CHAPTER - III

RESEARCH DESIGN

3.1 INTRODUCTION

Design is the heart of any research. In this chapter, samples for study, their procedure, the variables used in the study, the sources and methods of gathering data, tools used for collecting the data, the reliability of the tools selected or constructed and the statistical procedures adopted in the analysis are described.

3.2 STATEMENT OF THE PROBLEM

GENDER DIFFERENCES IN MATHEMATICAL ABILITY AMONG HIGH SCHOOL STUDENTS IN SALEM.

3.2 (a) Operational Definitions of terms

Gender differences

Gender differences in this study refer to the cognitive differences, affecting differences and psychomotor ability differences that are found among the two sexes."

The cognitive differences refer the 'cognitive constructs' viz. academic achievement, spatial visualization ability and logical reasoning ability' of boys and girls.
The affective differences refer to the 'Attitude towards mathematics, value for mathematics and attributional styles of the sexes.

The psychomotor differences indicate the 'Drawing skills and modeling skills' of the boys and girls.

Thus in this study, Gender differences does not indicate the sex differences in the Biological sense but in the intellectual abilities.

**Mathematical Ability**

Mathematical ability is the ability to solve various sorts of problems which are generally determined by many conditions and thus mathematical ability can be defined as the ability to understand the nature of mathematical problems, its symbols, methods and proofs to learn them, to retain in the memory and to reproduce them.

Mathematical ability was defined by Krutetskii as "Individual psychological characteristics that answer the requirements of school mathematical activity and that influence success in the creative mastery of mathematics as a school subject in particular a relatively rapid, easy and thorough mastery of knowledge, skills and habits in mathematics".

**High School students**

High school students in this study refer to Boys and Girls who are in standard VI and standard IX of the secondary level.

VI standard students were also included, because they have joined in the high schools after completing the primary education IX
standard students were selected as they have just entered into the secondary level. The students of VI and IX classes represent the high school students.

Salem

'Salem' is a 'Corporate city' and it is in Tamil Nadu, India, 'Salem' indicate the 'Educational District Salem'. Salem Educational District covers the rural areas of geographical Salem District and few rural areas of the neighbouring districts also.

3.3 OBJECTIVES OF THE STUDY

1. To measure the mathematical ability of high school students in cognitive, affective and psychomotor outcomes.

2. To find out the gender differences of high school students in mathematical ability in cognitive, affective and psychomotor outcomes.

3. To study the interactive effect of gender differences in the cognitive, affective and psychomotor outcomes.

4. To find the relation that may exist in the mathematical ability of high school students in the cognitive, affective and psychomotor outcomes.

5. To find the factors that lead to gender differences in mathematical ability.
3.4 MAJOR HYPOTHESES OF THE STUDY

1. There is interaction between sex and mathematical ability.
   a. There is interaction between sex and cognitive mathematical ability based on the sub samples.
   b. There is interaction between sex and affective mathematical ability based on the sub samples.
   c. There is interaction between sex and psychomotor mathematical ability based on the sub samples.
   d. There is interaction between sex and mathematical ability based on the sub samples.

2. Boys and girls differ in their mathematical ability.
   a. Boys and girls of VI standard differ in their mathematical ability.
   b. Boys and girls of IX standard differ in their mathematical ability.

3. Boys and girls differ in their mathematical ability in the cognitive, affective and psychomotor outcomes.
   a. Boys and girls differ in the subcomponents of cognitive constructs.
   b. Boys and girls differ in the subcomponents of affective objectives.
   c. Boys and girls differ in the subcomponents of psychomotor skills.
4. Boys and girls of VI standard differ in their mathematical ability in the cognitive, affective and psychomotor outcomes.

5. Boys and girls of IX standard differ in their mathematical ability in the cognitive, affective and psychomotor outcomes.

