CHAPTER III

METHODOLOGY
Methodology occupies a very important position in any kind of research. The accuracy and adequacy of the research findings depend upon the method adopted. This chapter describes the methodology adopted in this study. It includes the research design, selection of variables, objectives, hypotheses, and description of samples, description of tools used, mode of data collection, statistical technique used and summary of procedure.

3.1 THE DESIGN OF THE STUDY

The research design is the detailed plan of the investigation. The selection of the research design is obviously based upon the purpose of investigation, types of variables and the condition in which the research is to be conducted.

One of the most commonly used methods to solve educational problems is ‘Normative Survey’. This method involves comparison, measurement, classification, evaluation and generalization- all directed towards a proper understanding and solutions of significant educational problems. Hence the investigator decided to use normative survey for the investigation.

3.2 VARIABLES OF THE STUDY

The study under investigation is *A STUDY OF GROUP DIFFERENCES IN COMPUTATIONAL SKILLS OF SECONDARY SCHOOL STUDENTS*. Hence the variables are categorized as independent and dependent variables as given below:

3.2.1 Dependent Variables

The dependent variables for the present study are different kinds of computational skills - computational ability in the four fundamental operations,
measured separately for speed of performance and for power of performance, for whole numbers, fractional numbers and decimal numbers, as detailed below:

3.2.1.1 Computational Speed Variables (CS):

1) Addition (Whole Numbers)
2) Subtraction (Whole Numbers)
3) Multiplication (Whole Numbers)
4) Division (Whole Numbers)
5) Addition (Fractions)
6) Subtraction (Fractions)
7) Multiplication (Fractions)
8) Division (Fractions)
9) Addition (Decimals)
10) Subtraction (Decimals)
11) Multiplication (Decimals)
12) Division (Decimals)
13) Computational Speed Total (CS Total) [Sum of the series of variables 1-12]

3.2.1.2 Computational Power Variables (CP):

14) Addition (Whole Numbers)
15) Subtraction (Whole Numbers)
16) Multiplication (Whole Numbers)
17) Division (Whole Numbers)
18) Addition (Fractions)
19) Subtraction (Fractions)
20) Multiplication (Fractions)
21) Division (Fractions)
22) Addition (Decimals)
23) Subtraction (Decimals)
24) Multiplication (Decimals)
25) Division (Decimals)
26) Computational power Total (CP Total) [Sum of series of variables 14-25]

3.2.2 Independent Variables

The criteria selected to decide groups for the study of their differences in the dependent variables were the independent variables of the study. Five such criteria thus considered as the independent variables. They are

- Intelligence
- Class Achievement in Mathematics
- Gender of Subjects (Male/Female)
- Socio-Economic Status
- Locale (Urban/Semi-urban/Rural)

3.3 TOOLS USED FOR THE COLLECTION OF DATA

In order to collect the data needed for the present study the investigator used the following tools:

3.3.1 Test of Computational Skills (standardized by the investigator)
3.3.2 The Kerala University Verbal Group Test of Intelligence (standardized test)
3.3.3 General Data Sheet
3.3.4 The Kerala Socio-Economic Status Scale (Revised)

In addition, class achievement in mathematics was also collected from school records for comparison with the results arrived from other tools.

3.3.1 Test of Computational Skills

In order to measure the skills in mental computation of mathematics of the
Secondary School students, twelve tests in computation were constructed and standardized by the investigator. The questions included fundamental operations with whole numbers, fractional numbers and decimal numbers. Computational skill contains twelve different variables each under ‘CS’ and ‘CP’. Since computational skill is the total of all these variables the investigator decided to introduce two additional variables, viz. ‘computational speed total’ (CS Total) and ‘computational power total’ (CP Total), thus making a total of thirteen variables in each group. ‘CS’ Total was obtained by summing scores of the twelve components of the ‘CS’ variables by giving equal weightage to each of the twelve components. A similar procedure was adopted for defining the variable ‘CP’ Total. The following steps were adopted in the construction and standardization of the tests:

3.3.1.1 Planning the test

Computational skill is essentially the skill or capability of doing the four basic operations of addition, subtraction, multiplication and division with numbers. These are called fundamental operations in mathematics, because they are complete in themselves and make use of no other operations. Arithmetic is that part of mathematics which deals with numbers. The three important and independent forms of numbers dealt with in arithmetic are whole numbers, fractions and decimal numbers. Though percentage calculation in arithmetic, algebra and geometry are also fundamental operations they make use of the basic operations addition, subtraction, multiplication and division. Algebra is generalized arithmetic and geometry is applied arithmetic. So without the knowledge of the four basic operations no other mathematical operation can be learnt. Same is the case with any test including the four fundamental operations with whole numbers, decimals and fractions and is sufficient to measure the basic computational talent regarding all other operations. Hence such a test serves the purpose of the investigation.
3.3.1.2 Preparation of Preliminary Test

The items can be used to measure skills in computation were selected. A test which measures the skills in all four basic operations of computation, viz. addition, subtraction, multiplication and division was decided to be included. The preliminary test contained 300 multiple choice items divided among 12 areas for the preliminary try out. The final test contained 12 parts and 180 items in total, each part having 15 items.

The investigator prepared the test after consulting experts in the field of mathematics education and teachers who are teaching mathematics at school level. The items were collected by referring to the following books:

. *Teaching Elementary Mathematics* (Kutz, Ronald E.)
. *Teaching Elementary School Mathematics* (Riedesel, C. Alen 1990)
. *Learning Mathematics* (Anthony Orton.)
. *Teaching the essentials of Arithmetic* (P.B Ballard)
. *How Children Learn Mathematics* (Richard W. Copeland.)
. *An arithmetic for Teachers* (William F and Tayler Mary S.)

