students. Ellen Rose (1994) investigating the relationship between the learning styles based on perceptual preferences and academic achievement reported significant differences in the achievement of pupils with different learning styles. Researchers like Ornstein (1973), Wittrock (1978), Hilliard (1989) etc. studied the impact of hemispherical dominance on the nature of the cognitive processes and advocated the distinct learning styles - (i) analytical thinking resulting from left hemisphere dominance and (ii) global thinking resulting from right hemisphere dominance.
The social interaction approach classified pupils as individual/group learners with respect to their learning styles. Studies of Miller et al. (1990) and Hall Mark (1994) report that achievement in Mathematics is not significantly influenced by cooperative learning. However, Poppers (1991) found that students in the collaborative consultation model made significantly higher gains in Mathematics than students in the resource room model. Thus, it could be inferred that studies on individual/group learning do not suggest any definite, direction of relationship with pupils achievement.

In the light of the above research findings, the following research hypothesis has been framed with respect to learning styles of pupils and its influence on their achievement in Mathematics.

Hypothesis I

The three achievement groups in Mathematics viz. high, moderate and low, exhibit differential learning styles.

The following sub-hypotheses concerning learning styles based on thinking preferences, preferred perceptual mode, hemispherical dominance and social interaction are also formulated.

i. The high, moderate and low achieving groups in Mathematics exhibit differential learning styles displaying predominantly any one of the learning styles categorizing them as assimilator, accommodator, converger or diverger.
ii. The high, moderate and low achieving groups in Mathematics exhibit different preferred perceptual mode of learning (Auditory, visual, kinesthetic or tactile) characterizing their learning styles.

iii. The high, moderate and low achieving groups in Mathematics exhibit differential preference for individual/group social settings in learning.

iv. The hemispheric dominance in learning styles (analytical and global) differentiate the high, moderate and low achieving groups in Mathematics.

3:2:02 Intelligence and Achievement in Mathematics

Intelligence has been found to influence one's scholastic achievement to a great extent as reported in the research studies of Mehrotra (1958), Ghosh (1960), Sinha (1968), Stubbs (1963) and Yadav (1991). Intelligence coupled with socio-economic status seem to determine 64% of variation in academic achievement [Ramoji Rao, 1963]. In line with these findings, a research hypothesis concerning the influence of intelligence on achievement in Mathematics has been set up.

Hypothesis II

Level of Intelligence significantly influences pupils' achievement in Mathematics.

Two sub hypotheses have also been framed as stated below.

i. The Superior, normal and below average students in intelligence, significantly differ in their levels of achievement in Mathematics.

ii. Intelligence of students and their achievement in Mathematics are significantly and positively related.
Learning Environment and its influence on Achievement in Mathematics

Among the environmental factors, pupils' learning environment has not attracted much attention of the researchers. However, few studies [Desai (1979), Mitchell (1992), Diaz (1997)] investigating the influence of school as well as home learning environment report their significant influence on pupils' academic achievement.

Thinking on the lines of the research studies reported above, the following hypothesis has been framed as given below.

Hypothesis III

Learning environment in Mathematics significantly influences students' level of achievement in Mathematics.

As Srinivasan (1997) has analysed learning environment in terms of school environment, home environment and the total environment, in the present study also, learning environment has been investigated in terms of school and home mathematical learning environment. Hence the following sub-hypotheses concerning the school, home and total learning environment in Mathematics as related to achievement in Mathematics of pupils have been framed as stated below:

i. Learning environment in Mathematics discriminates the high, Moderate and low achieving groups in Mathematics.
ii. The three achievement groups in Mathematics will significantly differ in their school learning environment in Mathematics.

iii. The three achievement groups in Mathematics will significantly differ in their home learning environment in Mathematics.

3.2.04 Intelligence and Learning Styles

There are host of research studies reporting that intelligence as it is conventionally perceived is due to hemispherical dominance [Ornstein (1973), Samples (1975), Wittrock (1978)]. However, the relationship between intelligence and learning styles based on the three categories of learning styles, preferred thinking process, preferred perceptual mode and social interaction are not investigated adequately so as to crystalise definite conclusion in this regard. Having these in mind, the following hypothesis has been framed for the present study.

Hypothesis IV

Level of intelligence influences the learning styles of students.

On differentiating learning styles into four categories based on thinking process, perceptual mode, social interaction and hemispherical dominance, four sub hypotheses emerged which have been stated below:

i. Students categorized into four types based on their preferred thinking process get differentiated with respect to their intelligence.
ii. Students categorized into three types based on their preferred perceptual mode of learning get differentiated with respect to their intelligence.

iii. Students preferring individual and group learning styles get differentiated significantly with respect to their intelligence.

iv. Students categorized as analytical or global, based on their hemispheric dominance get differentiated with respect to their intelligence.

3:2:05 Intelligence and Learning Environment in Mathematics

Though studies have highlighted the relationship between learning environment and socio-economic status of the parents of pupils, not much has been known on the influence of intelligence in relation to one's learning environment and hence a null hypothesis has been formulated for the present study as cited below.

Hypothesis V

There may not be significant relationship between learning environment (both school and home) in Mathematics and intelligence

3:2:06 Learning Styles and Learning Environment in Mathematics

Studies of Crampton (1990), and Ogato (1991) reported that achievement and learning modality were not related. However, studies of Cooper (1991), Doyle (1991) and Varma (1992) reported significant
differences in the patterns of learning styles and the relation to school environment. Based on these and similar research studies, a research hypothesis has been proposed for the present study.

Hypothesis VI

Students with different learning styles have differential learning environment in Mathematics.

