CHAPTER V

EXPERIMENTAL DESIGN AND EXECUTION

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5.0 Introduction:

Research design is strategy on paper like an architect's plan. Certain fundamental steps of research design must be given importance when proposed to be used. The operation of the design, that is planning must be carried out with patience and accuracy. The purpose of research design is to impose controlled restrictions on observations of natural phenomena. It helps the investigator, what to do during the study.

The quality of research depends upon the quality of its design. If the research design is faulty then the final results would be faulty. Therefore, a proper design is needed for valid analysis.

This chapter deals with the selection of proper research design for the study. For validational study, the experimental design was used. Research tools and sampling procedure are described.
5.1 Basic Elements of Research Method:

The basic elements of research method are Variables, Hypotheses, Research tools, and Sample selection. Each one of the four elements are described in detail below.

5.1.1 Variables Therein:

There are several Special programmes available for developing various abilities like creativity, self-concept, divergent thinking and attitude. There were also programmes like SMSG, SMP and PSSC for developing improved instructional materials. But all of them are special programmes that can not be used in an ordinary classroom without disturbing its activities. A programme that could be used without causing any inconvenience to the pupils has to be developed. Lesson Idea Programme (LIP) provides such type of facility.

LIP produces cognitive and affective behaviour in pupils through mathematics using certain modes of teaching or strategies. Since one of the objectives of the study is to study its effect on pupils' Achievement, affective behaviour of the pupils and Attitude towards mathematics. Thus, treatment was chosen as an independent variable.

Several studies have shown that sex is an important biological factor that influences other variables like
achievement, attitude and creativity. Hence, Sex was taken as independent variable.

* I.Q is an effective variable in nurturing and audiencing the creativity levels of the pupils. So I.Q was taken as independent variable.

Socio-economic factors like standard of living, parental income, caste and parental education have much influence on pupil's behaviour and his school performance. Hence, parental education was also chosen as an independent variable.

Thus, there are four independent variables each of two levels. Achievement, Affective behaviour and Attitude are the three dependent variables. The details of these variables are shown in table 5.1.

**TABLE 5.1**

**VARIABLES AND THEIR LEVELS**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of the Variable</th>
<th>Nature of the variable</th>
<th>No. of Levels</th>
<th>Name of levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Treatment (LIP)</td>
<td>Independent</td>
<td>2</td>
<td>1. Treatment ($A_1$) 2. No Treatment ($A_2$)</td>
</tr>
<tr>
<td>2.</td>
<td>Sex</td>
<td>Independent</td>
<td>2</td>
<td>1. Boys ($B_1$) 2. Girls ($B_2$)</td>
</tr>
<tr>
<td>3.</td>
<td>I.Q</td>
<td>Independent</td>
<td>2</td>
<td>1. High ($C_1$) 2. Low ($C_2$)</td>
</tr>
<tr>
<td>4.</td>
<td>Parental Education</td>
<td>Independent</td>
<td>2</td>
<td>1. High ($D_1$) 2. Low ($D_2$)</td>
</tr>
</tbody>
</table>
(vi) Affective Behaviour Rating Scale,
Developed by the investigator.

(i) Lesson Idea Programme:

This programme is developed by the investigator. It has twenty five ideas, covering the content of mathematics of Std. seven of Gujarat state. This lesson idea programme was described in detail in chapter four.

The aim of this programme is to develop the thinking and feeling aspects of the pupils. Each lesson idea programme tries to develop one cognitive and one affective behaviour. The teacher has used certain selected strategies.

Each idea supplements and enriches the usual classroom instruction. All the Lesson Idea Programmes are appended in Appendix 1.

(ii) Achievement test in Mathematics:

This achievement test is developed by the investigator. It has two parts. Section I and section II. Section I consists of objective type questions and Section II consists syllogistic reasoning test in Mathematics. The content of this achievement test covers the topics of Lesson Idea programme. There are twenty questions in section I and ten questions in section II. With the help of this tool investigator wanted to measure the achievement
score in Mathematics. The reliability of this test has been established by Test-retest method. The test-retest interval was about two weeks. The test-retest reliability was found 0.89. This indicates that the test is reliable. This Achievement test is shown in Appendix 2.

(iii) **Attitude Test:**

Mathematical Attitude test was developed by H.G. Desai. The test has twenty statements.

The pupils should fill the primary information themselves, given in the beginning of the Mathematical Attitude test such as Name in full, Name of the school, Age, Male or female, standard, class and date.

The instructions are given below.

1. The following twenty statements show an opinion about Mathematics. Put a (✓) mark against statements as per your likely opinion.

2. Give your correct opinion. This opinion will be kept secret.

It has twenty statements. Each statement shows a person's feeling towards mathematics. Each pupil is asked to tick the statements that he felt as appropriate.