3.3.1.3 Administration of Preliminary Test

For try out the test was administered to a group representing the whole population. From the schools of Kottayam district 400 students of Standard IX were selected at random and they were given the computational skill test of 300 multiple choice items. Necessary instructions were given prior to the administration of the test. The responses were marked by the students in the separate response sheets given to each individual. Enough time was given to the students so as to
enable them to complete the test. The average time used was noted to fix the time limit for the final test.

3.3.1.4 Scoring

For easiness of scoring the investigator prepared a scoring key for the test. The scoring scheme of the test was one mark for each correct answer and zero score for every incorrect answer. Incomplete and manipulated scoring sheets were rejected. Only 370 response sheets were taken for future analysis.

3.3.1.5 Item Analysis

It is the process of establishing the suitability of an item for inclusion in the final test. The quality of each item was ascertained by analyzing two important characteristics of the item, namely (i) Difficulty Index (ii) Discriminating Power.

For the present study the procedures and formula suggested by Ebel and Frisbie (1991) were used to calculate the Difficulty Index and Discriminating Power (pp.225-233).

\[
\text{Index of item difficulty} = \frac{U + L}{2N}
\]

\[
\text{Index of Discriminating Power} = \frac{U - L}{N}
\]

Where,

- \(U\) = Number of right responses in the upper group.
- \(L\) = Number of right responses in the lower group.
- \(N\) = Number of subjects in any of the group.

The answer sheet of each section of the test was analysed separately.
3.3.1.5.1 Selection of items for the final test

Items to be in the final test were selected on the basis of Difficulty Index and Discriminating Power of the items. Generally Difficulty Index of a good item is considered to lie between 0.4 and 0.6 and Discriminating Power more than 0.4 is considered to be ideal. This means that an item satisfying both the above criteria is readily acceptable.

After preliminary test, in order to get sufficient number of questions, the investigator took the items with Difficulty Index ranging from 0.3 to 0.75 and Discriminating Power greater than or equal to 0.3.

The investigator finally selected 15 items for each test and arranged in the increasing order of difficulty under each type so that easy items appeared in the beginning and difficult items at the end. The selected questions were printed in the form of a booklet. Necessary information and other details were added before printing to get final draft of the test. Separate score sheets were also printed. The Test of Computational Skills, the details regarding the difficulty index and discriminating power of each item, final Test of Computational Skills and Scoring Sheet (Response Sheet) of the Test of Computational Skills are given as Appendix I, Appendix II, Appendix III and Appendix IV respectively.

After try out with smaller samples, the exact time-limit for each final test was fixed at four minutes for speed test and eight minutes for power test.

3.3.1.6 Validity of the Computational Skill Test

The principal method of establishing validity involves “the appraisal of theoretically expected patterns of relationship among item scores or between test scores and other measures” (Messick, 1995, p.743). As far as computational skill test is concerned, face validity, content validity and criterion-related validity are important.
3.3.1.6.1 Face Validity

In order to establish the face validity of the final computational skill test, it was submitted to a panel of experts who certified it after scrutinizing the items of test.

3.3.1.6.2 Content Validity

Content validity refers to the degree to which the test actually measures, or is specifically related to, the traits for which it was designed. It shows how adequately the test samples the universe of knowledge and skills that a student is expected to master. Content validity is based upon careful examination of course text books syllabi, objectives and the judgment of subject matter specialists (Best, John W. 1996 p.219).

To ensure content validity of the test the items were selected from different sources, viz. course text books and standard reference books. It was further supplemented by interviewing selected mathematics scholars and experts. The items selected from all the areas were finalized on the basis of the suggestions of subject experts. The content validity of the test was thus ensured.

3.3.1.6.3 Criterion-related Validity

The criterion-related validity of the test was estimated by correlating the test score with that of an external criteria, viz. the marks obtained by the same students in mathematics for the first quarterly examination. The comparison was made for a sample of 100 students. The finally prepared test on ‘Test of Computational Skills’ was administered to them. The correlation between these two scores was found by using Pearson’s Product Moment Method.
$$r = \frac{\Sigma XY - \Sigma X \Sigma Y}{\sqrt{\Sigma X^2 - (\Sigma X)^2} \cdot \Sigma Y^2 - (\Sigma Y)^2}$$

Where,  
\( r \) = coefficient of correlation  
\( \Sigma X \) = Sum of X score  
\( \Sigma Y \) = Sum of Y score  
\( \Sigma XY \) = Sum of product of paired X and Y  
\( \Sigma X^2 \) = Sum of squared X score  
\( \Sigma Y^2 \) = Sum of squared Y score  
\( N \) = Number of paired scores

The product Moment coefficient correlation calculated for each test is given in table 3.1.