6. Boys and girls of VI standard differ in their mathematical ability in the cognitive constructs of the samples based on the sub-samples.
   a. Types of school
   b. Locality
   c. Medium of instruction
   d. Management of school
   e. Birth order

7. Boys and girls of VI standard differ in their mathematical ability in the affective objectives of the samples based on the sub samples.
   a. Types of school
   b. Locality
   c. Medium of instruction
   d. Management of school
   e. Birth order

8. Boys and girls of VI standard differ in their mathematical ability in psychomotor skills of the samples based on the sub samples.
   a. Types of school
   b. Locality
   c. Medium of instruction
   d. Management of school
   e. Birth order
9. Boys and Girls of IX standard differ in their mathematical ability in cognitive constructs of the samples based on the sub samples.
   a. Types of school
   b. Locality
   c. Medium of instruction
   d. Management of school
   e. Birth order

10. Boys and Girls of IX standard differ in their mathematical ability in the affective objectives of the samples based on the sub samples.
    a. Types of school
    b. Locality
    c. Medium of instruction
    d. Management of school
    e. Birth order

11. Boys and Girls of IX standard differ in their mathematical ability in psychomotor skills of the samples based on the sub samples.
    a. Types of school
    b. Locality
    c. Medium of instruction
    d. Management of school
    e. Birth order

12. There is relation in the mathematical ability of high school students in three domains.
12(a). There is relation in the mathematical ability of VI standard students in the three domains.

12(b). There is relation in the mathematical ability of IX standard students in the three domains.

13. There is association between attributional styles and mathematical ability.
   a. There is association between attributional styles and cognitive constructs.
   b. There is association between attributional styles and affective objectives.
   c. There is association between attributional styles and psychomotor skills.

14. There is association between sex and attributional style.
   a. There is association between sex and attributional style of VI standard students.
   b. There is association between sex and attributional style of IX standard students.

3.5 VARIABLES SELECTED FOR THE STUDY

a. Types of Schools

Types of schools refer to the different Boards of Secondary Education namely the Tamil Nadu State Board of Secondary Education, Matriculation Board of Secondary Education and Central Board of Secondary Education. The syllabi of these boards differ much. It is
believed that the performance ability of the pupils in these schools differ from one another due to various factors. Hence this variable is included in this study.

b. Locality

There are many factors in the social environment of an individual, which affect his attitude and achievement in a subject. Lalithamma (1975) has concluded that urban pupils were found to be superior to rural pupils in their achievement in Mathematics. Kolhe (1985) compared boys and girls of urban and rural population on attitude towards Mathematics and indicated significant differences between the attitudes of urban and rural students towards Mathematics irrespective of sex. The above studies indicate that an individual may differ with locality he comes from, as there are a lot of differences in socialisation process between rural and urban localities.

c. Medium of Instruction

Education imparted through the mother tongue enables the pupils to acquire knowledge with facility to express themselves clearly and to think with precision and vigour. Learning through foreign language compels the students to concentrate on cramming instead of mastering the subject matter. Language plays a vital role in the life of a nation, with the introduction of western culture, learning English is regarded as social prestige. At present, as English is also offered as medium of instruction, apart from the mother tongue in all the Tamil Nadu State
Board High Schools and much competition and craze prevails among the pupils and their parents to get education through English, medium of instruction is also taken into consideration in the present study. The influence of medium of instruction is also studied.

d. Management of Schools

Government schools, Corporation schools, Municipal schools, and Private schools were taken into study. Different managements do have influence on the performance of the pupils. In Government, Corporation and Municipal schools, nearly 75% of pupils are from the lower strata socio-economic status families while in Self-financing schools; nearly 75% of pupils are from high strata socio-economic status families. In Private Aided schools, pupils from all types of socio-economic status will be studying. According to the type of management, the institutional climate also varies. The quality of education imparted also differs. Hence this component is also taken into consideration in the present study.

e. Birth order

The filial order of the sample is also taken up in the study. The filial order of the sample is classified as first born, middle born, last born and single children. As far as abilities in Mathematics is concerned, many studies have revealed that the filial order does play a vital role in the performance in Mathematics. Hence this variable is also taken up.
f. Age

Studies done in mathematical ability and performance in mathematics have shown that age factor also plays a vital role in the performance in mathematics. Many researches done in mathematical ability have reported that the performance of the students differ due to the age factor. During childhood, the preference and performance of students follow a pattern. During adolescence, their preferences and performance varies. The present study aims to focus on age factor and its influence on mathematical ability. To differentiate the age; from classes VI and IX, the samples are selected.

g. Gender

Once women were considered weaker of the two sexes. Now they have taken up dual function of making a career and managing the household. This is likely to evolve different pattern personality and motivational forces influencing their achievement compared to their male counterparts. Evolutionary theory considered the male to have been shaped for thought and creativity, the females for reproduction. Many researches were done to find the variability within and between sexes. It is to be noted that the magnitude of sex differences varies from study to study. When studies look for sex differences in specific mathematical abilities, they use measures, which demand a range of different abilities. The various studies looking at the 'quantitative abilities' of males and females have shown conflicting results. The effect
of gender in mathematical abilities in Indian context is to be studied in the present study.

