CHAPTER III

PLAN AND PROCEDURE
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3.1. INTRODUCTION

This chapter describes clearly the procedure adopted to conduct the investigation. The entire chapter has been discussed under various sub-headings such as rationale for the study, statement of the problem, hypotheses framed, objectives formulated, locale of research, operationalization and measurement of variables, sampling procedure, techniques of data collection and statistical techniques employed therein.

3.2. RATIONALE FOR THE STUDY

Teaching is an unique and complex activity. It is mysterious in its successes and failures. A peep into the research on teachers and teaching effectiveness conducted during the current century reveals that majority of the studies in this area were directed towards finding out characteristics of effective and ineffective teachers.

An effective teacher is amongst the fore most factors contributing to educational improvement, which is very difficult to achieve. Lakhs of rupees have been spent on committees and commissions in bringing about qualitative improvement in education. As a result workers in the educational field have endeavoured to develop better curriculum, textbooks, teaching aids and techniques of
teaching. But, all in vain, unless schools are staffed with effective teachers.

The importance of an effective teacher in the educational process is, indeed indisputable and it draws the attention of the investigator to what extent, the personal characteristics of teachers like age, marital status, type and nature of the school, teacher pupil ratio, classes handled, medium of instruction, qualification, teachers category, basic pay, experience and teachers' personality dimensions such as dominance, neuroticism, empathy, need-achievement, ego-ideal, introversion, self-confidence dogmatism and pessimism affect their effectiveness in teaching. With this in view, the present study had been undertaken by the investigator.

3.3. SIGNIFICANCE OF THE STUDY

1. The study will throw some light on the characteristics of effective teachers.

2. It will also throw light on the personality dimensions of effective teachers.

3. The study also will provide information on personal characteristics which are directly or indirectly related to the above two.

4. The study also will provide information on characters which discriminate the effective and non-effective teachers.
3.4. STATEMENT OF THE PROBLEM

The study was entitled as "TEACHER EFFECTIVENESS AND PERSONALITY DIMENSIONS OF HIGH AND HIGHER SECONDARY SCHOOL TEACHERS OF V.O.C. DISTRICT IN RELATION TO PUPIL ACHIEVEMENT".

3.5. DEFINITIONS OF THE TERMS

3.5.1. TEACHER

"Teacher is one whose profession is, or whose talents are the ability to impart knowledge, practical skill, or understanding".

- Macdonald (1976)

"The right kind of teacher is one who possesses a vivid awareness of her mission. She not only loves her subject, she loves also those whom she teaches".


3.5.2. EFFECTIVENESS

Effective means having power to effect: causing, something successful in producing a result or effect.


"Teacher effectiveness is an area of research which is concerned with relationship between the characteristics of teachers, teaching acts and their effects on the educational outcomes of classroom teaching".

- Flanders and Simon (1969).
3.5.3. PERSONALITY

"Personality is defined as the pattern of the individual's total behaviour".

- Gestaltist.

3.5.4. PERSONALITY DIMENSIONS

It includes dominance, neuroticism, empathy, need-achievement, ego-ideal, introversion, self-confidence, dogmatism and pessimism of teachers.

3.5.5. HIGH SCHOOL

The term high school is one which is having standards from VI to X.

3.5.6. HIGHER SECONDARY SCHOOL

The term higher secondary school is one which is having standards from VI to XII.

3.5.7. PUPIL ACHIEVEMENT

An achievement test is essentially a tool or device of measurement that helps in ascertaining quantity and quality of learning attained in a subject of study or group of subjects after a period of instruction by measuring the present ability of the individual concerned.

"One important role of assessment of achievement is to guide the day by day decision of the classroom teacher as to what is to be taught, studied by, or practised by child or two or by the class as a whole".

- Thorndike and Hegon.
3.6. OBJECTIVES

1. To measure the teacher effectiveness of High and Higher Secondary School teachers.

2. To assess the personality dimensions of High and Higher Secondary School teachers.

3. To study the demographic variables on teacher effectiveness and personality dimensions of High and Higher Secondary School teachers.