TABLE 3.1

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Name of test component</th>
<th>Validity coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Addition (Whole Numbers)</td>
<td>0.72</td>
</tr>
<tr>
<td>2</td>
<td>Subtraction (Whole Numbers)</td>
<td>0.59</td>
</tr>
<tr>
<td>3</td>
<td>Multiplication (Whole Numbers)</td>
<td>0.63</td>
</tr>
<tr>
<td>4</td>
<td>Division (Whole Numbers)</td>
<td>0.51</td>
</tr>
<tr>
<td>5</td>
<td>Addition (Fractions)</td>
<td>0.52</td>
</tr>
<tr>
<td>6</td>
<td>Subtraction (Fractions)</td>
<td>0.49</td>
</tr>
<tr>
<td>7</td>
<td>Multiplication (Fractions)</td>
<td>0.53</td>
</tr>
<tr>
<td>8</td>
<td>Division (Fractions)</td>
<td>0.41</td>
</tr>
<tr>
<td>9</td>
<td>Addition (Decimals)</td>
<td>0.64</td>
</tr>
<tr>
<td>10</td>
<td>Subtraction (Decimals)</td>
<td>0.53</td>
</tr>
<tr>
<td>11</td>
<td>Multiplication (Decimals)</td>
<td>0.59</td>
</tr>
<tr>
<td>12</td>
<td>Division (Decimals)</td>
<td>0.58</td>
</tr>
<tr>
<td>13</td>
<td>Whole test</td>
<td>0.55</td>
</tr>
</tbody>
</table>
3.3.1.7 Reliability of the test

Reliability of the test refers to the degree of consistency and accuracy with which it measures. Reliability of computational skill tests was estimated by the investigator using test-retest method. The interval given was four weeks. Pearson's Product Moment formula was used for finding correlation coefficient between the two test scores. The obtained score of each test is given in Table 3.2

### TABLE 3.2

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Name of test component</th>
<th>Reliability coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Addition (Whole Numbers)</td>
<td>0.80</td>
</tr>
<tr>
<td>2</td>
<td>Subtraction (Whole Numbers)</td>
<td>0.65</td>
</tr>
<tr>
<td>3</td>
<td>Multiplication (Whole Numbers)</td>
<td>0.78</td>
</tr>
<tr>
<td>4</td>
<td>Division (Whole Numbers)</td>
<td>0.72</td>
</tr>
<tr>
<td>5</td>
<td>Addition (Fractions)</td>
<td>0.65</td>
</tr>
<tr>
<td>6</td>
<td>Subtraction (Fractions)</td>
<td>0.59</td>
</tr>
<tr>
<td>7</td>
<td>Multiplication (Fractions)</td>
<td>0.63</td>
</tr>
<tr>
<td>8</td>
<td>Division (Fractions)</td>
<td>0.61</td>
</tr>
<tr>
<td>9</td>
<td>Addition (Decimals)</td>
<td>0.72</td>
</tr>
<tr>
<td>10</td>
<td>Subtraction (Decimals)</td>
<td>0.64</td>
</tr>
<tr>
<td>11</td>
<td>Multiplication (Decimals)</td>
<td>0.68</td>
</tr>
<tr>
<td>12</td>
<td>Division (Decimals)</td>
<td>0.67</td>
</tr>
<tr>
<td>13</td>
<td>Whole test</td>
<td>0.66</td>
</tr>
</tbody>
</table>

The indices of validity and reliability indicate that computational skill test has acceptable properties to measure computational skill of Secondary School Pupils.
3.3.1.8 Objectivity

The objectivity is a pre-requisite of reliability, therefore, validity of a test. In the computational test prepared, the objectivity was ensured by including objective type test items of the multiple choice- form. The application of scoring key for evaluation also ensured objectivity.

3.3.1.9 Practicability

Steps were taken to ensure the practicability of the test. The prepared computation skill test was easy to administer as it was in the booklet form. It was economical as well as reusable. In this study, the duration of the test, type of items included, provisions for separate answer sheets and scoring key add to the practicability of the test.

3.3.2 The Kerala University Verbal Group Test of Intelligence

The Kerala University Verbal Group Test of Intelligence developed by A.S. Nair (1968) is intended to measure the general intelligence “g” of the pupils of Secondary Schools of Kerala. It is composed of five sub-tests to test (a) verbal analogy, (b) verbal classification, (c) proverbs, (d) number series and (e) arithmetic reasoning. Each test consists of 20 items with one mark for each correct answer. The five sub-tests, number of items and time limit for each are given in Table 3.3.

3.3.2.1 Validity of the test

Validity of the test was ensured mainly by adopting components from other tests of proved merit and partly by ensuring high internal validity attained through item analysis. Further the inter-correlations of the 5 tests in the battery were worked out. The matrix of inter-correlations (N=120) is given in Table 3.4.
TABLE 3.3
Test Components with Details of the Kerala University Verbal Group Test of Intelligence

<table>
<thead>
<tr>
<th>No. of Sub-Test</th>
<th>Name of test components</th>
<th>No. of Items</th>
<th>Time in minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Verbal analogy</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Verbal classification</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Proverbs</td>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Number series</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>Arithmetic reasoning</td>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>

TABLE 3.4
Inter-Test Correlation Matrix

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Name of test components</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Verbal analogy</td>
<td>–</td>
<td>0.75</td>
<td>0.66</td>
<td>0.45</td>
<td>0.56</td>
</tr>
<tr>
<td>2</td>
<td>Verbal classification</td>
<td>0.75</td>
<td>–</td>
<td>0.63</td>
<td>0.47</td>
<td>0.41</td>
</tr>
<tr>
<td>3</td>
<td>Proverbs</td>
<td>0.66</td>
<td>0.63</td>
<td>–</td>
<td>0.47</td>
<td>0.41</td>
</tr>
<tr>
<td>4</td>
<td>Number series</td>
<td>0.45</td>
<td>0.47</td>
<td>0.47</td>
<td>–</td>
<td>0.32</td>
</tr>
<tr>
<td>5</td>
<td>Arithmetic reasoning</td>
<td>0.56</td>
<td>0.41</td>
<td>0.41</td>
<td>0.32</td>
<td>–</td>
</tr>
</tbody>
</table>
The Validity Coefficient of Subtests 1 to 5 assessed using school marks as an external criteria (N=300) where 0.61, 0.53, 0.65, 0.67 and 0.45 respectively. With Ravens Progressive Matrices Test as the external criteria, the Validity Coefficient of the test (total scores in the five tests) was found to be 0.56 (N=120).

