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CHAPTER - IV

DESIGN OF THE STUDY

4.0 INTRODUCTION:

Planning plays an important role in even a day-to-day activity. It is necessary for any kind of research without which the satisfactory results cannot be achieved. A right planning means the half of the work is completed. The planning should involve certain fundamental steps that are important regardless of the type of research design.

Thus, the importance of planning is emphasised for the process of research work.

In the words of McGruth¹:

'Planning is a mapping strategy'and he puts it...

"The activities related to design in research are comparable to those of the architect in designing an intricate structure. As the architect does his designing before construction and activities get underway. So should the researcher do his designing before he gets his project underway."

The review of literature gives the research worker ideas for improving his procedure and these ideas should be incorporated into his revised research plan.

To complete the work it needs to be well planned otherwise its execution takes a longer period resulting in loss. A good research work can justify it. It includes a number of operations carried out with patience and accuracy for such a serious work. Planning requires utmost care and insight.

Here the reviews made in chapter III have traced the path to the investigator for her necessary planning and procedure in the study entitled:

"A study of creative ability of higher secondary school children in relation to their environment and teacher's creativity."

For detail research study, the work is planned in four steps given as under:

(1) The construction of creative ability test for the higher secondary school students in Gujarati ... Because there is no such test available in Gujarati for Higher Secondary Schools students owing to the lack of research work done so far.

(2) Adaptation of the environment inventory in Indian culture in Gujarati language as not available previously.
Translation of creative personality inventory by
psychologist Eugene Raudsepp is available in English
into Gujarati.

The studies of creative ability of the Higher Secondary School students in relation to certain variables
viz., streams, I.Q. and Environmental conditions.

4.1. SPECIFIC OBJECTIVES:

The chief objectives of the present investigation are:

(1) To provide a reliable and valid tool to measure the
creative thinking ability of students.

(2) To assess the nature of creativity of students studying
in various higher secondary streams.

(3) To investigate the trends of creative thinking among
the various streams.

(4) To study the impact of intelligence of pupils on their
creative levels.

(5) To study the influence of environment in which the
pupils are brought up upon their creative levels.

(6) To study the interactive effect of the independent
variables under study upon the pupils' creativity.

(7) To study the trend analysis of the creativity score of
students of three streams.
To study the trend analysis of the creativity scores of teachers of three various streams.

To suggest recommendations based upon the pupils' creativity.

To arrive at the above mentioned objectives the investigator thought of planning for the study in four above mentioned parts separately. First the planning for test construction of measuring the creativity among Higher Secondary School Student account. It is mentioned in the next caption.

4.2. PLANNING FOR THE TEST CONSTRUCTION:

Right from the planning to completion of the work, the tool needs much care to get strong reliable and valid results. Regarding the plan and procedure the following process is adopted. The existing test both available in foreign countries and India are reviewed to select the base for the type of items to be included in the present test before preparing a design of the test construction.

The reference adopted for this work is listed under Chapter III. The review of the existing test is helpful to the investigator in selecting the format i.e. the test items. The principles and procedure of Kogan and Wallach test of creativity are being adopted by the investigator for this study.
4.2.1. **Test Format:**

To measure the creative ability the various tests which can be used are the Torrance Test, Passi's test, Mehdi's Test and Kogan-Wallach Test. However, that of Kogan-Wallach creative ability test is preferred because of the following reasons:

1. The Torrance test of creativity is found to be lengthy one and is difficult to score.
2. Passi's test consists of six sub-tests in which verbal and non-verbal sub-tests have different weightages.
3. Mehdi's test of creativity has two formats. One is verbal and the other is non-verbal. Their weightages are equal. Though equal in weightage both these tests are time consuming so far as the scoring is concerned.
4. All the above tests do not test numerical ability.

Hence the Koggan-Wallach creativity ability test including new sub-test pertaining to numerical aspect is adopted. The test consists of three sub-tests:

(A) Verbal Creativity Test  
(B) Figural Creativity Test  
(C) Numerical Creativity Test

The format of this test has been standardized by Dr. J.Z. Patel, Reader, Sardar Patel University in Gujarati
for his project work for students of Grade V to X and is
accepted thoroughly. Also the same is developed and stan-
dardized by Dr. L.C. Chawda for his project work for stu-
dents of primary school. As the test format for the higher
secondary school level student is not yet standardized so
the essential steps of standardization process should be
applied in every new test.