4. To identify the variables which affect teacher effectiveness and personality dimensions of High and Higher Secondary School teachers.

5. To discriminate the factors responsible for effective teaching of high and higher secondary school teachers.

3.7. HYPOTHESES

Following are the major hypotheses formulated in the study.

1. Teachers of different age groups will not differ in their Teacher Effectiveness Dimensions Index (TEI), Personality Dimensions Index (PDI), Teacher Effectiveness Score (TES) and Teachers Level (TELE).

2. Teachers of different sex will not differ in their Teacher Effectiveness Dimensions Index (TEI), Personality Dimensions Index (PDI), Teacher Effectiveness Score (TES) and Teachers Level (TELE).

3. Teachers of different marital status will not differ in their Teacher Effectiveness Dimensions Index (TEI),
Personality Dimensions Index (PDI), Teacher Effectiveness Score (TES) and Teachers Level (TELE).

4. Teachers of different caste (FC, BC, MBC and SC) will not differ in their Teacher Effectiveness Dimensions Index (TEI), Personality Dimensions Index (PDI), Teacher Effectiveness Score (TES) and Teachers Level (TELE).

5. Teachers of different type of the school (Boys, Girls and Co-education) will not differ in their Teacher Effectiveness Dimensions Index (TEI), Personality Dimensions Index (PDI), Teacher Effectiveness Score (TES) and Teachers Level (TELE).

6. Teachers of government and private school will not differ in their Teacher Effectiveness Dimensions Index (TEI), Personality Dimensions Index (PDI), Teacher Effectiveness Score (TES) and Teachers Level (TELE).

7. Teachers who are teaching through different medium of instruction will not differ in their Teacher Effectiveness Dimensions Index (TEI), Personality Dimensions Index (PDI), Teacher Effectiveness Score (TES) and Teachers Level (TELE).

8. Teachers of different category Secondary Grade (SG), B.T. Assistant (BT), P.G. Assistant (PG) will not differ in their Teacher Effectiveness Dimensions Index (TEI), Personality Dimensions Index (PDI), Teacher Effectiveness Score (TES) and Teachers Level (TELE).
9. Teachers of Arts and Vocational, Science and Vocational, Language and Vocational, Mathematics and Vocational, Arts and Science, Language and Arts, Arts and Mathematics, Science and Language, Science and Mathematics, Language and Mathematics will not differ in their Teacher Effectiveness Dimensions Index (TEI), Personality Dimensions Index (PDI), Teacher Effectiveness Score (TES) and Teachers Level (TELE).

10. Teachers of different range of experience will not differ in their Teacher Effectiveness Dimensions Index (TEI), Personality Dimensions Index (PDI), Teacher Effectiveness Score (TES) and Teachers Level (TELE).

11. Teachers of high and higher secondary schools will not differ in their Teacher Effectiveness Dimensions Index (TEI), Personality Dimensions Index (PDI), Teacher Effectiveness Score (TES) and Teachers Level (TELE).

3.8. LOCATION

V.O.C. district is located in the south eastern side of Tamil Nadu. It is situated between the latitudes 8.65° and 9.30° in the north and longitudes 77.05° and 78.25° in the east. The district is bound on the north by Virudhunagar district, on the south by Kanyakumari district, on the east by Gulf of Mannar and on the west by Nellai district. The district map is given in figure 3.1. The map also shows that the places where the samples were taken.
Figure 3.1: Map of V.O.C. District in the State of Tamil Nadu

Bay of Bengal
3.9. POPULATION

The teachers who are working in the high and higher secondary schools adopting Tamil Nadu State Board Syllabus in V.O.C. district constituted the population. As per Government order M.S.No.618 dated 01.07.97, V.O.C. district was renamed as Tuticorin District.

3.10. SAMPLE FOR THE STUDY

Selection of sample is an important aspect of the descriptive research. The sample should be so selected as to enable one to draw meaningful conclusions and generalizations. Sample should represent the population and would also be adequate enough to achieve the ultimate objectives. In order to realise this purpose, the researcher adopted the following procedure.