As learning styles have been investigated in terms of four categories, four sub hypotheses have also emerged as detailed below.

i. Students categorized into four types based on their preferred thinking process get differentiated with respect to their learning environment in Mathematics (both school and home).

ii. Students categorized into three types based on their preferred perceptual mode get differentiated with respect to their learning environment in Mathematics (both school and home).

iii. Students preferring individual and group learning styles get differentiated with respect to their learning environment in Mathematics (both school and home).

iv. Students categorized into two types based on their hemispheric dominance get differentiated with respect to their learning environment in Mathematics (both school and home).
Relationship among the Learning Styles based on different frames

No attempt has been made so far to study different forms of learning styles based on different frames of reference and hence no precedence could help our thinking in framing a research hypothesis concerning the relationship between the different styles of learning and as such, a null hypothesis has been preferred.

Hypothesis VII

There will be no significant relationships among learning styles based on thinking process, perceptual modes of learning, social settings in learning and hemispheric dominant learning styles.

3:2:08 Relationship among the Experimental Variables

Keeping in mind the influence of the variables, ‘intelligence’ and ‘learning environment’ on achievement in Mathematics (as already discussed in 3:2:02 and 3:2:03), the following research hypothesis has been set up.

Hypothesis VIII

The variables, ‘intelligence’ and ‘learning environment in Mathematics’ have significant but of different amount of bearing on students' achievement in Mathematics.
Influence of Presage variables of students on the Experimental variables of the Study

The following null hypotheses regarding the influence of sex, type of schools and types of management of schools and medium of instruction on achievement in Mathematics have been formulated as briefed below.

Hypothesis IX

a. Sex has no significant bearing on pupils' achievement in Mathematics, intelligence and their learning environment in Mathematics.

b. Types of schools has no significant bearing on pupils' achievement in Mathematics, intelligence and their learning environment in Mathematics.

c. Types of management of schools has no significant bearing on pupils' achievement in Mathematics, intelligence and their learning environment in Mathematics.

d. Medium of instruction has no significant bearing on pupils' achievement in Mathematics, intelligence and their learning environment in Mathematics.

Influence of the Experimental Variables and Sex on Achievement of students in Mathematics

To study the differential patterns of the experimental variables exhibited on mathematics achievement of pupils, the following hypothesis has been proposed.
Hypothesis X

The effect of experimental variables on the achievement in Mathematics of boys and girls will display differential patterns.

3.3 TOOLS AND TECHNIQUES USED IN THE STUDY

To collect the pertinent data for the present investigation, standardised tools have been employed to quantify the variables involved in the study. Wherever no such tool / test has been available, the investigator has himself developed the same for use in this study.

(A) Learning Styles

The variable "Learning Styles" in this present study has been assessed in three different ways.

a. Kolb's categorisation of students as accommodator, assimilator, converger, or diverger based upon their preferred learning styles.

b. J.M. Reid's categorisation of students based upon their preferred perceptual mode of learning - visual, auditory and kinesthetic / tactile as well as the categorisation based upon the two social interaction styles viz. individual and group learning.

c. Categorisation of learners as described by A. Hilliard based upon their hemispheric dominance viz. analytic and global learning.
3)  **Intelligence**

The Standard Progressive Matrices Test designed by Raven has been widely used in this part of our country as it is a culture free test. So it has been thought as highly suitable to identify the intellectual capacity of pupils in the sample studied.

C)  **Mathematics Learning Environment**

Learning environment in Mathematics has been assessed in terms of the nature of home and school environment facilitating pupils' learning of Mathematics. Mathematics Learning Environment Scale developed by L.J. Srinivasan (1997) has been adopted suitably for the present study by incorporating necessary changes.

D)  **Achievement in Mathematics**

The dependant variable "achievement in Mathematics" has been assessed through an achievement test, constructed and validated by the researcher himself to measure the academic performance of students in Mathematics.

E)  **Socio-Economic - Status**

The socio-economic status scale initially constructed and validated by Prof.B. Kuppuswamy and subsequently modified by Dr.K. Nagarajan has been made use of in the present study to identify the socio-economic status of the pupils in the sample.
Kolb's Learning Style Inventory

Description

A learning style inventory developed by David. A. Kolb (1976) was used in this study (Appendix-I) to measure the degree to which an individual displays specific learning styles. The learning style inventory accomplishes this by weighing the relative emphasis a learner places on one of the four learning modes: (a) Abstract conceptualization (AC) (b) Concrete Experience (CE) (c) Active Experimentation (AE) and (d) Reflective observation (RO). This inventory lists nine sets of four descriptions, each description qualifies one of the four learning styles.

eg:  Happy  Fast  Angry  Careful

Administration

The inventory on learning styles was administered after highlighting the purpose of the inventory and providing clear cut directions as to how the learning inventory should be responded. The following instructions were given to the students.

"There are nine sets of four descriptions, listed in the inventory. Give a number in between 1 and 4 to the words in each set to indicate how well that word describes, or relates to you and your approach to carrying out tasks. To do this, place the number 4 against the word that is most like you, the number 3 against the word that is second most like you, the number 2 against the word that is third most like you and the number 1 against the word that is least like you". Students were encouraged to respond to all the nine sets without omitting any. A time limit of 30 minutes was set for the completion of this inventory.
3:3:01:3 Scoring

Using scoring sheet (Appendix-IA) responses of the pupils have been categorised and scored appropriately so as to obtain scores for the four learning traits viz. Abstract conceptualization (AC), Concrete Experience (CE), Reflective Observation (RO) and Active Experimentation (AE). These learning traits formed two learning dimensions (AC-CE) and (AE-RO). AC minus CE indicates the degree to which the learning style is biased towards abstraction (positive number) or concreteness (negative number) and AE-RO reflects a positive bias towards activity (a positive number) or reflection (negative number). By having (AC-CE) and (AE-RO) dimensions as axes, four quadrants had been formed using learning style inventory scoring grid (Appendix-IB). By considering an individual’s score for the two dimensions (AC-CE) and (AE-RO), he/she could be assigned to one of the four quadrants which reveals the predominant style of learning of the individual.