The seven independent variables are briefly explained. The study focuses on the effect of these independent variables on the selected dependent variables, namely, the mathematical ability in the cognitive, affective and psychomotor outcomes.

**Mathematical abilities in the cognitive constructs**

In the cognitive constructs i) achievement in Mathematics, ii) achievement in different subject areas, iii) achievement in objectives of cognitive domain such as knowledge, understanding and application iv) spatial visualization verbal ability and logical reasoning were the dependent variables selected.

**Affective outcomes**

In the affective outcomes, i) the value for the power of mathematics ii) Attitude towards mathematics and iii) Attributional styles were the three dependent variables selected.

**Psychomotor skills**

In the psychomotor domain, the skills in i) drawing mathematical figures ii) preparing mathematical models were the two dependent variables selected.
3.6 SAMPLE SELECTED

The present study is normative survey type. The sample was
chosen by using the stratified random sampling technique. 500 samples
were selected. They represented all the selected independent variables
namely, gender, types of schools, management of schools, medium of
instruction, gender, birth order and age. The sample details are shown
below.
### TABLE - 1

**SAMPLE DETAILS**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Types of Schools</th>
<th>Management</th>
<th>Locality</th>
<th>Medium of Instruction Tamil</th>
<th>Type</th>
<th>Gender</th>
<th>VI</th>
<th>IX</th>
<th>Total</th>
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<td>Corporation</td>
<td>Urban</td>
<td>Tamil</td>
<td>Girls</td>
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<td>English</td>
<td>Girls</td>
<td>10</td>
<td></td>
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<td>Urban</td>
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<td></td>
<td></td>
<td>Girls</td>
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<td>Tamil</td>
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<td></td>
<td>Girls</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Figure - 1a and 1b)
Figure - 1

BIRTH ORDER OF THE SAMPLE

[type of schools of the sample]

TYPE OF SCHOOLS OF THE SAMPLE

State

Central

Matric
Figure - 1a

MANAGEMENT OF SCHOOLS OF THE SAMPLE

Corporation

Private

Government

LOCALITY OF SCHOOLS OF THE SAMPLE

Rural

Urban
## TABLE - 2

**SAMPLE DETAILS BASED ON SELECTED VARIABLES**

<table>
<thead>
<tr>
<th>Birth Order</th>
<th>Type of School</th>
<th>Management</th>
<th>Locality</th>
<th>Medium</th>
<th>Gender</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a</td>
<td>(i)</td>
<td>R</td>
<td>E</td>
<td>B</td>
<td>VI</td>
</tr>
<tr>
<td>2</td>
<td>b</td>
<td>(ii)</td>
<td>U</td>
<td>T</td>
<td>G</td>
<td>IX</td>
</tr>
<tr>
<td>3</td>
<td>c</td>
<td>(iii)</td>
<td>E</td>
<td>T</td>
<td>B</td>
<td>VI</td>
</tr>
<tr>
<td>4</td>
<td>(i) Government</td>
<td>R</td>
<td>E</td>
<td>T</td>
<td>B</td>
<td>IX</td>
</tr>
<tr>
<td>5</td>
<td>(ii) Corporation</td>
<td>U</td>
<td>T</td>
<td>B</td>
<td>G</td>
<td>VI</td>
</tr>
<tr>
<td>6</td>
<td>(iii) Private</td>
<td>E</td>
<td>T</td>
<td>B</td>
<td>G</td>
<td>IX</td>
</tr>
</tbody>
</table>

1) First Born  
2) Middle  
3) Last Born  
4) Single Child
3.7 TOOLS USED

A personal data sheet was given to each sample which collected details of the sample on i) sex, ii) age, iii) class studying at, iv) type of school, v) management of school, vi) locality, vii) medium of instruction, viii) birth order, ix) parental education level, x) monthly income, and xi) employment details of the parents.