Using random numbers, twenty five per cent of the schools available in V.O.C. district were selected at random and the total comes to thirty five schools. In each school all the teachers engaged in teaching languages, mathematics, science, arts and vocational were taken as the respondents. A total of seven hundred sixteen teachers were interviewed with the help of a pre-tested questionnaire. The schools selected were shown in Appendix. Categorywise distribution of the sample is shown in Table I.
## TABLE I

**CATEGORYWISE DISTRIBUTION OF THE SAMPLE**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Category</th>
<th>Variables</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age</td>
<td>Younger age</td>
<td>147</td>
<td>20.53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium age</td>
<td>437</td>
<td>61.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aged</td>
<td>132</td>
<td>18.44</td>
</tr>
<tr>
<td>2</td>
<td>Sex</td>
<td>Male</td>
<td>263</td>
<td>36.73</td>
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<td></td>
<td></td>
<td>Female</td>
<td>453</td>
<td>63.27</td>
</tr>
<tr>
<td>3</td>
<td>Marital status</td>
<td>Married</td>
<td>665</td>
<td>92.88</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unmarried</td>
<td>51</td>
<td>7.12</td>
</tr>
<tr>
<td>4</td>
<td>Caste</td>
<td>FC</td>
<td>95</td>
<td>13.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BC</td>
<td>473</td>
<td>66.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MBC</td>
<td>113</td>
<td>15.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SC</td>
<td>35</td>
<td>4.89</td>
</tr>
<tr>
<td>5</td>
<td>Type of School</td>
<td>Boys</td>
<td>264</td>
<td>36.87</td>
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<tr>
<td></td>
<td></td>
<td>Girls</td>
<td>302</td>
<td>42.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Co-education</td>
<td>150</td>
<td>20.95</td>
</tr>
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<td>6</td>
<td>Nature of the school</td>
<td>Government</td>
<td>219</td>
<td>30.59</td>
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<tr>
<td></td>
<td></td>
<td>Private</td>
<td>497</td>
<td>69.41</td>
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<td>7</td>
<td>Medium of Instruction</td>
<td>Tamil</td>
<td>590</td>
<td>82.40</td>
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<td></td>
<td></td>
<td>English</td>
<td>46</td>
<td>6.43</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Both (Tamil &amp; English)</td>
<td>80</td>
<td>11.17</td>
</tr>
<tr>
<td>8</td>
<td>Teachers Category with respect to subject</td>
<td>Languages</td>
<td>238</td>
<td>33.24</td>
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<tr>
<td></td>
<td></td>
<td>Mathematics</td>
<td>41</td>
<td>5.73</td>
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<tr>
<td></td>
<td></td>
<td>Science</td>
<td>289</td>
<td>40.36</td>
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<td></td>
<td></td>
<td>Arts</td>
<td>126</td>
<td>17.60</td>
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<td></td>
<td></td>
<td>Vocational</td>
<td>22</td>
<td>3.07</td>
</tr>
<tr>
<td>9</td>
<td>Teachers Category</td>
<td>S.G.</td>
<td>222</td>
<td>31.00</td>
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<tr>
<td></td>
<td></td>
<td>B.T.</td>
<td>282</td>
<td>39.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P.G.</td>
<td>212</td>
<td>29.61</td>
</tr>
<tr>
<td>10</td>
<td>Teachers experience</td>
<td>Below 5 years</td>
<td>114</td>
<td>15.92</td>
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<tr>
<td></td>
<td></td>
<td>6 -10 years</td>
<td>140</td>
<td>19.55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11-15 years</td>
<td>128</td>
<td>17.89</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16-20 years</td>
<td>141</td>
<td>19.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above 20 years</td>
<td>193</td>
<td>26.95</td>
</tr>
<tr>
<td>11</td>
<td>Schools</td>
<td>High school</td>
<td>28</td>
<td>3.91</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Higher secondary</td>
<td>688</td>
<td>96.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>716</td>
<td>100.00</td>
</tr>
</tbody>
</table>

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3.11. SELECTION OF VARIABLES

For this study thirteen independent variables and four dependent variables viz. Teacher Effectiveness Dimensions Index (TEI), Personality Dimensions Index (PDI), Teacher Effectiveness Score (TES) and Teachers Level (TELE) of teachers were selected.