3.3.2.2 Reliability

The split-half reliability was worked out for the whole test battery as well as for the component tests, (N=120) and corrected for shortening using Spearman-Brown Formula. The values are given in table 3.5.

TABLE 3.5
Reliability Coefficient of the Kerala University Verbal Group Test of Intelligence

<table>
<thead>
<tr>
<th>No. of Sub-Test</th>
<th>Name of test components</th>
<th>Reliability Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Verbal analogy</td>
<td>0.88</td>
</tr>
<tr>
<td>2</td>
<td>Verbal classification</td>
<td>0.86</td>
</tr>
<tr>
<td>3</td>
<td>Proverbs</td>
<td>0.66</td>
</tr>
<tr>
<td>4</td>
<td>Number series</td>
<td>0.86</td>
</tr>
<tr>
<td>5</td>
<td>Arithmetic reasoning</td>
<td>0.84</td>
</tr>
<tr>
<td>6</td>
<td>Whole test</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Test-Retest reliability of the whole test was calculated, the interval between the test and re-test being one month (N= 86). The coefficient of reliability came to 0.79.

The test was re-validated by the investigator using a sample of 100 students. The validity and reliability of the whole test were found to be 0.68 and 0.82 respectively. A specimen copy of The Kerala University Verbal Group Test of Intelligence and response sheet are given as Appendix V and Appendix VI respectively.
3.3.3 Class Achievement in Mathematics (CAM)

Recording of school marks

In February 2004 when the mark sheets of pupils were ready, the investigator went to the respective schools and collected from the school register the achievement scores in Mathematics of those pupils who were the subjects of study. The scores of the first two terminal examinations were taken and their average was calculated.

The achievement scores of the students collected from the school records were converted into standard scores to avoid bias with respect to the standard of the schools, the difference in the difficulty level of question papers and mode of correction. For the purpose of descriptive and inferential analysis, the standard scores were taken into consideration. This score is taken as ‘CAM’.

Standard score

Z-score and T-score are Standard scores. When a raw score (X) is converted in terms of Arithmetic mean (M) and Standard Deviation (σ) we get Z score.

When we transform Z-score with assumed mean 50 and S.D10 we get T-score

Formula

\[ Z\text{-score} = \frac{X-M}{\sigma} \]

\[ T = 50 + 10Z \]

3.3.4 General Data Sheet

The investigator made use of a standard form of general data sheet to collect information about respondents and to measure the variables: Parental Education,
Parental Occupation, Parental Income and SES. A copy of the General Data sheet used for the study is given as Appendix VIA (English version). Its Malayalam version is given as VIB.

The General Data sheet consists of four sections. Section one collects the general information about the respondent (respondent's name, age, sex, name of the school, locale etc.). Section two is for collecting information regarding the level of education of parents, siblings and other members in the subjects' family. Section three provides information regarding the occupation of the parents and other members of the family. Section four offers details relating to the income of family members.

The school records were used for verifying information in the General Data sheet. The details, which were not available in the school records, were collected through direct questioning of the respondent during administration of the test. The General Data Sheet helped to classify subjects on the basis of Parental Education, Parental Occupation and Parental Income.

3.3.4.1. Administering the General Data Sheet

Soon after the completion of the second test the General Data Sheet was administered. The investigator personally supervised the administration of the same and clarified the difficulties of individual pupils. Every precaution was taken to ensure that accurate and reliable data were entered in the sheet.

3.3.5 The Kerala Socio-Economic Status Scale (Revised)

The investigator used the up-dated socio-economic status scale prepared by Kuppuswamy (1962) and published by Manasayan. A.S. Nair modified and developed the same scale in 1970. The investigator also modified the scale according to the pay scale existing at the time of administration of the tool. The
socio-economic status of a student is determined in terms of the three variables, viz. education, occupation and income of parents. Each variable is classified into six categories.

**Income: Classification and Weightage**

On the basis of monthly income also, people were classified into six categories. For the group having a monthly income of above Rs. 15,000, a score of 10 is given. For the group with a monthly income in the range from Rs. 9,001 to Rs. 15,000, a score of eight is given. For the group whose monthly income is in the range from Rs. 6,001 to Rs. 9,000 a score of six and for those having a monthly income in the range from Rs. 3,001 to Rs. 6,000 a score of four is given. For the group having monthly income in the range from Rs. 1,500 to Rs. 3,000 a score of two and for those having monthly income below Rs. 1,500 a score of one is given. The weightage given to the various categories are presented in the consolidated form in table 3.6.

**Classification of Occupations**

The procedure of quantifying ‘Father’s Occupation Level’ is given below. Parental Occupation is classified into 6 categories: These are High Professional, Semi Professional, Skilled Workers, Semi-Skilled Workers, Unskilled Workers and Unemployed.

**High Professional**


**Semi Professional**

Chemists, Druggists, Managers, Superintendents of offices, Qualified
Nurses, Small Landlords, Sub Inspectors of Police, Sub Registrars, Assistant Educational Officers, Block Development Officers, Officers of Sub District level, Public Health Workers and similar categories.

**Skilled Workers**

Mechanics, Fitters, Electricians, Drivers, Photographers, Laboratory Assistants, Carpenters, Document Workers, Vakil Clerks, Head Constables, Village Officers and similar categories.

**Semi-Skilled Workers**

Farmers, Small-Scale Merchants, Library Attenders, Office Attenders and similar categories.

**Unskilled Workers**

Coolies, Ordinary Labourers, Watchmen, Peons and other low-level employees and similar categories.