3:3:02 J.M. Reid’s Perceptual Learning Style Questionnaire

3:3:02:1 Description

J.M. Reid’s perceptual learning style preference questionnaire (1987) was used to measure the learning style preference of the subjects. The learning style approach on which the questionnaire (Appendix-II) is based includes three perceptual learning styles (Visual, auditory and kinesthetic / tactile) and two social interaction styles (Individual and group learning). This questionnaire consists of thirty statements; the details of which are presented in Table - 3.1.
Table 3.1

Showing the items under different perceptual modes of learning and social interaction styles

<table>
<thead>
<tr>
<th>Category of Learning</th>
<th>Statement Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditory</td>
<td>1,7,9,17,20</td>
</tr>
<tr>
<td>Visual</td>
<td>6,10,12,24,29</td>
</tr>
<tr>
<td>Kinesthetic / Tactile</td>
<td>2,8,11,14,15,16,22,25</td>
</tr>
<tr>
<td>Individual Learning</td>
<td>13,18,26,27,28,30</td>
</tr>
<tr>
<td>Group Learning</td>
<td>3,4,5,19,21,23</td>
</tr>
</tbody>
</table>

3:3:02:2 Administration

The purpose of the questionnaire and the direction to record the responses for the items were explained in the beginning. The following instructions were given:

"This is not a test. There are 30 statements. Read each statement carefully. Please respond to the statements as they apply to your study of Mathematics. Record your response for each of the 30 items as you think appropriate by putting a mark (x) against one of the five categories given (Strongly agree / Agree / Undecided / Disagree / strongly disagree). There is no right or wrong answer for any of these items. Please respond to each statement quickly, without too much thought; try not to change your responses after you choose them. Be as fast as you can and complete the questionnaire". Students were encouraged to clarify the doubts, if any, in filling up the questionnaire. Almost all students completed the questionnaire within 30 minutes."
3:02:3 Scoring

For each of the statement, weights of 2,1,0,-1 and -2 were given for the categories strongly agree, agree, undecided, disagree and strongly disagree respectively.

The net score of an individual for each one of the five categories which is the sum total of the weights for the items assigned for the respective category has been computed and converted into respective percentage score. The maximum percentage score obtained by an individual among the three perceptual categories (Auditory, visual and kinesthetic / Tactile) reveals the predominant perceptual learning style. Between the two percentage scores obtained for the social interaction style categories, the one which is higher indicates his / her predominant learning style based on social settings. Thus, from the pupils' responses for this questionnaire, Pupils' were classified for the two-types of learning styles: one for their predominant perceptual mode of learning and the other for their style of social interaction.

3:03 A. Hilliard's hemispheric dominance learning style inventory

3:03:1 Description

A. Hilliard's hemispheric dominance learning style inventory (1989) was used to measure the learning style based on hemispheric dominance in brain functioning. This inventory (Appendix-III) attempts to classify the learners into holistic and analytic type based on simultaneous hemispheric style and successive hemispheric style of learning respectively. It consists of 11 items and each item has two forced choice selection, between the one under analytic style category and the other under global style category.
Administration

Before administering the inventory, the following instructions were given; "Here you are not tested. We would like to know your learning style based on hemispheric dominance. There are 11 items. Under each item, there are two statements. Select one choice between the two given for each item which is the most descriptive of you and put a tick (✓) against it. Do this for all items in this inventory. Though there is no time limit for completing this inventory, usually, most people finish within 15 minutes. Try as fast as you can".

Scoring

The number of ticks recorded under each of the two categories of hemispheric dominance was taken to represent the individuals' score for that category. The highest score obtained between the two categories indicates the predominance of that particular hemispheric dominance in learning.

Thus the scores obtained from this inventory indicate the learning style of the subject based on hemispheric dominance.

Raven's Standard Progressive Matrices Test

Description

This culture-free test has been repeatedly found to be a satisfactory non-verbal general intelligence test for a variety of testing purposes. High correlations have been found between this test and many verbal intelligence
tests and academic performance [Shinn (1958), McBea (1960), Desai (1960), Passi (1970), Deb and Ghosh (1971), David and Donald (1972), Nagarajan (1983)]. This test consists of 60 matrices or designs. They are divided into 5 sets A, B, C, D and E, containing 12 matrices in each. A portion of each matrix is removed and the same is given below the matrix as one of 6 or 8 alternatives. The subject has to find out the removed portion of the matrix from the alternatives provided.

3:3:04:2 Administration

The test is administrated as a group test. A set of 35 test booklets have been prepared and used. Each student in the sample has been provided with a test booklet and a printed response sheet (Appendix-IV). The pupils to be tested are asked to fill in particulars about themselves on the response sheet. The investigator then gave the instructions as under:

"Open the test booklet to the first page. At the top, it says 'set A' and you have a column on your response sheet, for set A. See this is A_, (investigator shows the picture in the booklet). You see the upper part is a pattern with a bit missing. Each of the pieces below (pointing to each, in turn) is the right shape to fit the space, but they do not all complete the pattern. Number 1, (pointing to the piece and then to the pattern) is quite the wrong pattern. Number 2 and 3 are wrong - they fit the space, but they are not the right pattern. What about number 6? The pattern is the same; but it does not go all over. Number 4 is the right one. So the answer to A_, is 4. Write 4
against A₁ in set A in the response sheet given to you. Don’t write anything on the booklet.