For the present study the investigator used the following independent variables viz.

3.12. INDEPENDENT VARIABLES

3.12.1. AGE

It is the number of years completed by the respondent and it is denoted by \( X_1 \).

3.12.2. MARITAL STATUS

The respondents were classified into two categories viz.

i) Married and

ii) Unmarried.

For the purpose of analysis the married were given the score one, unmarried were given the score two. This variable is denoted by \( X_2 \).

3.12.3. CASTE

The respondents were classified into four categories on the basis of their community viz.
(i) Forward Caste (FC) - People who are supposed to be in the higher stratum in the society.

(ii) Backward Community (BC) - people who are occupying position next to the forward community.

(iii) Most Backward Class (MBC) - people who are occupying just below the backward community.

(iv) Schedule Caste (SC) - people who are in the lowest stratum in the society.

For the purpose of analysis the FC were given the score four, BC were given the score three, MBC were given the score two, and the SC were given the score one. This variable is denoted by $X_3$.

3.12.4. TYPE OF THE SCHOOL

The selected schools were classified into three types viz.

(i) Girls school - consisting of girls only.

(ii) Boys school - consisting of boys only and

(iii) Co-Education school - consisting of boys as well as girls in any proportion.

For the purpose of analysis the girls school were given the score three, boys school were given the score two, and the co-education schools were given the score one. This variable is denoted by $X_4$. 
3.12.5. NATURE OF THE SCHOOL

The schools were divided into two types viz.
1. Government school - Government school is one which comes under the direct control of the state government.
2. Private school - Private school is one which is under the control of the private persons or schools run by private bodies.

For the purpose of analysis the Government schools were given the score one and the private schools were given the score two. This variable is denoted by $X_5$.

3.12.6. CLASSES HANDLED BY THE TEACHER

In high schools, there are classes from VI to X whereas in higher secondary schools there are classes from VI to XII. A teacher is expected to handle one or more of these standards. The variable refers to the standards taught by the teachers. This variable is denoted by $X_6$.

For the purpose of analysis averages of the standards to which the teacher taught was taken.

3.12.7. TEACHER PUPIL RATIO

It is a number of students per teacher in any class room. This variable is denoted by $X_7$.

3.12.8. MEDIUM OF INSTRUCTION

The respondents were classified into three categories viz.
i. Teachers who are teaching the subjects through Tamil (mother tongue).

ii. Teachers who are teaching the subjects through English.

It is the language through which subjects are taught to the students in our state. The students are taught either in mother tongue (Tamil) or through English. The teachers may handle either one or both types.

In our study teachers teaching through Tamil only is given the score one. Those teaching through both is given the score two and those teaching through English alone is given the score three. This variable is denoted by $X_8$.

3.12.9. TEACHERS QUALIFICATION

This includes the possession of degrees such as Secondary grade, B.A., B.Sc, B.Com, M.A, M.Sc, M.Com, B.Ed, M.Ed, M.Phil., by the respondents. It is the educational training undergone by a teacher. The number of years needed to obtain the degree and training is taken as the score value for each individual. This variable is denoted by $X_9$.

3.12.10. TEACHERS CATEGORY

Three types of teachers are employed in high and higher secondary schools. They are

1. Secondary Grade - teachers who passed standard XII examination and taken two years teacher training course. They were given the score one.
2. B.T. Assistant - teachers with Bachelor degree and one year teacher training degree on education. They were given the score two.

3. P.G. Assistant - teachers with the Post graduate degree with one year teacher training degree on education. They were given the score three. This variable is denoted by $X_{10}$.

3.12.11. TEACHERS BASIC PAY

It is the basic salary drawn by the individual teacher.