4.2.2. Try-out:

The try-out process of the test items is divided into
three phases viz.,

- (a) Pre-pilot Try-out
- (b) Pilot Try-out
- (c) Final form of the test.

(a) Pre-pilot Try-out:

For pre-pilot tryout the test items are taken from
Koggan and Wallach test as are necessary. Some test items
are constructed in the field of mental ability test.
Nunnally\(^2\) has suggested to construct test items three times
more than required for the preliminary tryout. However,
Mehrotra\(^3\) has recommended to construct twice the test items
required. As this test is to measure creative ability,


3. Mehrotra and Mehrotra. *Mental Testing and Standardi-
which is rather a divergent thinking where the scoring is
difficult, the view of Mehrotra is taken into consideration
by adopting the double the test items required as the pre­
pilot tryout test.

Hence for the pre-pilot prepared for try out on a
small group of children only 26 items are included so that
the final form of the test could be of 14 items. The part-
wise numbers of items to be included are shown in the follo-
wing table:

Table: 4.1
Part-wise numbers of items in manuscript and final form

<table>
<thead>
<tr>
<th>Part</th>
<th>Type of test</th>
<th>Sub-parts</th>
<th>No. of items</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Manual scripts</td>
</tr>
<tr>
<td>1</td>
<td>Verbal</td>
<td>Instances</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alternate uses</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Figural</td>
<td>Line meaning</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pattern meaning</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Numerical</td>
<td>Number</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sum of Numbers</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Making Number</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solve the equation</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Total</strong></td>
<td><strong>26</strong></td>
</tr>
</tbody>
</table>
The pre-pilot test containing 26 items in all is given to a very group of 30 students for try-out. The main objective of this try out is to confirm the applicability of the pre-pilot test. Hence no statistical calculations are involved at that level. The specific objectives of this try out are listed as under:

(1) To see whether the pupils follow the instructions.
(2) To confirm whether the pupils follow the language of the test items.
(3) To check whether items work well with the students.
(4) To find out, if there is any ambiguity in the items.
(5) To determine the time limit for each of the item.
(6) To fix-up the necessary time intervals for relaxation.
(7) To find out the items which are responded in varied ways by the respondents.
(8) To find out the items which are found to be effective in getting the uncommon responses.

Keeping in mind the following criteria, the test items are selected on the basis of observation:

(1) The difficulty level of the items could be judged from the number of responses or ideas developed by the students.

(2) The number of categories of the ideas should be sufficient to measure the flexibility in scoring.

(3) Goodness of creative items can be determined by the unique responses by the students.
Hence forth the pilot form of creative ability test is arrived at by the investigator.

(b) Pilot Try-out:

From the observations of the varied responses obtained during the pilot try-out, the investigator selected the necessary and sufficient number of items for each part of the test. On discussing the efficacy of the test items with the guide and experts the number of items included in the pilot form are as shown below:

Table: 4.2

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
<th>Sub-parts</th>
<th>Number of pilot form</th>
<th>Item in a final form</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Verbal</td>
<td>Instances</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alternate uses</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Figural</td>
<td>Line meaning</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pattern meaning</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Numerical</td>
<td>Number</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sum of number</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Making number</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solve of education</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Total 18 12
The pilot tryout test governs the part test administrator, scoring key and gives final selection of items. Hence due to consciousness required in conducting this test, following are the other specific objectives which should be adhered to:

1. Instructions for each of the part are to be finalised.
2. To check the reactions of pupils to the creative ability test, which is prepared after modifications and necessary corrections.
3. The utility of the revised answer booklet is to be checked up and finalised.
4. To get the general idea about the time required is finalised during the pre-pilot tryout.
5. To select the items for the final testing according to the response analysis.