On every page in your booklet, there is a pattern with a bit missing. You have to decide each time which of the pieces below is the right one to complete the pattern above. When you have found the right bit, you write its number down on your response sheet against the number of the pattern. They are simple at the beginning and get harder as you go on. There is no catch. If you pay attention to the way the easy ones go, you will find the later ones less difficult. Try each in turn, from the beginning, right to the end of the booklet. Work at your own pace. Don’t miss any one. Do not turn back once you start. Let us see how many you can get right. You can have as much time as you like. Turnover and do A₂ onwards”.

3:30:43 Scoring

Key for the scale has been taken from the manual of J.C. Raven. The Score is the number of matrices answered correctly. Based upon the intelligence scores, students were classified as under:

<table>
<thead>
<tr>
<th>Score</th>
<th>Score Range</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>46 and above</td>
<td>above 75th percentile</td>
<td>Superior</td>
</tr>
<tr>
<td>33-45</td>
<td>between 25th and 75th percentiles</td>
<td>Moderate</td>
</tr>
<tr>
<td>32 and below</td>
<td>below 25th percentile</td>
<td>Below average</td>
</tr>
</tbody>
</table>
3:05 Mathematics Learning Environment Scale

3:05:1 Description

In order to identify the conducive learning environment for the study of Mathematics, Mathematics Learning Environment Scale developed by J. Srinivasan (1997) has been adopted suitably for this present study. This scale (Appendix-V) has as many as 55 statements, divided into two parts i.e. Part A and Part B. Part A consists of 39 statements, to assess the learning environment in the school. Part B consists of 16 statements related to Mathematics learning environment at home. Each item of the learning environment scale employs four alternatives, namely strongly agree, agree, disagree and strongly disagree.

3:05:2 Administration

The following instructions were given to the subjects. "This is not a test. Here we try to understand how you feel about your mathematics class and the facilities available for learning Mathematics at home so that we can arrange for more help and assistance, if at all required. There are 55 statements. You read each item and record your opinion as you think appropriate by putting a tick (✓) against one of the four categories viz. strongly agree/agree/disagree/strongly disagree for each of the items. The most appropriate response for each item is the one with which you concur as you think it fit or applicable to you. Be frank and record your responses accordingly for all the items, without omitting any. Be as fast as you can and complete the questionnaire. Try to finish the scale within 45 minutes".
### 3:05 Scoring

For each statement, weights of 2, 1, -1 and -2 were given for the categories strongly agree, agree, disagree and strongly disagree respectively except for item no.29. The order of weights was reversed for item no.29. The score of an individual in this scale is the sum of all the scores for the fifty five items. In this scale, the scores range from -110 to +110 in the direction of increasing level of favourableness of the perceived mathematics learning environment. Thus the higher the score, the more favourable is the pupils’ perception of the mathematics learning environment.

Apart from calculating the mathematics learning environment score for each student, two more related measures have been obtained.

1. **Mathematics learning environment score for the school.**
   
   This is obtained by adding all the scores for the 39 items in Part A pertaining to the school learning environment in Mathematics.

2. **Mathematics learning environment score for the home.**

   This is obtained by adding all the scores for the 16 items related to the home learning environment in Mathematics.

### 3:06 Socio-Economic Status Scale

#### 3:06:1 Description

In determining the socio-economic status of subjects, Kuppuswamy’s socio-economic status scale as adapted and modified by Dr.K. Nagarajan has
seen made use of. The following features were considered and incorporated in he modified scale (Appendix-VI).

i. In giving scores for educational, occupational and economic status for the parents of each student, both father and mother were taken for consideration and scores were assigned separately for each.

ii. The distance education programmes have made the access for graduate and post graduate degrees much easier.

iii. The top income range can no longer be taken as Rs.1000/- p.m. since even class IV employees draw more than Rs.3,000/- p.m.

3:3:06:2 Administration

To get a comprehensive socio-economic status score, a copy of the socio-economic status scale was distributed to each student, after explaining the purpose of the scale. Students were encouraged to present a real picture about their socio-economic status. They took 10 minutes to complete the scale.

3:3:06:3 Scoring

The responses were scored as per the scoring sheet (Appendix-VI A). The maximum possible scores are as follows:

i. Educational status - 16 points
ii. Occupational status - 20 points
iii. Income status - 24 points

Total - 60 points
Based upon the socio-economic status score, the students were classified as under.

<table>
<thead>
<tr>
<th>Score Range</th>
<th>Socio-Economic Status Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>35-60</td>
<td>High</td>
</tr>
<tr>
<td>20-34</td>
<td>Moderate</td>
</tr>
<tr>
<td>19 and below</td>
<td>Low</td>
</tr>
</tbody>
</table>

For the present investigation, students with low socio-economic status level were alone selected for the sample.

3:3:07 Achievement Test in Mathematics

3:3:07:1 Description

The dependent variable 'Achievement in Mathematics' was assessed through a Mathematics Achievement Test, specially developed and validated for the present study. This objective type achievement test (Appendix-VII) consisting of multiple choice items only is based on ninth standard syllabus of Tamil Nadu State Board of Secondary Education. The development of the achievement test involved a systematic process having the following well defined stages.