This variable is represented by $X_{11}$.

3.12.12. TEACHERS EXPERIENCE

Total number of years which a teacher has put in teaching various classes is called teachers experience and the number of years is taken as the score value for each individual. This variable is represented by $X_{12}$.

3.12.13. SEX

The respondents were classified into two categories viz. male and female.

For the purpose of analysis the female were given the score two and male were given the score one. This variable is denoted by $X_{13}$. 
3.13. DEPENDENT VARIABLE

"The dependent variable is response variable or output. It is an observed aspect of the behaviour of an organism that has been stimulated".


The dependent variable is that factor which is observed and measured to determine the effect of the independent variables.

In this investigation, four dependent variables were taken,

1. Teacher Effectiveness Dimensions Index (TEI). It is the average of an individual's total score and multiplied by hundred. Teacher effectiveness dimensions includes personal characteristics, subject matter, methodology, audio-visual aids, communication, discipline and evaluation.

2. Personality Dimensions Index (PDI). It is the average of an individual's total score and multiplied by hundred. Personality dimensions includes dominance, neuroticism, empathy, need achievement, ego-ideal, introversion, self-confidence, dogmatism and pessimism.

3. Teacher Effectiveness Score (TES). It is the total score obtained by each teacher in all the seven dimensions viz. personal characteristics, subject matter, methodology, audio-visual aids, communication, discipline and evaluation.
4. Teachers' Level (TELE). It is the rating given by the students about their teachers.

3.14. TOOLS

In this investigation two standardised tools were employed to seek information from the teachers of high and higher secondary schools. They were

1. Self made standardised teacher effectiveness scale and

3.15. DESCRIPTION OF THE TOOL

3.15.1. TEACHER EFFECTIVENESS SCALE

The questionnaire on "Teacher effectiveness" was prepared by the investigator for the purpose of collecting information from the teachers. The questionnaire consists of 95 items which contains major required informative aspects essential for the objectives of the research. These items were selected on the basis of previous studies and interviews with thirty high and higher secondary school teachers, ten Headmistresses/Head masters of high and higher secondary schools, five teacher educators and lecturers of psychology. These items belong to the following categories.

1. Personal characteristics of a teacher.
2. Subject matter.
3. Methodology.
4. Audio-visual aids.
5. Communication.

6. Discipline and


These items were again discussed with teachers, principals and teacher educators and seventy nine items were selected and rewritten. The scale with seventy nine items was then administered to two hundred teachers, randomly selected from high and higher secondary schools of V.O.C. District only to test the scale.

3.15.1.1. VALIDITY

The validity index of an item is determined by the extent to which the given item discriminates among examinees who differ sharply in the function measured by the test as a whole. Biserial correlation procedure is used in the item analysis. As a general rule, items with validity indices of .20 or more are regarded as satisfactory. But items with lower indices will often serve, if the test is long. Items showing the validity indices below .20 were discarded. After analysing all the items, 64 items were selected with a validity index of .20 and above.

3.15.1.2. RELIABILITY

The split-half reliability (correlating the odd and even items) of the scale, applying the Spearman-Brown Prophecy formula is found to be 0.859 (N=200):
The test retest reliability of the scale is also studied. It is found to be 0.89 (N=200) with a month interval time.

3.15.1.3. TEACHER EFFECTIVENESS SCALE

The teacher effectiveness scale in its final form consists of 64 highly discriminating items.

3.15.1.4. ADMINISTRATION

The teacher effectiveness scale is a self-administering scale. The purpose of the scale is frankly explained to the subjects. It is assured that their replies would be kept confidential. The subjects were requested to read the instructions carefully and ask the tester if there is any difficulty in the understanding of the instructions. It has been emphasized that no item should be omitted and there is nothing right or wrong about these questions. There is no time limit for the scale.