The value of each statement is provided in the scoring key.

The scoring method is quite simple. If a particular
student has ticked statements 3, 4, 6 and 15 then his total score will be \(5.82 + 2.26 + 1.95 + 2.31 = 12.34\). The average is 3.085. This will be the attitude score of that person. A low score indicates high positive attitude towards mathematics. A high value of attitude score shows low positive attitude towards mathematics.

The test is developed by H.G. Desai and each statement is carefully selected after subjecting into statistical treatment. The selected statements have good discriminative power and hence can discriminate between pupils having high attitude and low attitude towards Mathematics.

Reliability: The split half and test-retest reliabilities were found to be 0.86 and 0.74 respectively.

Validity: The validity of the attitude scale was determined on the basis of teacher's ratings of the pupil's attitudes. The validity coefficient thus obtained was 0.66.

This test is appended in Appendix 3.

(iv) General Ability Test (I.Q. test)

Keeping in view the criteria for selection, the General Ability Test for Std. V, VI & VII developed and standardized by J.Z. Patel was selected for finding I.Q of the pupils for the present study.

"The General Ability Test is the test of General Intelligence (or I.Q.) meant for Gujarati speaking children."
The test is rather unique in that it does not require reading, arithmetic or any other form of school achievement.\(^1\)

The objectives of part I is to test the pupils' familiarity with the world around him which he has gathered through his experience, in the home, in the school and in the community. Part I consists of thirty-eight items measuring information about Indian culture, science, social sciences, community affairs and the arts. The test items relate to the pupils' general knowledge of his surroundings gained through his observations, hobbies, radio, films, T.V., filmstrips and conversations with other people. Part II consists of thirty-eight items measuring abstract reasoning. They are all non-verbal and cultural free items. Hence, this part is equally challenging to all the pupils irrespective of their culture. The information part of the test consists of items testing the individual's ability to grasp meanings, recognize relationships and understand the basic concepts.

**Reliability of the test:**

The reliability of the test has been established by various methods, which are:

1. Test-Retest method, 

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2. Split-Half method,
3. Method of rational equivalence using K.R. Formula 20 and 21, the Rylon Formula, the Flanagan Formula and Tucker's Formula,

The test that is selected for establishing the part score norms has reliability coefficients ranging from 0.83 to 0.97. Thus, the test has a good reliability.

Validity of the test:

Different types of validities of General Ability Test have been established by the author which are:

1. Concurrent validity,
2. Congruent validity,
3. Cross validity, and
4. Factorial validity.

The concurrent and congruent validity coefficients are 0.54 and 0.77 respectively. The study of the factorial validity shows that the test is highly loaded with one factor called General Ability. This discussion leads to state that the test is valid too.

After administered the general ability test, all the answer sheets were scored with the use of windo stencils. Total raw scores were written partwise in the space provided in the answer sheets. It is appended in Appendix 4.

Two groups were made on the basis of I.Q scores.
Here 104 is the median value.

A score of 104 or less than 104 was taken as low I.Q and a score greater than 104 was taken as high I.Q of the pupils.

(v) Profile of Parental Education:

This is a very simple tool designed by the investigator. It contains items like name of the school, Name of the student, standard and division. There is a table for recording parental education. The student is required to tick the appropriate box for both father and mother.

The scaling is shown below.

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>V standard</td>
<td>0</td>
</tr>
<tr>
<td>S.S.C</td>
<td>1</td>
</tr>
<tr>
<td>Graduate</td>
<td>2</td>
</tr>
<tr>
<td>Post Graduate</td>
<td>3</td>
</tr>
</tbody>
</table>

The total of the both scores gives the parental education score of a pupil. A score of three or less than three was taken as low and a score greater than three was taken as high.

This profile is appended in the Appendix 5.

(vi) Affective Behaviour Rating Scale:

The investigator constructed himself a tool to measure the affective behaviour of the pupil. This tool contains two pages. In the first page particular informations of the pupil and how to answer the statements method
is given. Statements are given on the second page.

In the beginning, the sheet of the tool was given to every pupil under the study. Pupils were asked to write in the sheet pupils name, Roll No., Std., Date and Name of the school. Teacher explained the following instructions:

Here with this sheet you are provided Affective behaviour tool to measure Affective behaviour. There are twenty statements. These statements reflect the opinion about the mathematical affective behaviours. You have to put a tick (✔) mark against the statement whether you are agree, neutral or disagree.

1. If you are agree with the statement put a tick (✔) mark in the box of agree.

2. If you are not disagree or agree with the statements, put a tick (✔) mark in the box of Neutral.

3. If you are disagree with the statement put a tick (✔) mark in the box of disagree.

You are required to respond your response for the each statement, reading perfectly. Your opinion would be kept totally confidential. You have to put only one right mark against each statement.