**Unemployed**

Persons without permanent employment, special qualifications or skills.

**Computation of Socio-Economic Status (SES) of the families of Students:**

Full weightage was given to the head of the family. Half the credit was given to the other parent. If the elder sister’s/brother’s education, occupation or income is higher than that of parents, one point weightage is given and a maximum of two points if both the sister and brother are higher in education, occupation or income. If the sister or brother is unmarried or staying with the family after marriage one point is the weightage given. The total of the scores obtained for the three components of Socio-Economic Status designated above yielded a composite score for each member. The sum of the composite score obtained for all members in the family was taken as the Socio-Economic Status of the family.
So Socio-Economic Status had been determined by quantifying the data giving weightage as described in the Table 3.6

TABLE 3.6

**Weightage given to items in the Socio-Economic Status Scale**

<table>
<thead>
<tr>
<th>Education</th>
<th>Score</th>
<th>Occupation</th>
<th>Score</th>
<th>Income</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masters Degree/Professional</td>
<td>10</td>
<td>High Professional</td>
<td>10</td>
<td>Above Rs. 15,000</td>
<td>10</td>
</tr>
<tr>
<td>Degree &amp; Above</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bachelor's Degree</td>
<td>8</td>
<td>Semi Professional</td>
<td>8</td>
<td>Rs. 9001-15,000</td>
<td>8</td>
</tr>
<tr>
<td>Pre degree/T.T.C/I.T.I</td>
<td>6</td>
<td>Skilled Workers</td>
<td>6</td>
<td>Rs. 6001-9000</td>
<td>6</td>
</tr>
<tr>
<td>Std VIII-X</td>
<td>4</td>
<td>Semiskilled Workers</td>
<td>4</td>
<td>Rs. 3001-6000</td>
<td>4</td>
</tr>
<tr>
<td>Std I-VII</td>
<td>2</td>
<td>Unskilled Workers</td>
<td>2</td>
<td>Rs. 1500-3000</td>
<td>2</td>
</tr>
<tr>
<td>Illiterate</td>
<td>1</td>
<td>Unemployed</td>
<td>1</td>
<td>Below Rs. 1500</td>
<td>1</td>
</tr>
</tbody>
</table>

3.4 SAMPLES FOR THE STUDY

As per the statement of the problem, the Secondary School Pupils form the target population for the study. Standard IX being the middle stage of high school education, is likely to represent the whole features of secondary education. Therefore students of standard IX of the schools under the state scheme (SSLC) were selected as samples. The investigator had to draw adequate number of samples by considering the following aspects:

a. sample size

b. sampling technique

c. factors to be represented in the sample

3.4.1 Sample Size

The size of the sample for the study was initially fixed to be 1000. Such a
large sample is fixed in order to include sufficiently large number of sub-samples for statistical processing. But the final sample size was reduced to 788 after rejection and elimination to correct experimental errors.

3.4.2 Sampling Technique

The dependability of any study is determined to a great extent by the selection of the sample. The sample selected should exhibit all properties of the population it represents. The manner in which a sample is drawn is an extremely important factor in determining how useful the sample is for making judgments about the population from which it is drawn. The investigator, therefore, used Stratified Random Sampling technique as the population consists of a number of strata like gender of the student (boys/girls), locale of the school (urban, semi-urban, rural), instructional efficiency of the school, type of management of the school, etc.

3.4.3 Factors to be represented in the Sampling Technique

While selecting the sample due representation was given to the following factors:

a. Gender of the student
b. Locale of the school
c. School categories according to type of management
d. Spatial distribution of schools
e. Instructional efficiency

The rationale for selection of each of the strata is as follows:

3.4.3.1 Gender of the Student

The gender of the student has an important role in the selection of a sample because in many of the studies, gender difference has been found to have an impact
on the results. So the investigator gave almost equal representation to boys and girls in the sample. As there are single-sex schools and co-education (mixed) schools both type of schools were selected.

3.4.3.2 Locale of the School

Because of difference in life situations in rural and urban areas and learning facilities available in schools, the performance of the students in tests differs in rural and urban schools. Often different levels of performance in examination are noticed in rural and urban area schools. In most of the studies only these two categories, viz. urban and rural schools, were selected. But these are extreme categories and there exists another category in between these two, which is included by the investigator in her study. This additional category of schools may be called semi-urban schools. Urban, Semi-urban and Rural schools were differentiated on the basis of locale of the school and not on the basis of place of residence of the pupils. From each area five schools were selected.

A school is treated as of urban if it is situated in a municipality/corporation and has proximity to urban facilities such as railway station, major bus station, collectorate, judicial courts, stadiums, parks, banks, hospitals, etc., whereas a school situated in a municipality and enjoys only a part or none of the above said facilities is categorized as semi-urban school. A school situated in a Panchayath is considered as rural school. From each of these categories five schools were selected.

3.4.3.3 Type of Management of Schools

There are two categories of schools in the state. They are schools owned by the government and those owned by private management. Again private schools are of two types, aided schools and unaided schools. Academic environment of these three types of schools is different. The investigator selected a total of 15
schools covering these three categories, viz. government, aided private and unaided private.

3.4.3.4 Instructional Efficiency

The school performance of the students will depend upon the type of instruction, the facilities available, better teacher-pupil interaction and enthusiasm of the teacher. It has been observed that better pupils are attracted to schools where the above-mentioned conditions are maintained. This may be the reason for higher standards of performance of pupils in certain schools. There is no actual index for measuring instructional efficiency. The closest approximation is to depend upon the pass percentage in the common SSLC examinations. The pass percentage of pupils in the common SSLC examinations is taken as the criterion for classifying schools. The percentage of pass in the common SSLC examination of the schools of the state for 2003 was obtained from official records.