To measure the cognitive constructs, i) an achievement test in mathematics was conducted ii) an objective test paper to test the spatial visualization ability, visual ability and logical reasoning was given.

3.7.1 ACHIEVEMENT TEST PAPERS IN MATHEMATICS

In order to test the achievement of the samples in Mathematics, an achievement test was conducted. The content was the previous class Mathematics syllabus (i.e.,) for IX standard samples; the achievement test was on VIII standard Mathematics syllabus. For VI standard samples, the test content area was V standard Mathematics syllabus. In order to select the content area and types of question, ‘Sainik Schools Entrance Examinations Question Papers’ were referred to. The two test papers; administered to measure the cognitive constructs were prepared by the Investigator.
3.7.1(a) DETAILS OF ITEMS IN THE ACHIEVEMENT TEST PAPERS

The achievement test papers of both the classes consisted of twenty questions each for 50 marks. These questions were selected from Sainik Schools Entrance Examination Question Papers. The content area included arithmetic, algebraic and geometrical problems. The questions tested either knowledge or understanding or application level objectives. Time to given to take up the test was 1½ hours.

3.7.2 TEST PAPER TO TEST THE SPATIAL VISUALIZATION, VERBAL ABILITY AND LOGICAL REASONING ABILITY

The spatial visualization ability question paper consisted of two parts. Each part had 5 questions for both the classes. The first part questions were of three dimensional/rotational, transformational effect type, while the second part consisted of questions of field independence type. Each question carried one mark.

Logical reasoning ability test paper for both the classes consisted of five questions. Each question carried two marks. To complete this paper 30 minutes were given.

3.7.2 (a) INVENTORY OF MEASURING VALUE FOR THE POWER OF MATHEMATICS

Attitude towards mathematics’ was measured using a 20 items attitude scale of ‘Likert type’, with three point scoring system for each (agree, no opinion and disagree). An inventory for measuring the ‘value
for the power of mathematics consisted of 20 items, for each of which the student was required to respond by putting a ‘✓’ against one of the three categories - agree, no opinion, disagree. These two scales are standardised tools.

The investigator prepared a tool namely, a questionnaire on ‘attributional style’. It contained fifteen statements of completion type. The samples have to fill in the blanks with the suitable words given by the investigator.

3.7.3 TOOLS USED TO MEASURE THE PSYCHOMOTOR SKILLS

To measure the psychomotor skills; the investigator prepared a test paper which tested the skills of the students in (i) drawing mathematical figures and (ii) preparing mathematical models.

The test paper consisted of five items in each of the above skills.

3.7.4 STANDARDISATION OF THE TOOLS

The achievement test papers were standardized by the investigator.

3.7.4.1 (a) ITEM ANALYSIS OF ACHIEVEMENT TEST PAPER

The original draft of the test paper consisted of 50 items for both the classes. A sample of 40 students was selected and to them the test was conducted. By group try- out method; item analysis was done. Only the items, which had positive discriminatory index and difficulty level
25-75 were selected. The questions that did not have positive discriminating index and difficulty levels <25 and >75 were deleted. The final draft of the test paper was prepared. The question papers were both in English version and Tamil version. The final draft of achievement test paper consisted of 20 questions. They were from the content areas arithmetic, algebra and geometry which tested either knowledge, understanding or application level objective. The test papers were based on blue prints (Enclosed as Appendix 1-A).

3.7.4.1 (b) VALIDITY AND RELIABILITY OF THE ACHIEVEMENT TEST

The test papers were circulated to mathematics teacher educators and mathematics P.G. Assistants to establish the face validity and Content Validity.

The reliability of the test papers was established by means of test-re-test method. The English version and Tamil version of the test papers were administered on pilot samples of 40 each. (i.e.) English medium and Tamil Medium students; the same test was conducted to the sample selected after a period of fifteen days. Then reliability co-efficient for each of the test was calculated. The same procedure was adopted for both the classes. For IX Standard the reliability co-efficient for English version was 0.843 and for Tamil version was 0.851. for VI Standard; the reliability co-efficient for English version was 0.821 and
for Tamil version was 0.819. The reliabilities of the English and Tamil Version of the tests were assumed to indicate test equivalence.