Stage I: Planning of the Test

An objective type test with 120 multiple choice items, covering all the ten units of ninth standard mathematics syllabus of Tamil Nadu State Board of Secondary Education, has been planned for two and half hours.
For this purpose, a ‘Blue Print’ has been prepared as detailed below.

Table 3.2

Showing the Weightages for Objectives

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Objectives</th>
<th>Marks Allotted</th>
<th>Percentage of Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>Knowledge</td>
<td>38</td>
<td>31.67%</td>
</tr>
<tr>
<td>02.</td>
<td>Understanding</td>
<td>41</td>
<td>34.16%</td>
</tr>
<tr>
<td>03.</td>
<td>Application</td>
<td>27</td>
<td>22.5%</td>
</tr>
<tr>
<td>04.</td>
<td>Skill</td>
<td>14</td>
<td>11.67%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>120</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 3.3

Showing the Weightages for the content areas

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Content</th>
<th>Marks Allotted</th>
<th>Percentage of Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>Number System</td>
<td>11</td>
<td>9.17%</td>
</tr>
<tr>
<td>02.</td>
<td>Set Language</td>
<td>15</td>
<td>12.5%</td>
</tr>
<tr>
<td>03.</td>
<td>Algebra</td>
<td>16</td>
<td>13.33%</td>
</tr>
<tr>
<td>04.</td>
<td>Mensuration</td>
<td>11</td>
<td>9.17%</td>
</tr>
<tr>
<td>05.</td>
<td>Application</td>
<td>11</td>
<td>9.17%</td>
</tr>
<tr>
<td>06.</td>
<td>Statistics</td>
<td>11</td>
<td>9.17%</td>
</tr>
<tr>
<td>07.</td>
<td>Geometry</td>
<td>14</td>
<td>11.66%</td>
</tr>
<tr>
<td>08.</td>
<td>Construction</td>
<td>9</td>
<td>7.5%</td>
</tr>
<tr>
<td>09.</td>
<td>Graphs</td>
<td>13</td>
<td>10.83%</td>
</tr>
<tr>
<td>10.</td>
<td>Computer Programming</td>
<td>9</td>
<td>7.5%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>120</td>
<td>100%</td>
</tr>
</tbody>
</table>
Table 3.4

Showing the blue print of the achievement test in Mathematics (Preliminary form)

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Chapter</th>
<th>Knowledge</th>
<th>Understanding</th>
<th>Application</th>
<th>Skill</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>Number System</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>02.</td>
<td>Set Language</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>03.</td>
<td>Algebra</td>
<td>3</td>
<td>6</td>
<td>7</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>04.</td>
<td>Mensuration</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>05.</td>
<td>Application</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>06.</td>
<td>Statistics</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>07.</td>
<td>Geometry</td>
<td>8</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>08.</td>
<td>Construction</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>09.</td>
<td>Graphs</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>10.</td>
<td>Computer Programming</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>38</td>
<td>41</td>
<td>27</td>
<td>14</td>
<td>120</td>
</tr>
</tbody>
</table>

Stage II : Writing the Test Items

120 Objective type items, all of which are multiple choice items were developed, according to the tables of specifications.

Stage III : Reviewing and Editing the Items

The pool of 120 items for a maximum score of 120 marks had been reviewed with the help of senior practising teachers and expert teacher educators in the field of Mathematics. Some of the items had been reworded, modified or replaced based on their suggestions. Concise directions indicating
the duration of the test, maximum marks allotted and the marks allotted for each test item were included in the question paper.

Stage IV: Preparation of Scoring Key

A scoring key (Appendix - VII A) had been prepared with the help of experts in the field to evaluate the responses of the subjects who take the test.

Stage V: Field Testing

Students included for the pilot study were informed about the test 15 days in advance and during the last week of February 2002, the test was administered on 80 students drawn from two schools which were not included for the main study. Students recorded their responses in the test paper itself. Students' responses were scored as per the scoring key.

Stage VI: Item Analysis

Item analysis of the achievement test (Appendix-VIIB) was carried out by computing the index of discrimination and difficulty level for each of the items in the test. Only those items whose discriminative index is above 0.2 and difficulty level between 0.2 and 0.8 were chosen for the main study.

Thus the 20 items with number 2, 8, 13, 30, 32, 34, 35, 38, 40, 47, 61, 73, 74, 75, 76, 85, 91, 94, 95 and 98 have been omitted and the remaining 100 items had been rearranged as per the sequence of the content areas to constitute the final form of the test.
Stage VII: Final Form of the Achievement Test

The test for the main study consists of 100 multiple choice items for a maximum of 100 marks to be answered in two hours.

The tables of weightages and the blueprint for the final form of the achievement test in Mathematics have been presented below.