Since the sample consists of students from Kottayam district the number of Secondary Schools in the district falling into each category was worked out from the published statistics.

The pass percentage of the year 2003 was 62.87. There are 240 high schools in Kottayam Revenue District in the following order: 89 schools in Kottayam Educational District, 63 schools in Kanjirappally Educational District, 47 in Palai Educational District and 41 in Kaduthuruthy Educational District. Of these, 118 have a pass percentage above 80 and 58 schools have pass percentage ranging from 60 to 80. The remaining 64 schools have pass percentage less than 60. So the schools are classified into three:

A - above average- pass above 80 percent
B - average- pass between 60 and 80 percent
C - below average- pass below 60 percent
Schools from these three categories were drawn from different educational districts and each locale category.

3.4.3.5 Spatial Distribution of Schools

The educational attainment of the various districts of Kerala is more or less the same when each district is taken as a whole. The investigator selected Kottayam district alone for the study due to three practical reasons.

1) In Kottayam district all types of schools are available as in the whole state.

2) Since the investigator is working in Kottayam district, it was easier to get co-operation from the schools under study.

Kottayam district is divided into four educational districts, viz. Kottayam, Kaduthuruthy, Kanjirappally and Pala. The investigator covered all these educational districts including remote areas as well as schools in urban areas. Five schools each were selected from urban, semi-urban and rural categories.

Details of the school-wise distribution of the final sample are given in table 3.7.

3.5 ADMINISTRATION OF THE FINAL TEST

The investigator personally visited the schools selected and obtained prior consent from the concerned Heads. The test was conducted for two days in each school as per a pre-fixed schedule. The investigator administered 13 tests on the sample selected. On the first day Whole numbers and Fractional numbers with the four fundamental operations were administered and on the second day, Decimals with four fundamental operations and Intelligence tests were administered. The tests were conducted in the months of January and February 2004 with due co-operation from the concerned authorities.
TABLE 3.7
Details of the School-wise Distribution of the final sample

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the School</th>
<th>Locale</th>
<th>Nature of School</th>
<th>Type of Management</th>
<th>Efficiency Level</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Boys</td>
</tr>
<tr>
<td>1</td>
<td>CMS College H.S, Kottayam</td>
<td>Urban</td>
<td>Boys</td>
<td>Private Aided</td>
<td>Above Average</td>
<td>70</td>
</tr>
<tr>
<td>2</td>
<td>Mount Carmel H S S, Kanjikuzhy</td>
<td>Urban</td>
<td>Girls</td>
<td>Private Aided</td>
<td>Above Average</td>
<td>---</td>
</tr>
<tr>
<td>3</td>
<td>H F H S S, Kottayam</td>
<td>Urban</td>
<td>Co-edn</td>
<td>Private Aided</td>
<td>Below Average</td>
<td>37</td>
</tr>
<tr>
<td>4</td>
<td>M D H S S, Kottayam</td>
<td>Urban</td>
<td>Co-edn</td>
<td>Private Aided</td>
<td>Average</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>Sri Vidyadhraja Vidya Bhavan</td>
<td>Urban</td>
<td>Co-edn</td>
<td>Private Unaided</td>
<td>Above Average</td>
<td>23</td>
</tr>
<tr>
<td>6</td>
<td>St. Thomas H S, Pampady</td>
<td>Rural</td>
<td>Co-edn</td>
<td>Private Aided</td>
<td>Below Average</td>
<td>--</td>
</tr>
<tr>
<td>7</td>
<td>Govt. Model H S S, Changanacherry</td>
<td>Semi-Urban</td>
<td>Co-edn</td>
<td>Govt.</td>
<td>Below Average</td>
<td>45</td>
</tr>
<tr>
<td>8</td>
<td>Govt. H S S, Kulasekharamangalam</td>
<td>Rural</td>
<td>Co-edn</td>
<td>Govt.</td>
<td>Below Average</td>
<td>22</td>
</tr>
<tr>
<td>9</td>
<td>Govt. Girls H S S, Vaikom</td>
<td>Semi-Urban</td>
<td>Girls</td>
<td>Govt.</td>
<td>Average</td>
<td>--</td>
</tr>
<tr>
<td>10</td>
<td>K T J M H S Idamattom</td>
<td>Rural</td>
<td>Co-edn</td>
<td>Private Aided</td>
<td>Above Average</td>
<td>28</td>
</tr>
<tr>
<td>11</td>
<td>St. Thomas H S S, Palai</td>
<td>Semi-Urban</td>
<td>Boys</td>
<td>Private Aided</td>
<td>Above Average</td>
<td>35</td>
</tr>
<tr>
<td>12</td>
<td>St. Mary's G H S S, Palai</td>
<td>Semi-Urban</td>
<td>Girls</td>
<td>Private Aided</td>
<td>Above Average</td>
<td>--</td>
</tr>
<tr>
<td>13</td>
<td>A K J M H S S, Kanjirappally</td>
<td>Semi-Urban</td>
<td>Boys</td>
<td>Private Unaided</td>
<td>Above Average</td>
<td>56</td>
</tr>
<tr>
<td>14</td>
<td>C M S H S, Kanam</td>
<td>Rural</td>
<td>Co-edn</td>
<td>Private Aided</td>
<td>Average</td>
<td>42</td>
</tr>
<tr>
<td>15</td>
<td>Baselios English School, Devagiri</td>
<td>Rural</td>
<td>Co-edn</td>
<td>Private Unaided</td>
<td>Above Average</td>
<td>21</td>
</tr>
</tbody>
</table>
3.5.1 Mode of Data Collection

The standardized Test of Computational Skill was administered to students with an explanatory statement that the test is intended to measure the speed and ability in different aspects of computation. The tests were conducted in such a manner that each subject would get two scores for each variable. The students were asked to answer maximum questions they could in given time limit (four minutes - Speed test) which was to be indicated by using a red colour pen on the response sheet and the rest to be answered by using blue pen in the prescribed time (Power test). The tests were administered under ideal conditions prescribed for psychometric testing. Before starting the tests, subjects were asked to go through the instructions given in the front page thoroughly. Their doubts were cleared and enough time was given to acquaint them with the task and the manner of doing this. The total time for answering all the twelve tests in computation was 96 minutes. But the instructions, pauses, etc. took another 24 minutes on the average.