3.7.4.2 STANDARDIZATION OF TEST PAPER ON SPATIAL VISUALIZATION ABILITY AND LOGICAL REASONING ABILITY

The first draft of this test paper consisted of 15 items. A pilot study was conducted on the selected 40 samples. Based on their performance, item analysis was done. After deleting the items that were very easy and very difficult and items with negative and zero discriminatory indices, the final draft was prepared. It consisted of 10 items. The validity of the final draft was established by showing them to mathematical experts. Thus their face, content and predictive validities were established. By test-re-test method, reliability was established. The reliability of test paper of Class VI-English version was 0.784 and Tamil version was 0.768. For class-IX - English version was 0.812 and Tamil version was 0.82. To test the logical reasoning ability of the students of the both the classes, investigator prepared a question paper consisting of five logical reasoning ability (verbal) testing questions. When this question papers was administered to the samples on the pilot study it was found that the items had moderate difficulty level and with positive discriminative index. Hence the items were retained has such. The content and space validity of this paper was established from Jury opinion has 0.712 and 0.801 respectively. (Enclosed as Appendix - 1B).
3.7.4.3 STANDARDIZATION OF TOOLS ON AFFECTIVE OUTCOME

The investigator constructed a tool to measure the 'attributional styles' of the sample. The tool is a questionnaire. It consisted of 15 statements. The tool was shown to experts to determine its values. Reliability was established by means of Test-re-test method and was found for English version as 0.736 and for Tamil version as 0.751 (Enclosed as Appendix 1-c).

The other two tools were standardized tools. The attitude scale and the inventory to measure the value for the power of mathematics were the tools prepared and used by P.V. Meenakshi Ammal (Tools used in the paper presented by her at Cornell University, New York, 1987). (Enclosed as Appendix 1-D and Appendix 1-E)

3.7.4.4 TOOLS ON PSYCHOMOTOR SKILLS

To measure the psychomotor skills of the samples, the investigator constructed a tool for both the classes. The tools consisted of two parts. The first part tested the drawing skills of the samples while the second part tested their ability to construct mathematical models.

Both the test papers consisted five questions in each part. 30 minutes were given to take up this test.
3.7.4.4 (1) STANDARDIZATION OF TOOLS ON PSYCHOMOTOR SKILLS

The investigator prepared a test paper each for both the classes. The first draft consisted of 10 questions each in two parts. A pilot study was made on the selected samples. Based on their performances item analysis was done. The final draft was prepared consisting of 5 questions in each part. The final version was translated into Tamil also. The papers were circulated to experts and validity was established. By test-re-test method, the reliability was also established. For Class IX English version - reliability co-efficient was 0.804 while the reliability of Tamil version paper was 0.821. For Class VI; the English version paper had the reliability of 0.732 and the Tamil version had 0.764. (Enclosed as Appendix 1-F).

3.8 ADMINISTRATION OF THE TOOL

The investigator went to all the selected schools and administered all the six tools. After introduction; the samples were asked to clarify their doubts; if any. After that the test papers were given to the students. They were given 3 hours to answer. While taking up the test; no guidance was given to the samples.
3.9 SCORING PROCEDURE

3.9.1 TOOLS ON COGNITIVE CONSTRUCTS

The test papers were scored by giving full marks to every correct answer that was found. The total possible marks in achievement test was 50 the minimum possible score was zero.

In the spatial visualization and logical reasoning ability test also; the total possible score was 10 and minimum possible score was 0. To take up the each of these tools 10 minutes time was allotted.

3.9.2 TOOLS ON AFFECTIVE OUTCOME

For the three point attitude scale and inventory, for each agree, not decided and disagree scores given for positive statements were 3, 2 and 1 respectively. For negative statements the scores were 1, 2 and 3 respectively. The maximum possible scores were 60 and minimum possible score was twenty.

The tool on attributional style was just classified into four categories namely i) attribution to luck ii) ability iii) hard work iv) elders.