Table 3.5

Showing the Weightages for objectives in the final form of the achievement test

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Objectives</th>
<th>Marks Allotted</th>
<th>Percentage of Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>Knowledge</td>
<td>29</td>
<td>29%</td>
</tr>
<tr>
<td>02.</td>
<td>Understanding</td>
<td>33</td>
<td>33%</td>
</tr>
<tr>
<td>03.</td>
<td>Application</td>
<td>26</td>
<td>26%</td>
</tr>
<tr>
<td>04.</td>
<td>Skill</td>
<td>12</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>100</td>
<td>100%</td>
</tr>
<tr>
<td>S.No.</td>
<td>Objectives</td>
<td>Marks Allotted</td>
<td>Percentage of Marks</td>
</tr>
<tr>
<td>-------</td>
<td>-------------------------</td>
<td>----------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>01.</td>
<td>Number System</td>
<td>9</td>
<td>9%</td>
</tr>
<tr>
<td>02.</td>
<td>Set Language</td>
<td>9</td>
<td>9%</td>
</tr>
<tr>
<td>03.</td>
<td>Algebra</td>
<td>14</td>
<td>14%</td>
</tr>
<tr>
<td>04.</td>
<td>Mensuration</td>
<td>11</td>
<td>11%</td>
</tr>
<tr>
<td>05.</td>
<td>Application</td>
<td>8</td>
<td>8%</td>
</tr>
<tr>
<td>06.</td>
<td>Statistics</td>
<td>10</td>
<td>10%</td>
</tr>
<tr>
<td>07.</td>
<td>Geometry</td>
<td>11</td>
<td>11%</td>
</tr>
<tr>
<td>08.</td>
<td>Construction</td>
<td>8</td>
<td>8%</td>
</tr>
<tr>
<td>09.</td>
<td>Graphs</td>
<td>12</td>
<td>12%</td>
</tr>
<tr>
<td>10.</td>
<td>Computer Programming</td>
<td>8</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
Table 3.7

Showing the blue print for the final form of the achievement test in Mathematics

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Chapter</th>
<th>Knowledge</th>
<th>Understanding</th>
<th>Application</th>
<th>Skill</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>Number System</td>
<td>0</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>02.</td>
<td>Set Language</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>03.</td>
<td>Algebra</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>04.</td>
<td>Mensuration</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>05.</td>
<td>Application</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>06.</td>
<td>Statistics</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>07.</td>
<td>Geometry</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>08.</td>
<td>Construction</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>09.</td>
<td>Graphs</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>10.</td>
<td>Computer Programming</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>29</strong></td>
<td><strong>33</strong></td>
<td><strong>26</strong></td>
<td><strong>12</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
3:3:07:2 Administration of the Achievement Test (Final Form)

The achievement test in Mathematics was administered during the month of March 2002, well before their annual examinations. The following instructions were given before administering the test. "The achievement test in Mathematics is intended to find how far you have prepared yourself to face the annual examinations. You are expected to answer all the items in the test paper, without omitting any. This test will serve you as a rehearsal for the annual examination to be conducted by your school in the month of April 2002. Be serious and try to complete the test in two hours. The evaluated answer scripts will be given back to you within a week so that you can get feedback about your performance." Thus all the students were motivated to answer the test paper with all their seriousness.

3:3:07:3 Scoring

The answer scripts of the students were evaluated, using the already prepared scoring key.

3:4 SAMPLE FOR THE STUDY

The present study is mainly concerned with the ninth standard students studying in schools following the syllabus of Tamil Nadu State Board of Secondary Education.

As X standard students are to face their public examinations, they have been put on a tight schedule of work in schools and as such, authorities are
very reluctant to let access to these students for any research investigation. Hence only IX standard students were taken to constitute the population for the present study.

For the present study, a sample of 662 students of standard IX studying in the schools at Chennai during the academic year 2001-2002 were chosen, using stratified random sampling technique.

To control the variable of socio-economic status, only those students of low socio-economic status had been included in the present study. Thus, the sample for the main study shrunk from 662 to 585.

Of the 10 schools in the sample, 5 are Government schools and the remaining are Government aided schools. Among the 585 students in the sample, 221 (37.8%) are boys and 364 (62.2%) girls. 49.1% of the sample (287) are of English medium students and the rest 50.9% (298) are in Tamil medium.

The details of the sample composition with respect to the different characteristics are presented below.
<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of the School</th>
<th>Sex</th>
<th>Management of the Schools</th>
<th>Types of Schools</th>
<th>Medium of Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Boys</td>
<td>Government</td>
<td>Boys' School</td>
<td>English</td>
</tr>
<tr>
<td>01.</td>
<td>Government Boys' High School, Villivakkam, Chennai - 49.</td>
<td>31</td>
<td>31</td>
<td>31</td>
<td>-</td>
</tr>
<tr>
<td>03.</td>
<td>Singaram Pillai Higher Secondary School, Villivakkam, Chennai - 49.</td>
<td>-</td>
<td>61</td>
<td>61</td>
<td>61</td>
</tr>
<tr>
<td>04.</td>
<td>Padi Britannia Higher Secondary School, Chennai - 50.</td>
<td>44</td>
<td>45</td>
<td>89</td>
<td>89</td>
</tr>
<tr>
<td>05.</td>
<td>Government Higher Secondary School, MMDA Colony, Chennai - 106.</td>
<td>36</td>
<td>59</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>06.</td>
<td>Bentinck Girls' Higher Secondary School, Vepery, Chennai - 7</td>
<td>-</td>
<td>69</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>S.No.</td>
<td>Name of the School</td>
<td>Sex</td>
<td>Management of the Schools</td>
<td>Types of Schools</td>
<td>Instruction</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------------------------------------</td>
<td>-------</td>
<td>---------------------------</td>
<td>------------------</td>
<td>-------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boys</td>
<td>Government</td>
<td>Government aided</td>
<td>Boys' School</td>
</tr>
<tr>
<td>08.</td>
<td>Assumption Higher Secondary School, Chennai - 34</td>
<td>28</td>
<td>-</td>
<td>48</td>
<td>-</td>
</tr>
<tr>
<td>09.</td>
<td>Government Boys' High School, Choolaimedu, Chennai - 94.</td>
<td>47</td>
<td>47</td>
<td>-</td>
<td>47</td>
</tr>
<tr>
<td>10.</td>
<td>Jaiygal Carodia Government Girls' Higher Secondary School, Choolaimedu, Chennai - 94.</td>
<td>-</td>
<td>82</td>
<td>82</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>221</td>
<td>364</td>
<td>283</td>
<td>302</td>
</tr>
<tr>
<td></td>
<td>Percentage</td>
<td>37.8%</td>
<td>62.2%</td>
<td>48.4%</td>
<td>51.6%</td>
</tr>
</tbody>
</table>
Fig. 3.1
Pie Diagram showing the composition of the sample in terms of Sex and Medium of instruction