The test of intelligence was also administered under almost similar conditions and as specified in the test manual. Accordingly data from 840 samples were collected.

3.5.2 The Scoring and Consolidation of data

Scoring was done as per the scheme provided with various tests. Scoring was done by the investigator, with the help of some of her students who were given some initial training in scoring techniques. Answers marked with red pen were taken as the score for speed test and all answers marked with red pen as well as blue pen were taken as score for power test. The same was done in each of the 12 computational skill tests.
All the information relating to each subject (test scores, demographic details, etc.) were consolidated and obtained in a single line on a consolidated data sheet. A serial number was assigned to each subject for identification. All entries were made against their serial number. Thus scores on independent and dependent variables were consolidated and coded for computer processing. As the incomplete response sheets had to be deleted, the size of the final sample was reduced to 788 numbers.

3.6 CLASSIFICATIONARY TECHNIQUES

(a) Classification of the Total Sample into High, Average and Low groups

For this the subjects (total sample) were classified into three groups based on the scores of the independent variables, viz. intelligence, class achievement in mathematics and socio-economic status using mean ($M$) and standard deviation ($\sigma$) as cut-off points. In the present study for total sample pupils with scores above $M+1\sigma$ were considered as High groups. Those who got $M-1\sigma$ were considered as Low groups and whose scores fall between $M-1\sigma$ and $M+1\sigma$ as Average groups.

(b) Classification of the Total Sample into Above-Average groups and Below-Average groups

For this the subjects (total sample) were classified into two groups based on the scores of the independent variables, viz. intelligence, class achievement in mathematics and socio-economic status using Median as the cut-off point. Subjects who obtained scores above Median were treated as Above-Average groups and subjects who obtained scores equal to and below Median were treated as Below-Average groups.

(c) Procedure for obtaining equated groups

The equated groups were obtained by controlling the following variables, viz. intelligence, class achievement in mathematics (CAM), gender, locale and socio-
economic status (SES) taken two at a time. In total there are five independent variables out of which four are controllable at a time, the fifth one being used for the purpose of equating groups. Out of these four, the researcher controlled only two variables at a time because if all of them had been controlled, only a very few samples would have been available for analyzing. It would also have reduced the generalisability of the test results. However the selection of class achievement in mathematics and intelligence as controlled variables are the most meaningful in this particular study. But when we have to equate intelligence or achievement groups, we need a third suitable controlled variable. Hence the selection of gender as the third one.

(d) Equated High Intelligence and Low Intelligence groups formed by controlling CAM and Gender

Since the groups are equated on the basis of intelligence, groups having high intelligence and low intelligence are formed from the subjects. Each of the above two groups was divided on the basis of gender. First a pair of boys alone was formed with one from each group (high and low intelligence), who had the same class achievement in mathematics. Different such pairs were formed on the basis of varying class achievement in mathematics. There were 20 such pairs of boys. The processes were repeated for girls also and there were 22 pairs. In total there were 42 pairs of high and low intelligence groups formed by controlling class achievement in mathematics and gender.

The equated groups yielded 42 subjects from each intelligence-based group.

The application of the Test of Significance for equated groups required the correlation between the scores for the compared groups. The correlation between scores was obtained and used for the t-test. Test of Significance for difference
between means of large dependent samples was applied for the data.

(c) **Equated high Class Achievement in Mathematics and low Class Achievement in Mathematics groups formed by controlling Intelligence and Gender.**

Since the groups are equated on the basis of Class Achievement in Mathematics, groups having high Class Achievement in Mathematics and low Class Achievement in Mathematics, are formed from the subjects. Each of the above two groups was divided on the basis of gender. First a pair of boys alone was formed with one from each group (high and low), who had the same intelligence. Different such pairs were formed on the basis of varying intelligence. There were 16 such pairs of boys. The processes were repeated for girls also and there were 18 such pairs. In total there were 34 pairs of high and low Class Achievement in Mathematics groups formed by controlling Intelligence and Gender.

(f) **Equated groups of Boys and Girls formed by controlling Intelligence and Class Achievement in Mathematics**

First the subjects were divided into groups based on gender. The pairs were formed with one from each group (one boy and one girl) having the same intelligence. Out of these pairs only those having the same ‘CAM’ for both members were selected. (This order should be interchanged by first selecting Class Achievement in Mathematics as basis for pair-formation and then selecting Intelligence for the second step.) Thus 72 pairs of boys and girls were formed with each pair having distinct levels of Intelligence and Class Achievement in Mathematics.

(g) **Equated high Socio-Economic Status and low Socio-Economic Status groups formed by controlling Intelligence and Class Achievement in Mathematics**

Since the equated groups were to be formed on the basis of ‘SES’, groups
having high ‘SES’ and low ‘SES’ were formed from the subjects. Then pairs were formed with one from each group having the same intelligence. Out of these pairs, only those having the same Class Achievement in Mathematics for both members were selected. The resultant was 33 pairs of boys and girls with each pair having distinct levels of Intelligence and Class Achievement in Mathematics.