3.15.1.5. SCORING

All the 64 items of the scale are positively worded. Items are given a score of $+2, +1, 0, -1, -2$ for strongly agree, agree, undecided, disagree and strongly disagree respectively. The sum of the values give the teacher effectiveness score for the subject. The total score ranges from $+128$ to $-128$ showing the highest teacher effectiveness score to least teacher effectiveness score.
3.15.2. MULTIVARIABLE PERSONALITY INVENTORY (B.C. MUTHAYYA 1973)

Multivariable personality inventory was the tool developed by B.C. Muthayya 1973. It showed that nine dimensions were influential in determining the personality of a teacher. The nine dimensions were

1. Dominance.
2. Neuroticism.
3. Empathy.
4. Need-achievement.
5. Ego-ideal.
6. Introversion.
7. Self-confidence.
8. Dogmatism and

There were 50 items which satisfied the requirement of the criteria for the item selection. There were five items on empathy, five items on ego-ideal, six items on pessimism, seven items on neuroticism, six items on introversion, five items on need-achievement, five items on self-confidence, five items on dogmatism, and six items on dominance. The answers for the categories provided were 'Yes' or 'No' for each items.

3.15.2.1. PILOT STUDY

The investigator selected one hundred high and higher secondary school teachers for the pilot study. The questionnaire were given to the teachers and filled in
tools were collected. The questionnaire was modified based on the experiences gathered in the pilot study.

3.15.2.2. VALIDITY

By using the percentages of the high and the low groups answering the item in a given direction, it was possible to find out the validity index of each item from the Planagan’s Table. After analysing all the items, the same fifty items were taken with the validity index of .20 and above.

3.15.2.3. RELIABILITY

The split-half reliability (correlating the odd and even items) of the scale, applying the Spearman - Brown Prophecy formula is found to be 0.8 (N=100).

The test re-test reliability of the scale is also studied. It is found to be 0.89 (N=100) with a month interval of time.

3.15.2.4. SCORING

The answered - categories for the items in the personality inventory were ‘Yes’ or ‘No’ where the former indicates the presence of the variables in the respondent and the latter, the absence of it. A score '1' is given for the presence of the variable. The whole inventory was scored for negative orientation. On the basis of this scoring scheme, the higher the score, greater the prevalence of negatively oriented personality.
3.16. METHOD

Normative survey method was employed to study the teacher effectiveness and personality dimensions of high and higher secondary schools of V.O.C. District. The term normative implies the determination of normal or typical conditions or practices. The term normative survey, is generally used for the type of research that we intend to consider here, the research which proposes to ascertain what is the normal or typical condition or practice at the present time.

3.17. PROCEDURE OF DATA COLLECTION

Before starting the final data collection, appeal with the purpose and objectives of the study was made to all the Headmasters/Headmistresses of the selected high and higher secondary schools, seeking their co-ordination, the process of data collection started in that institution.

The teacher effectiveness scale and multivariable personality inventory were handed over to all the teachers except the special teachers of selected schools. As requested by them, the investigator went to the school after a week, for the collection of the scale and questionnaire.

3.18. DELIMITATION

Every researcher will have certain limitations due to constraints. In this investigation

1. Matriculation schools, Kendriya Vidyalayas, Navodayas, Sainik and C.B.S.E. schools have been excluded.
2. Special teachers have been excluded from the teachers of a selected schools.

3. The study has been confined to the randomly selected high, higher secondary schools of V.O.C. District. Hence the findings will be applicable only to these group of schools.

3.19. STATISTICAL TECHNIQUES USED

3.19.1. SIMPLE CORRELATION

Simple correlation is used to find the strength of relation between two variables. The simple correlation between $x$ and $y$ is being calculated by the formula.

$$ r = \frac{n\Sigma xy - \Sigma x \Sigma y}{\sqrt{n\Sigma x^2 - (\Sigma x)^2} \sqrt{n\Sigma y^2 - (\Sigma y)^2}} $$

where $n$ is the size of the sample and $r$ being tested by the 't' statistic.

$$ t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} $$

which follows the 't' distribution with $(n-2)$ degrees of freedom.