During the course of application of the test construction, the following factors have to be reckoned with: (i) Time limit, (ii) Instruction for the test construction, (iii) Selection of the sample and (iv) Mental readiness of the pupils.

(c) Final form of the test:

Final form of the test will be discussed in the next caption.
4.2.2.1. Time Limit:

The time limit to be fixed largely depends upon the purpose of the test. According to Cronbach L.J.⁴: "The current trend in making the new test is to provide sample time for nearly every one can finish."

The test is not a speed test but it is a power test. In case of power test, the time limit is fixed in such a way that almost all individuals have the opportunity to consider all the items of the test. Even in such a creative test, the period of incubation should be also accounted and hence the children can respond the test item without the time limit. But the responses should be marked as no time limit. (NTL).

If the responses are obtained as data in a particular situation viz., in a class room, the time limit should be fixed in such a way that a child can respond in various categorial ways. This system of administration is called with time limit (WTL). From the manuscript try-out, it is found that 4 minutes for each item in a test would suffice completely to react the item within a fixed time limit. Investigation has to test the time of relaxation within the fixed time limit and to observe the need of it.

---

4.2.2.2. **Instruction for the test construction:**

The instruction used for the pilot testing would be the same as these for the final testing. Hence the observations of the pre-pilot try out, are necessary for the modifications to be done while adopting the pilot try-out.

4.2.2.3. **Selection of the sample:**

In the pilot try out the size of the sample will be a larger one than the size of the pre pilot try out sample. Moreover, the sample should include the students of the relevant standard on which the study is made.

4.2.2.4. **Mental readiness of the pupils:**

As the success of any programme depends upon the respondent, it is very essential to think of their mental conditions. Before administering the test to the students, the researcher builds a sympatheitical report to make them mentally ready to take a test in a free conditions.

4.2.3. **Final Form of the Test:**

The final form of the test is a result of the process of all the try outs of test items and the directions on an anvil. It gives clear idea to the investigator about the administering the test systematically and psychologically. The final form of the test contains 12 items as shown in table Nos. 4.1 and 4.2.
The items in each part should be checked for its order and should be arranged psychologically in a sequence. Also the format in view of the sufficient space for the available responses.

The investigator would minutely observe the ideas of students during the pilot testing and would note the accountable points observed by the researcher to measure the components of creativity as \( N = \) Number of ideas (fluency), \( C = \) category of ideas (Flexibility) and \( U = \) uniqueness (Originality). The total of all these scores enables the creativity score of the students on the creativity test developed in the study.

4.2.3.1. **Norms Established:**

The raw score as it is, cannot be interpreted though it is a fundamental piece of information. The raw score does not give any idea about the individual. To interpret the meaning of the raw score, some points reference is a norm. Describing it, Anastasi writes: "As its name implies a norm is the normal or average performance."

For inter-individual comparison, the following norms have been established for the present test:

1. Standard Score Norms: \( O^- \) score, \( Z \) score
2. Percentile Rank Norms
3. Stannine Score

---

A standard score i.e. the deviation of score \( x \) from the mean \( \bar{x} \) is standard deviation \( \sigma \) units is calculated by using the formula:

\[
\sigma - \text{score} = \frac{x - \bar{x}}{\sigma}
\]

Hence the investigator had obtained a standard score i.e. Z-score by converting above \( \sigma \) score by taking the means of the distribution as 50 and the standard deviation as 10. So that Z score is calculated by the formula.

\[
Z - \text{score} = 10 \times \frac{x - \bar{x}}{\sigma} + 50
\]

The standard scores (\( \sigma \) score and Z score) have been shown in Appendix- VII.

The percentile ranks are calculated for the Higher Secondary school children by using the formula as:

\[
P_R = \left[ \left( \frac{P - 1}{P} \right) F + F \right] \times \frac{100}{N}
\]

The percentile ranks for each raw score obtained as creative ability test have been shown in the Appendix- VII.

4.2.3.2. Test Reliability and Validity:

A research is always dependent upon measurement. Two important constructs in measurement are 'reliability' and 'validity'. The construct of any psychological tool
can never be considered as complete unless it is tested for its reliability and validity.