After the completion of the instructions, pupils respond their responses against each statement at the proper place.
Scoring Key:

If the pupil puts a tick mark against agree then he will get two marks, if he puts a tick mark against Neutral, he will get one mark and if he puts a tick mark against disagree, he will get zero mark.

Summated total score of the each statement is called the Affective behaviour score.

This Affective behaviour rating scale is appended in Appendix 6.

5.1.4 Sample Selection:

A major link in the chain of reasoning for inferential statistics is the sample. Samples are selected from population, and measures computed from the samples (statistics) are used to make inferences about the population measures (Parametory). A sample is a subject of the population. But it is not necessary that the representative sample should be too large. The real worth at the sample lies not in its size but in its accuracy and representativeness.

According to Johnson²

"A representative sample is defined as one, with which the measurement made on its units are equivalent to those

which would be obtained by measuring all the elements of the population, except for the inaccuracy due to the limited size of sample."

Travers defined sampling as:

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

Hence, representative sampling should be carefully determined. There are different methods of sampling. According to Rumell, they are as below:

(i) Random sampling (ii) Stratified sampling (iii) Area sampling (iv) Systematic sampling (v) Purposive sampling and (vi) Quota sampling.

Garrett suggested the following methods:

(i) Random sampling (ii) Stratified sampling (iii) Incidental sampling and (iv) Purposive sampling.

Now the investigator had to select such a sample, which would satisfy the following characteristics:

------------------------
(a) In general I.Q. of the pupils should normally be distributed.

(b) The school should be known to the investigator for easy approach and full co-operation of the pupils as well as the staff.

(c) The school should have co-educational system.

(d) The school should have at least two classes of Std. VII.

Looking to the above requirements, the investigator selected the purposive sampling technique for this study. In most general sense, it means selection according to some purposive principles.

Purposive sampling is a non-probability form of sampling. Under this method one can select the available sample. This method has to be followed when it is not possible to identify all the subjects of the universe or when it is not possible to disturb the subjects due to administrative reasons as in the case of a classroom experiment.

Garrett⁶ defined purposive sampling as:

"A sample may be expressly chosen because, in the light of available evidence, it mirrors some larger group with reference to a given characteristic."

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⁶ Ibid., P. 207.
The schools satisfying all the requisite conditions named (i) Anand high school, Anand and (ii) The Pioneer high school, Anand were selected for the present study. In the pioneer high school, there were sixty eight pupils in Std. VII A and sixty seven pupils in Std. VII B. In Anand high school, Anand, there were sixty two pupils in Std. VII A and sixty three pupils in Std. VII B.

5.1.5 Formation of equal groups:

On the basis of I.Q score, two equal groups were made. For that, the General ability test developed by J.Z. Patel was administered to all the four classes and scores obtained as I.Q score. Comparing the score with pupil of VII A to pupil of VII B, equal pair were made. Thus, two groups were made. No. of pupils, Mean scores, S.D. of two selected groups A and B are shown in Table 5.2.

TABLE 5.2
NO. OF PUPILS, MEAN SCORES, S.D. OF TWO GROUPS A AND B

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Class</th>
<th>No. of Pupils</th>
<th>Mean of I.Q.Score</th>
<th>S.D.</th>
<th>C.R.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>A</td>
<td>80</td>
<td>104.912</td>
<td>8.989</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>B</td>
<td>80</td>
<td>104.925</td>
<td>9.022</td>
<td></td>
</tr>
</tbody>
</table>

Here, \[ M_1 = 104.925, \quad M_2 = 104.912 \]
\[ M_D = M_1 - M_2 \]
\[ = 104.925 - 104.912 \]
\[ = 0.013 \]
From the table 5.2, \( \sigma_1 = 8.989 \), \( N_1 = 80 \) 
\( \sigma_2 = 9.022 \), \( N_2 = 80 \)

Now, 
\[ \sigma_D = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}} \]
\[ = \sqrt{\frac{(8.989)^2}{80} + \frac{(9.022)^2}{80}} \]
\[ = 1.424 \]

\[ \text{C.R} = \frac{\text{MD}}{\sigma_D} \]
\[ = \frac{0.013}{1.424} \]
\[ = 0.0091 \]

\[ \text{DF} = N_1 + N_2 - 2 \]
\[ = 80 + 80 - 2 \]
\[ = 158 \]

Here, observed value of C.R. is 0.0091. It is less than the table value 1.96. Hence, it is not significant at both the levels.

Therefore, it is concluded that the two groups of class A and B are equal.

From above two equal groups, class A was selected as an experimental group and class B as a control group by random process.