EB 8%
EG 41%
TB 22%
TG 29%

EB - English Medium Boys
EG - English Medium Girls
TB - Tamil Medium Boys
TG - Tamil Medium Girls
Fig. 3.2
Pie Diagram showing the composition of the sample in terms of types of schools and types of management of schools

GB - Government Boys' Schools
GG - Government Girls' Schools
GC - Government Co-Education Schools
AB - Government Aided Boys' Schools
AG - Government Aided Girls' Schools
AC - Government Aided Co-Education Schools

Legend:
- GB: 28%
- GG: 15%
- AC: 23%
- AB: 6%
- AG: 22%
A pilot study was conducted on eighty students from two schools which were not included for the main study, to establish the reliability and validity of the different research tools used in this study, to streamline the instructions to be given for each test, to modify phrases or sentences that were ambiguous and to determine the optimum time duration for each test. The pilot study also helped to ensure comprehensibility of the items in the tests. (Kolb’s learning style inventory, J.M. Reid’s perceptual learning style questionnaire, A. Hilliard’s hemispheric dominance learning style inventory, Mathematics Learning Environment Scale and J.C. Ravan’s Standard Progressive Matrices Test were administered for pilot study in the month of November 2001 and achievement test in the last week of February 2002. All the above tests were administered on the same set of students at different points of time as indicated above.

3:6 Establishing Reliability and Validity of the Tools Used

3:6:01 Reliability

3:6:01:1 Kolb’s learning style Inventory

This learning style inventory is a standardised tool. Further, the reliability of the inventory had been found using the test-retest method. The obtained reliability coefficient $r = 0.84$ reveals that the tool is highly reliable.
3:6:01:2 J.M. Reid’s perceptual learning style questionnaire

Test-retest technique had been used to establish the reliability of the perceptual learning style questionnaire and it was found to be 0.76, indicating a high reliability of the tool.

3:6:01:3 A. Hilliards’ hemispheric dominance learning style inventory

The author of the inventory had already established the reliability by test-retest method (r = 0.65). In the present study, the reliability coefficient for the inventory computed by test-retest method yielded a high reliability coefficient of 0.69 for the right hemisphere dominance and 0.62 for the left hemisphere dominance. These values reveal that the tool used is highly reliable.

3:6:01:4 Mathematics Learning Environment Scale

Test-retest method is used in establishing the reliability of the scale.

Pearson product moment ‘r’ is worked out for these two sets of scores and it was found to be 0.78 which is the reliability coefficient. This has been converted into Fischer’s ‘z’ in order to find out the 0.99 confidence interval. The ‘z’ for 0.78 is 1.05.

The 0.99 limits of this ‘z’ are 1.05 ± (2.58 x 0.03) that is from 1.04 to 1.06. Converting these ‘z’s into r, the 0.99 limits of r are 0.78 to 0.79. Thus this scale has been considered to have high reliability.
6:01:5 Raven's Standard Progressive Matrices Test

While most of the European and American research studies report a very high value (an average of 0.79) of reliability through split-half technique, two Indian studies [Dolke (1976), Dolke and Sharma (1976)] report a Kuder-Richardson consistency of 0.67 and 0.87 respectively.

In the present study, the reliability coefficient of 0.64 has been obtained for whole test through split-half technique using Spearman-Brown formula

\[
\frac{2r_{hh}}{1+r_{hh}}
\]

3:01:6 Achievement Test in Mathematics

The reliability coefficient for achievement test in Mathematics is computed by the method of rational equivalence using the formula.

\[
r_{tt} = \frac{n}{n-1} \frac{\sigma_i^2 - \Sigma pq}{\sigma_i''}
\]

in which

- \( r_{tt} \) -> reliability coefficient of the test
- \( n \) -> number of items in the test
- \( \sigma \) -> standard deviation of the test scores
- \( p \) -> proportion of the group answering a test item correctly
- \( q \) -> \((1-p)\), the proportion of the group answering a test item incorrectly
The obtained reliability coefficient of 0.76 indicates that the achievement test developed in Mathematics is highly reliable.

6:02 Validity

6:02:1 Kolb’s learning style inventory

The Kolb’s learning style inventory is a standardised tool. In the present study to establish face validity of the test, it has been shown to teacher educators and psychologists to solicit their opinion. They found the tool to be valid for the present study. In the present investigation, the validity of the inventory has been computed in terms of the index of the reliability (square root of reliability coefficient) which gives the relationship between the variances of the obtained scores and their theoretical true counterparts. The obtained validity measure is 0.92 which is highly significant.

3:6:02:2 J.M. Reid’s perceptual learning style questionnaire

The validity of this questionnaire has been assessed by computing the reliability index. In the present case, it has worked out to be \( r = 0.87 \).

3:6:02:3 A. Hilliard’s hemispheric dominance learning style inventory

The validity of this inventory had already been established by the author. However in the present study, the validity measures are computed in terms of index of reliability. The obtained validity measures of 0.83 (for the right hemisphere dominance) and 0.79 (for the left hemisphere dominance) suggest that the tool used in this study is highly valid.
The obtained reliability coefficient of 0.76 indicates that the achievement test developed in Mathematics is highly reliable.