(A) **Reliability:**

According to Anastasi, "The reliability of a test refers to the consistency of scores obtained by one same individual on different occasions or with different sets of equivalent items."

According to Freeman, "The reliability of a test is its ability to yield consistent results from one set of measurement to another."

For determining the reliability of the test of creativity, the following four methods have been applied with sub-scales and total attitude score:

1. Test-retest method
2. Alternate or paralleled forms of test
3. Split-half method

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6. Anne Anastasi: Psychological testing (second ed.)

(B) **Validity:**

According to **Anastasi** \(^8\) "Validity must be determined with reference to the particular use for which it is being constructed."

According to **Guilford I.P.** \(^9\) "In crudest terms, we can say that a test is valid when it measures what it is perceived to measure."

Thus validity is the extent to which an instrument measures what it is supposed to measure.

The validity of the scale can be assessed by finding the correlation between the total scale score and score in each sub-scale using the product moment method.

Secondly, inter sub-scale correlations can be computed by the product moment method determining the validity scale.

Thus, these two qualities are essentially important in educational research, because most of the measurements attempted in this area are obtained indirectly. It is essential, therefore, for the investigator to assess the reliability and validity of the creativity scale, so that it would measure precisely and dependably what it is intended to measure.

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4.3 METHODOLOGY OF STUDY:

The creativity ability among the higher secondary school students is correlated with certain variables and it is discussed in detail in five sub-sections as shown below:

(1) Variables under study
(2) Hypothesis built
(3) Tools used
(4) Sample selected
(5) Statistical Techniques adopted.

4.3.1. Variables under study:

Any research is undertaken to examine the behavioural response of individual as a function of some variables, i.e. study the nature of relationship between dependent and independent variables. The independent variables may be either causal factors or associative factors related to dependent factors in form of varying effects or responses under observation when the independent variables are varied or manipulated according to the nature of the research design employed. In the present study the independent variables are four main factors and the dependent variable is only one.

In any experimental or survey research, the investigator measures or observes the dependent one or more variables while manipulating or varying the independent
variables keeping in control the extra-neous variables. (those independent variables not under study and still influencing) through randomization of subjects or matching group process in order to arrive at more accurate and valid inferences. The independent variables contribute to experimental variables and extraneous variables are supposed to be well controlled to take care of extraneous variances and thereby reduced error variance keeping in some how also due to carelessness in selecting representative random sample or due to inadequate tools or through making faulty measurements. As investigator has to take care of all these considerations, understanding the contribution of different type of variables, the variables studied in the present investigation are enumerated below:

(A) Independent Variables:

(1) Different streams of higher secondary school i.e. different streams of study at three levels: (i) Science, (ii) General and (iii) Technical.

(2) I.Q. of student: i.e., intelligence varied at two levels: (i) high and (ii) low on the basis of scores on General Ability Test of Dr. P.P. Patel.

(3) Student Environment: Environment (Home, school, social, study) at two levels: (i) Good and (ii) Poor. On the basis of score on Environment Inventory developed by investigator.
(4) Teacher's Creative Personality.

(B) Dependent Variables:

The creative score is included as dependent variable in this study keeping in view the independent variable the researcher builds the hypothesis to study the creativity of the students.

4.3.2. Hypotheses built:

The hypothesis is a powerful tool in research process to achieve dependable knowledge.

Hypotheses provide the bases for reporting the conclusions of the study. The researchers will find it very convenient to test each hypothesis separately and state the conclusions that are relevant to each on the basis of these conclusions, he can make the research report interesting and meaningful to the reader.

An attempt has been made in the present research to study the nature of creativity in context with three main variables out of many other factors associated viz. (1) Streams, (2) Intelligence, (3) Students' environment: Home, school, study and school.

To be functionally operational and more definite a number of more specific hypotheses have been formulated,
which can be tested for acceptance and rejection on the basis of the result arrived at by adequate analysis of data collected from the sample employed with the help of the tools used. In general it is expected that the variables under the study do contribute to the creative score. These hypotheses under study are mentioned below:

$H_0_1$ : There is no significant difference between the means of creativity score of the students studying in different streams of study.