(h) Equated groups of Urban and Rural subjects formed by controlling intelligence and Class Achievement in Mathematics

Since the equated groups were to be formed on the basis of locale, two groups of students hailing from urban and rural areas were formed from the subjects. Then pairs were formed with one from each group having the same Intelligence. Out of these pairs, only those having the same Class Achievement in Mathematics for both members were selected. The resultant is 48 pairs of boys and girls with each pair having distinct levels of Intelligence and Class Achievement in Mathematics.

3.7 STATISTICAL TECHNIQUES

The major statistical techniques used for processing the scores were:

1. Test of Significance for difference between means of large independent samples (for comparison of unselected groups).

2. Test of Significance for difference between means of large dependent samples (for comparison of equated groups).

3. Analysis of Variance (ANOVA) for the comparison of the means of three groups for two basic computational skills (CS Total and CP Total) for comparing the three groups formed on the basis of each independent variable—viz. Intelligence, Class Achievement in Mathematics, Socio-Economic Status and Locale.
4. Factor Analysis-Principal Component Analysis and Varimax Rotations for comparing the factor structures of the computational skill variables (CS and CP variables) of contrasted groups based on Intelligence (above-average intelligence and below-average intelligence), Class Achievement in Mathematics, (above-average mathematics achievement and below-average mathematics achievement), and Socio-Economic Status (above-average socio-economic status and below-average socio-economic status).

**Description of the techniques used**

1. **Test of Significance for difference between means of large independent samples**

For comparison of unselected groups the critical ratio (t) was calculated by using the formula

\[ t = \frac{|M_1 - M_2|}{\sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}} \]

Where \( M_1, \sigma_1, \text{ and } N_1 \) are the mean, S.D and size of the sample of the first group and \( M_2, \sigma_2, \text{ and } N_2 \) are the mean, S.D and size of the sample of the second group respectively. The use of two-tailed tests fixed the critical values at 1.96 and 2.58 respectively for significance at 0.05 and 0.01 levels.

2. **Test of Significance for difference between means of large dependent samples**

For the comparison of equated groups the following formula was used for computing ‘t’:
The estimate of population variance based on the variation between groups is known as the mean square 'between' groups. The estimate of the population variance based on the variation within groups is known as the mean square 'within' groups. The variance ratio, denoted by F is given by the formula

\[ F = \frac{\text{Mean square between groups}}{\text{Mean square within groups}} \]

The calculated value of F is computed with the critical value of F for (K-1, N-K) degrees of freedom (where K is the number of columns and N is the size of the whole group) at 5% and 1% levels of significance.

If the obtained F is significant, then the means are subjected to 't' test, taking two means at a time for this purpose, the standard error of the difference between the two means is calculated using the formula.

\[ SE_D = SD \sqrt{\frac{1}{N_1} + \frac{1}{N_2}} \]

Where SD is computed from 'within group s' variance, \( N_1 \) is the size of the first group and \( N_2 \) is the size of the second group.
\[ t = \frac{D}{SE_D} \]

where \( D \) is the difference between the means of two groups.

For degrees of freedom \((N-2)\), the critical ratio \( t \) is considered from the table at 0.05 level and 0.01 level.

Therefore \( D \) at (0.05) = \( t \) at (0.05) \( \times SE_D \)

\( D \) at (0.01) = \( t \) at (0.01) \( \times SE_D \)

Required \( D \) at (0.05) and \( D \) at (0.01) are compared with actual difference between the means of groups taken two at a time. Accordingly the hypothesis is rejected or accepted.

4. **Factor Analysis-Principal Component Analysis and Varimax Rotations**

Factor analysis is a statistical technique used to identify a relatively small number of factors that can be used to represent the relationships among sets of many inter-related variables. It helps to identify the underlying constructs that are not directly, observable.

The following criteria were used for identifying the factors:

(i) Locate the group of variables on which the factor has the highest loadings.

(ii) Locate the group of variables on which the factor has the lowest loadings.

(iii) Examine the possibility of different factors becoming independent (because of the orthogonality associated with the factors).

(iv) Treat factor loadings with absolute values greater than 0.3 as significant and other factor loadings as not significant.

In determining the degree of presence of each of the variable in a factor, the below mentioned criteria have been used. These are
(i) Factor loadings 0.90 and above—extremely high presence of the variable.
(ii) Factor loadings from 0.70 to 0.89—very high presence of the variable.
(iii) Factor loadings from 0.55 to 0.69—considerable presence of the variable.
(iv) Factor loadings from 0.40 to 0.54—variable present to some extent.
(v) Factor loadings from 0.30 to 0.39—variable present but low in degree.
(vi) Factor loadings below 0.30—variable not present.

Negative loadings are considered to indicate the negative of what is represented by the variable in the factor.

3.8 SUMMARY OF METHODOLOGY

The methodology used in the present research programme is summarized in the following flow chart for clarity and easy reference.
Flow chart showing summary of methodology

Variables

Independent Variables

- Intelligence
- CAM
- Gender
- SES
- Locale

Dependent Variables

- Computational Skills
  - Computational Speed
  - Computational Power
  - Fundamental operations with whole numbers, fractions and decimals

Tools

- Test of Computational Skills
- Test of Intelligence
- General Data Sheet
- SES scale

Sample

- Standard IX students
- N=788

Data collection

Administration of tools

Scoring and consolidation

Data Analysis

- Mean difference analysis for unselected groups and equated groups
- ANOVA
  - One way classification
- Factor analysis

Results and Interpretation