3.9.3 TOOLS ON PSYCHOMOTOR SKILLS

For each correct answer five marks were given. Hence the maximum possible score was 50. While, the minimum possible score was zero.
3.10 RESEARCH DESIGN

Independent Variables Selected

1. Types of schools - A
   - A1 - State Board
   - A2 - Matriculation Board
   - A3 - Central Board

2. Locality - B
   - B1 - Urban
   - B2 - Rural

3. Medium of Instruction - C
   - C1 - English
   - C2 - Tamil

4. Management of Schools - D
   - D1 - Corporation
   - D2 - Government
   - D3 - Private Aided
   - D4 - Private Unaided

5. Birth Order - E
   - E1 - First Born
   - E2 - Middle Born
   - E3 - Last Born
   - E4 - Single

6. Class - F
   - F1 - Class VI
   - F2 - Class IX

7. Gender - G
   - G1 - Male
   - G2 - Female
Dependent Variables Selected

I. Mathematical Ability - W

II. Cognitive Constructs - Z

$Z_1$ - Academic Achievement  
$Z_{1K}$ - Knowledge  
$Z_{1Ar}$ - Arithmetic

$Z_2$ - Spatial Visualization  
$Z_{1U}$ - Understanding  
$Z_{1Al}$ - Algebra

$Z_3$ - Logical Reasoning  
$Z_{1Ap}$ - Application  
$Z_{1G}$ - Geometry

III. Affective Outcomes - Y

$Y_1$ - Attitude

$Y_2$ - Value for Mathematics

$Y_3$ - Attributional Style

IV. Psychomotor Skills - X

$X_1$ - Drawing skills

$X_2$ - Modeling skills

TABLE - 3

RESEARCH DESIGN

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Category Tested</th>
<th>Test used</th>
<th>Design</th>
<th>Sub hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Interaction between Sex &amp; Mathematical Ability</td>
<td>'f'</td>
<td>GW</td>
<td>GWY, GWX</td>
</tr>
<tr>
<td>1a.</td>
<td>Interaction of Sex &amp; Cognitive Ability based on sub samples</td>
<td>'f'</td>
<td>GZF</td>
<td>GZFA, GZFB, GZFC, GZFB, GZFE,</td>
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<tr>
<td>1b.</td>
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<td>GYFA, GYFB, GYFC, GYFB, GYFE,</td>
</tr>
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<td>1c.</td>
<td>Interaction of Sex &amp; Psychomotor skills based on sub samples</td>
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<td>GXF</td>
<td>GXFA, GXFB, GXFC, GXFB, GXFE,</td>
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<td>Interaction of Sex &amp; mathematical ability based on sub samples</td>
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<td>GW</td>
<td>GWF, GWA, GWB, GWC, GWD, GWE</td>
</tr>
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<td>2.</td>
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<td>3.</td>
<td>Boys and Girls differ in Mathematical ability in Cognitive, Affective and Psychomotor outcomes</td>
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<td>$G_1WX, G_1WY, G_1WZ, G_2WX, G_2WY, G_2WZ,$</td>
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166
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<th>Difference in Mathematical ability of VI Boys &amp; Girls in Cognitive, Affective and Psychomotor outcomes</th>
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<td>11.</td>
<td>Relation in the mathematical ability of high school student in the three domains</td>
<td>'r'</td>
<td>GW</td>
<td>GWX, GWY, GWZ</td>
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<td>12(a).</td>
<td>Relation in the mathematical ability of VI standard students in the three domains</td>
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<td>13.</td>
<td>Association between attributional style and mathematical ability</td>
<td>χ²</td>
<td>FY₃W</td>
<td>FY₃W₁Y₃, FY₃W₁Y₄, FY₃W₁Y₅</td>
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<td>14.</td>
<td>Association between attributional styles and sex</td>
<td>χ²</td>
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168
3.11 STATISTICS USED

To verify the differential hypotheses 't' test is used. To test the relational hypotheses 'r' test is used. To find the interactive effect; 'F' test is used. To identify the factors that influence mathematical ability factor analysis is done. To study the effect of learners attributional style on mathematical ability $\chi^2$ test was used. To discriminate the from one another discrimination analysis was done. Multiple regression was calculated and equation was found.

3.12 SUMMARY

This chapter presented the Research Design of the present study. The next chapter reports on 'Data Analysis'.