$A_1$ : There is no significant difference between the means of creativity score of the students of science and general streams.

$A_2$ : There is no significant difference between the mean of creativity scores of the students of science, general and technical streams.

$H_0_2$ : There is no significant difference between the means of creativity scores of students having high and low I.Q.

$H_0_3$ : There is no significant difference between the means of creativity score of the students having good environment and poor environment.

$H_0_4$ : There is no significant interaction effect of different streams of study and I.Q. of the students on their creativity scores.
A₁: There is no significant interaction effect of science and general streams of the students on their creativity scores.

A₂: There is no significant interaction effect of science, general and technical streams of the students on their creativity score.

H₀₅: There is no significant interaction effect of different streams of study and environment of the students on their creativity scores.

A₁: There is no significant interaction effect of science and general streams environment of the students on their creative scores.

A₂: There is no significant interaction effect of science, general and technical streams environment of the students on their creative scores.

H₀₆: There is no significant interaction effect of I.Q. and environment of the students on their creativity scores.

H₀₇: There is no significant second order interaction effect of different streams of higher secondary, I.Q. and environment of the students on their creativity scores.

A₁: There is no significant interaction effect of science and general streams, I.Q. and
environment of the students on their creative scores.

A2: There is no significant interaction effect of Science, General and Technical streams, I.Q. and Environment of students on their creative scores.

The above mentioned hypotheses are to be formulated under various environment conditions, viz. Home, school, social and study and total environment.

So in total 35 hypotheses will be formulated in this particular study.

4.3.3. Tools used:

In order to collect evidence or data for a study, the researcher has to make use of certain testing and non-testing tools such as intelligence tests, aptitude tests, achievement tests, personality inventories, observation, interview, questionnaire, rating scales. The researcher must be well versed in the use of these tools and fully aware of their merits and demerits.

The research proposal should explain the reasons for selecting a particular tool or tools for collecting of the reliability and validity of the standardized tools for the purpose of the study. The researcher should take help
of mental measurement year book (Buros), Indian Mental Measurement Year Book (NCERT), and other similar literature.

On test development for the selection of appropriate standardized tools if he is developing his own tools, he should outline the procedure to be followed in their development.

As mentioned in the previous captions, the investigator attempted:

(A) The test for the students of the H.S.C. school to develop a tool to measure the creative ability.

(B) The standardized test of General Ability Test for H.S.C. student is used for the measurement of their intelligence.

(C) An environment inventory is used for the measurement of their environment condition among the subject.

(D) To measure the teachers' creativity, the creative personality inventory prepared by Psychologist Eugene Raudseppi is used.

The description and psychometric test used for the present students are shown below:

(A) General Ability Test:

For measuring the I.Q. of the H.S.C. students the general ability test developed by P.P. Patel is used. This is limited for Gujarati speaking students only. It is divided in two parts.
Part - I:

Part I tests the student's familiarity with the world around him through his experiences in the home, in the school and in the community. They are test-questions in various fields of Indian culture, Science, Social Sciences, Community Affairs and the Arts. The test questions relate to the students' general knowledge of his surroundings gained through his observations, his hobbies, radio, films, field-trips and conversations with other people.

Part - II:

Part II avoids any cultural content. It presents geometric drawings designed to test the student's power of abstract reasoning. This part of the test presents an equal challenge to all students regardless of their culture backgrounds.

The number of right answers for both parts of test are added together to get raw score to obtain the student's I.Q. and P.R. scores.

It is a simple procedure to obtain I.Q. and P.R. for the General Ability Test.

I.Q. and P.R. can be obtained with the help of the age group and raw score of the testee. First find out the age of the testee in terms of years and months. Then enumerate the correct items on the general ability test with the
help of the scoring key. The total of all the correct items is the raw-score of the testee.

Now refer the table No. 1 of JGAT Norms and look down the column of raw score until you come to the number of the raw score. Directly across from the number of the raw score are I.Q. and P.R. for the age-group of the testee.