3.19.2. MULTIPLE CORRELATION

Multiple correlation is used to find the maximum association of a set of independent variables on a dependent variable. It is denoted by $R_y(x_1, x_2, \ldots, x_n)$ where $y$ in the dependent variable and $x_1, x_2, \ldots, x_n$ are the set of independent variables. It is calculated by the formula
\[ R = \sqrt{1 - \frac{|P|}{|P_{11}|}} \]

where \( || \) stands for the determinant value, \( P \) is the zero order correlation matrix of \( y, x_1, x_2, \ldots, x_n \) and \( P_{11} \) is the minor of the 1st element in the 1st row.

\[ t = \frac{R \sqrt{K - n}}{\sqrt{1 - R^2}} \]

where \( K \) stands for the size of the sample and \( n \) stands for the number of independent variables.

3.19.3. MULTIPLE REGRESSION ANALYSIS

Multiple regression analysis is used to find the cause and effect relationship.

Linear Multiple regression equation of the form
\[ Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n \]
is used. The principle of least squares is used to estimate the coefficients \( \beta_0, \beta_1 \ldots \beta_n \) and 't' test is used to test the coefficients.

\[ t = \frac{\beta_i}{\sqrt{SE \ \beta_i}} \]

where S.E. stands for the standard error.
3.19.4. PATH ANALYSIS

Path analysis is used to find the direct and indirect effects of the independent variables on the dependent variable. The direct path values P1, P2, ... are obtained by solving the set of simultaneous equation.

The system of simultaneous equations

\[
\begin{align*}
    r_{11} P_1 + r_{12} P_2 + \cdots + r_{1K} P_K &= r_{1Y} \\
    r_{21} P_1 + r_{22} P_2 + \cdots + r_{2K} P_K &= r_{2Y} \\
    \vdots \quad \vdots \quad \ddots \quad \vdots \quad \ddots \quad \vdots \\
    r_{K1} P_1 + r_{K2} P_2 + \cdots + r_{KK} P_K &= r_{KY}
\end{align*}
\]

where \( r_{ij} \) is the simple correlation between \( x_i \) and \( x_j \) and \( r_{iy} \) the simple correlation between \( x_i \) and \( y \). The indirect path of \( x_i \) through \( x_j \) is estimated by \( r_{ij} P_j \) for \( j = 1, 2, \ldots, i = 1, 2 \ldots \).

3.19.5. DISCRIMINANT FUNCTION ANALYSIS

Discriminant function is used to identify the variable which discriminate two given groups. The general problem is to set up a function of the form

\[
Z = \lambda_1 x_1 + \lambda_2 x_2 + \cdots + \lambda_k x_k
\]

where \( x_1, x_2, \ldots, x_k \) are the \( k \) variable measured in both the group and \( \lambda_1, \lambda_2, \ldots + \lambda_k \) are the corresponding weight.
\[ \lambda_1 \sum x_1^2 + \lambda_2 \sum x_1 x_2 + \ldots + \lambda_k \sum x_k x_k = d_1 \]
\[ \lambda_1 \sum x_1 x_2 + \lambda_2 \sum x_2^2 + \ldots + \lambda_k \sum x_k x_k = d_2 \]
\[ \ldots \]
\[ \lambda_1 \sum x_k x_1 + \lambda_2 \sum x_k x_2 + \ldots + \lambda_k \sum x_k^2 = d_k \]

where \( x_i = x_i - \bar{x}_i \)

\[ d_i = \bar{x}_{ai} - \bar{x}_{bi} \]

where \( a \) correspond to the first group and \( b \) correspond to the second group and \( D \) is calculated by.

\[ D = \lambda_1 d_1 + \lambda_2 d_2 + \ldots + \lambda_k d_k \]

\( D \) is tested by the F statistic.

\[ F = \frac{n_a n_b}{(n_a + n_b)} D^2 \]

where \( n_a \) is the size of the sample in the first group and \( n_b \) is the size of the sample in the second group. \( F \) follows the \( F \) distribution with \( K, n_a + n_b - k - 1 \) degrees of freedom.

The ensuing chapter deals with analysis of data.