3:6:02 Validity

3:6:02:1 Kolb's learning style inventory

The Kolb's learning style inventory is a standardised tool. In the present study to establish face validity of the test, it has been shown to teacher educators and psychologists to solicit their opinion. They found the tool to be valid for the present study. In the present investigation, the validity of the inventory has been computed in terms of the index of the reliability (square root of reliability coefficient) which gives the relationship between the variances of the obtained scores and their theoretical true counterparts. The obtained validity measure is 0.92 which is highly significant.

3:6:02:2 J.M. Reid's perceptual learning style questionnaire

The validity of this questionnaire has been assessed by computing the reliability index. In the present case, it has worked out to be $r = 0.87$.

3:6:02:3 A. Hilliard's hemispheric dominance learning style inventory

The validity of this inventory had already been established by the author. However in the present study, the validity measures are computed in terms of index of reliability. The obtained validity measures of 0.83 (for the right hemisphere dominance) and 0.79 (for the left hemisphere dominance) suggest that the tool used in this study is highly valid.
6:02:4 Mathematics Learning Environment Scale

This tool has content validity as it contains the major components of class room climate and those of home environment. It had been validated by the opinions of as many as twenty senior teachers of Mathematics in schools and five professors each from Arts and Science Colleges and Colleges of Education.

Further, index of reliability could also be taken as a measure of validity and this works out to be $\sqrt{0.78} = 0.88$ and hence Mathematics learning environment scale has been considered to have criterion validity also.

3:6:02:5 Raven’s Standard Progressive Matrices Test

For English speaking children and adolescents, correlations of standard progressive matrices with the Binet and Wechsler scales range from +0.54 to +0.86 [Raven (1948), Taibi (1951), Banks and Sinha (1951), Mehrotra (1968), Moran (1972)]. When the external criterion for comparisons is actual school achievement assessed by school grades, examination results or teacher estimates, correlations generally fall between +0.42 to +0.64 [Looze (1954), Kechn & Prothro (1955), Elley & Mac Arthur (1962), Mac Aruthur et al., (1964), Fung (1966), Geogras (1970), Irvine (1966)] obtained a very high correlation (+0.9) with headmaster’s estimate for achievement for 1600 Rhodesian children. There is a tendency for concurrent validity estimates to be higher, when the criterion measures maths and science skills than when language skill or overall academic achievement are compared [Laroche (1959), Sinha (1968)].
The Progressive Matrices has been described as one of the purest and best measures of ‘g’ or general intellectual functioning available [Spearman (1938), Vernon (1942)]. Evidence for this claim comes from several factor analytic studies involving large numbers of children and adults. Investigations with British children reveal high loadings of up to +0.3 on ‘g’ and up to +0.81 with a U.S. Study [Zagar et al. (1970)].

In the present study, the validity coefficient is computed as the square root of the reliability coefficient and this works out to be $\sqrt{0.64} = 0.8$.

3.6:02:6 Achievement Test in Mathematics

The test was given to a panel of judges (10 senior teachers of Mathematics) seeking their views on the content coverage of the test. They found that the test contained questions from all the content areas of IX standard mathematics syllabus. Thus, the achievement test constructed and used in the present study can be said to have content validity. Further, the achievement test had been developed after framing a blue print and carrying out item analysis. It may be reasonably claimed that the test has construct validity also. Besides, the index of reliability could be taken as a measure of its validity also. In this case, it works out to be $\sqrt{0.76} = 0.87$ and hence the test has been considered to have high criterion validity [Garrett (1979)].

3.7 MAIN STUDY

The tools described below -

i. Kolb’s learning style inventory

ii. J.M. Reid’s perceptual learning style questionnaire

iii. A. Hilliard’s hemispheric dominance learning style inventory
iv. Raven's Standard Progressive Matrices Test  
v. Mathematics Learning Environment Scale  
vi. Socio-economic status scale  

vii. Achievement Test in Mathematics  

were used to collect the data for the main study following the procedures mentioned for the administration of the tests. The tests were administered on a sample of 662 ninth standard students. The sample size has reduced to 585 as only students of low socio-economic status have been included for the present study in order to control the variable 'socio-economic status'.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of the Tool</th>
<th>Time taken (in minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>Kolb's learning style inventory</td>
<td>30</td>
</tr>
<tr>
<td>02.</td>
<td>J.M. Reid's perceptual learning style questionnaire</td>
<td>30</td>
</tr>
<tr>
<td>03.</td>
<td>A. Hilliard's hemispheric dominance learning style inventory</td>
<td>15</td>
</tr>
<tr>
<td>04.</td>
<td>Raven's Standard Progressive Matrices Test</td>
<td>45</td>
</tr>
<tr>
<td>05.</td>
<td>Mathematics Learning Environment Scale</td>
<td>45</td>
</tr>
<tr>
<td>06.</td>
<td>Socio-economic status scale</td>
<td>10</td>
</tr>
<tr>
<td>07.</td>
<td>Achievement Test in Mathematics</td>
<td>120</td>
</tr>
</tbody>
</table>
The main study was conducted during the month of March 2002. The first six tests mentioned above had been administered in a single session having a break of 5 minutes in between the administration of the successive tools. The achievement test in Mathematics had been administered after a gap of 3 days.

3.8 CONCLUSION

Following the methods described earlier, all the tests were administered and scored and each student was assigned various scores (Appendix-VIII). The obtained data were analysed, using appropriate statistical techniques to study the relative influence of the different learning styles, intelligence and learning environment in Mathematics on achievement in Mathematics, the results of which are discussed in the light of the hypotheses formulated and the next chapter presents this analysis and discussion part of the study.