(B) Creative Ability Test:

The CAT has been constructed and standardized by the investigator for the students of higher secondary school. The detailed description of the process of test development, establishments of various norms and the reliability and validity estimated have been given in the following entire Chapter V.

(C) Environmental Inventory:

Environmental Inventory is the tool to measure the environmental conditions of the testee as published in the book 'Fourth eye' by P.N. Khandwala. It is adopted after relating the same with the Indian Culture for all the four types of various environment. This will be discussed in details in Chapter V.

(D) Creative Personality Inventory:

It measures the individual creative ability. Due to lack of research in the field of creativity, it was not available in Gujarati language. Hence the creative personality
inventory available in English prepared by Psychologist Eugene Raudsepp is being translated in Gujarati and it is used henceforth.

4.3.3.1. **Scoring Key of the tools used**:

Every standardized tool has its own manual for the objectives evaluation, the tools include the scoring key in a definite form.

In this study the researcher has to use for research tools which are discussed in next chapters in detail and shown in Appendix.

4.3.4. **Sample Selected**:

The process of selecting the subject is termed sample. The sample need not be too large but it should represent the collection of data from a small group, which is assumed to be a proper representation of a large group from where it is selected.

According to Borg:

"The factor that must often differentiate between good and poor research is not the funds available, the size of the sample or the sophistication of the statistics, it is care and thought that goes into the research plan."

The real worth of the sample lies not in its size, but in its accuracy in representation.

According to Traver:¹¹

"A representative sampling is one in which the characteristics of the sample are similar in important respects to the characteristics of the population sampled."

There are different methods of sampling according to different educationists.

According to Garrett:¹² they are:
1. Random Sampling
2. Stratified or Quota Sampling
3. Incidental Sampling, and
4. Purposive Sampling."

According to Rummel¹³ they are:
1. Random Sampling
2. Stratified Sampling
3. Area Sampling
4. Systematic Sampling
5. Purposive Sampling and
6. Quota Sampling.

This study is based on the stratified or quota sampling method.

**Stratified Sampling:**

According to Garrett:

"Stratified or quota sampling (also called controlled sampling) is a technique designed to ensure representation and avoid biases by use of a modified random sampling method."

According to Guilford:

"It is a procedure that is introduced in sampling to help to prevent biases and also to assure a more representative sample known as stratification."

It is used whenever it is necessary to use different sampling methods with different strata of the population, or when there are systematically different characteristics for sub-groups within population.

The same is the case for this study hence forth it is adopted.

---


4.3.5. Statistical Techniques:

(A) Factorial Design:

In this study the factorial design is to be used to test the null hypothesis, formulated in the foregoing caption, some factorial designs related to the influence of two or more independent variables are usually called factors, on a dependent variable. Here dependent variable is the creativity score, measured on creativity ability test (CAT) developed by the investigator while independent variables are streams, I.Q. and environment, usually called factors. The numbers of ways in which a factor is varied, is called the number of levels of the factors. A factor that is varied in two ways would be called to have two levels. In the each phase study, the streams have three levels: Science, General and Technical. I.Q. has two levels: high and low and environment also has two levels: good and poor.

Thus, each phase of study stream, I.Q. Environmental Factorial Design would have three factors with three levels of first factor, two levels of second factor and two levels of third factor. Thus $3 \times 2 \times 2$ factorial design could be evolved.
TABLE: A
Scores for 3 x 2 x 2 (Streams x I.Q. x Environment)
Factorial Design

<table>
<thead>
<tr>
<th>Stream</th>
<th>A₁</th>
<th>A₂</th>
<th>A₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.Q.</td>
<td>B₁</td>
<td>B₂</td>
<td>B₁</td>
</tr>
<tr>
<td></td>
<td>C₁</td>
<td>C₂</td>
<td>C₁</td>
</tr>
<tr>
<td>Environ-</td>
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</tr>
<tr>
<td>N</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>ₓ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ₑₓ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ₓₑᵦ²</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>σ</td>
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<td></td>
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</tr>
<tr>
<td>ₑ²</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

(6) **Homogeneity of Variance Test:**

After designing the experiment for required purpose, it is then incumbent on the investigator to go in for the test of homogeneity of variance.

Equality of group variance is an important assumption in many analysis of variance design. A simple approximate test is made possible by the $F_{max}$ statistics.

$$F_{max} = \frac{\text{Largest of the group variance estimate}}{\text{Smallest of the group variance estimate}}$$
(C) **Primary ANOVA:**

In this study factorial design with a randomized group is used to apply the analysis of variance. ANOVA techniques suggested by Werameir. ANOVA is a technique for partitioning the variation in the observed data into two parts: arrangable to different case or combinations or combinations of causes. In ANOVA, the sample data can be made to yield the independent estimated population variance.

(i) between group variance and

(ii) within group variance or error variance.

The partitioning of variance in a three way factorial design as shown in the figure below.

Before applying the ANOVA the investigator had to go through the test of homogeneity of variance by a simple approximate test known as $F_{\text{max}}$ test. $3 \times 2 \times 2$ factorial design have been evolved to test the null hypothesis. The summary of three way ANOVA has been given in the tabular form.

**TABLE**

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Sum of squares</th>
<th>Degree of freedom</th>
<th>Mean squares</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between group</td>
<td>SSB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between group</td>
<td>SSW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total group</td>
<td>SST</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Construction of Orthogonal Matrix for ANOVA:

The investigator tried to computerise ANOVA by means of orthogonal consideration. The concept of orthogonal contrasts is briefly described in the following paragraph.

One of the unique and salient features of a set of orthogonal contrasts is that they form the basis for a complete partitioning of the treatment sum of squares from the analysis of variance, for samples of equal size. The following conditions define a set of orthogonal contrasts.

(a) The sum of the contrasts co-efficient for contrast must be zero.

(b) The sum of cross products of co-efficient for every pair of contrasts must be zero.

For a set of a sample means sets of n-1 orthogonal contrasts can be constructed, in this way, the orthogonal contrasts 'consume' the degree of freedom available in the set of sample means various sets of orthogonal contrasts can be built on the same set of sample means. The number of orthogonal contrasts depends on the nature of the research design and the interest of the investigator. Each set will absorb the n-1 degree of freedom and will completely partition the treatment sum of squares.
TABLE for D
Orthogonal Matrix for 3 x 2 x 2 Factorial Design

<table>
<thead>
<tr>
<th>Groups</th>
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<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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<th>12</th>
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<tbody>
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<tr>
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<td>1</td>
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<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td>I.Q. $B$</td>
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<td>-1</td>
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<td>1</td>
<td>-1</td>
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<tr>
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<td>-1</td>
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<td>-1</td>
<td>1</td>
<td>-1</td>
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<td>-1</td>
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<tr>
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<td>1</td>
<td>-2</td>
<td>2</td>
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<td>2</td>
<td>-2</td>
</tr>
</tbody>
</table>

(E) Detailed ANOVA Model:

When the levels of factors are not randomly selected, the ANOVA model is referred to as a fixed effect model, when the levels of each factor have been randomly selected from the large population the ANOVA model is referred to as a random effect model. If the levels of some factors have been randomly selected and those of others have not, the ANOVA model is referred to as a mixed model.
Before proceeding with the ANOVA, it would be useful to look into the assumption underlying the ANOVA technique. They are parametric assumptions viz.

(1) An equal unit scale is assumed for the measurement of the dependent variable.

(2) Homogeneity of variance is the basic assumption, that is the samples of the group coming from the same population have equal variance.

### TABLE for E

ANOVA Summary for 3 x 2 x 2 Factorial Design

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MSdi</th>
<th>MSS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streams</td>
<td></td>
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<td></td>
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<tr>
<td>A₁</td>
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<tr>
<td>A₂</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.Q. B</td>
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</tr>
<tr>
<td>Environment C</td>
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<td></td>
</tr>
<tr>
<td>A₁B</td>
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<tr>
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</tbody>
</table>
In the same way, $3 \times 2 \times 2$ Factorial Design would be evolved for the different components of Environmental conditions as the independent variable for the study.

Now this planning and research design outlook would be the complete and right direction for the research in his study word.