7. Ibid., P. 461.
Now parental profile were administered to the two groups so that the sample could be further partitioned. The number of subjects in the sixteen cells are adjusted such that each cell had seven subjects. Then the control group and experimental group each has fifty six pupils. Out of them, twenty eight are boys and twenty eight are girls.

The choice of the institution and then the selection of the pupils made the sample purposive. Since the school chosen was a normal one, it can be assumed to be representative of the population.

5.2 Statistical Techniques : Experimental Design :

For testing the hypotheses an experimental design is needed. In the experimental design the investigator control one or more independent variables and observes the dependent variable for corresponding changes.

The designs are classified into two groups or categories :

1. Inadequate designs or quasi experimental designs, and
2. General experimental designs.

5.2.1 Quasi-experimental designs :

The one group design comes under the first category.
It is also known as one-short case study. Case studies fall under this group and enhance the name. In this design a group is exposed to some treatment and after a period the effect is measured. For example if a school wants to introduce a new curriculum and study its effects. After an year the student achievement is studied and found to be same or better. Symbolically it is denoted by \[ X \to Y \]

Here the dependent variable \( Y \) is studied while the independent variable \( X \) is assumed or imagined. Sometimes conclusions could be misleading.

Another form of one-group design is the pre test-post test type. This is an improvement over the previous method. The important characteristic of this design is that a group is compared with itself. This is theoretically sound since all the independent variables associated with the subjects' characteristics are controlled. The group is measured on the dependent variable \( Y \) before the experiment. It is called pre test. After the experimental manipulation again \( Y \) is measured. The difference in scores or \( Y_a - Y_b \) are studied. Symbolically it can be shown as \[ Y_b \to X \to Y_a \]

Though this appears to be sound it is not that simple. The difference might have been caused by variables like history or maturity.
5.2.2 **General Designs**:

(i) The experimental - control group design is one of the best design for many experimental purposes in Education and Psychology. The paradigm is

$$
\begin{array}{c|c}
R & \begin{array}{c}
\text{Experimental} \\
X & Y \\
\hline
X & Y \\
\end{array} \\
\text{Control}
\end{array}
$$

The R placed before the design shows that subjects are to be randomly assigned to the experimental group and control group.

There are two merits of the method:

1. The presence of a control group gives the comparability required by science, and
2. Randomization provides assurance that the two groups are approximately equal on variables that may be related to the dependent variable.

(ii) The two group- method subjects design is another. Here instead of randomization the subjects are matched on one or more attributes. Symbolically it is represented as:

$$
\begin{array}{c|c}
M & \begin{array}{c}
\text{Experimental} \\
X & Y \\
\hline
X & Y \\
\end{array} \\
\sim & \text{Control}
\end{array}
$$

The suffix r shows that after matching the members of each pair must be assigned to the two
groups randomly. This can be done by using random numbers. Odd numbered subjects are counted into one group and the even numbered subjects are counted into another group.

(iii) Three group before-after.

Its paradigm is

\[
\begin{array}{c}
\text{Yb} & \text{X} & \text{Ya} \\
\text{Yb} \sim \text{X} & \text{Ya} \\
\text{X} & \text{Ya} \\
\end{array}
\]

(Experimental)  (Control - 1)  (Control - 2)

This is an improvement over the previous design. It avoids the possible interactive effects of the pre-test. This is done by the second control group. If the treatment is effective than the means of experimental group and control group-2 will be significantly higher than the mean of control group-1.

(iv) Four-group, before-after (Solomon).

This design was proposed by Solomon.

Its paradigm is

\[
\begin{array}{c}
\text{Yb} & \text{X} & \text{Xa} \\
\text{Yb} \sim \text{X} & \text{Ya} \\
\text{X} & \text{Ya} \\
\sim \text{X} & \text{Ya} \\
\end{array}
\]

(Experimental)  (Control - 1)  (Control - 2)  (Control - 3)

This design has powerful controls. The salient features of the previous designs are included in this design. It is widely used by social scientists.
5.2.3 Choice of the Design:

In deciding an approach, the investigator has to take into consideration several factors like available setting, nature of objectives, and time.

Two separate and independent dimensions can help the investigator in the choice of approach. Fox\(^8\) (1969) had suggested the following table.

**Table 5.3**

**INTERACTION OF TIME AND INTENT DIMENSIONS**

<table>
<thead>
<tr>
<th>Dimension-2</th>
<th>Dimension-1 (Time in which interest lies)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Past</td>
</tr>
<tr>
<td>Intent of Research</td>
<td>Historical</td>
</tr>
<tr>
<td>Description</td>
<td>Simple historical</td>
</tr>
<tr>
<td></td>
<td>Case study</td>
</tr>
<tr>
<td>Comparison</td>
<td>Parallel historical</td>
</tr>
<tr>
<td></td>
<td>correlation survey</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Historical and criterion measure</td>
</tr>
<tr>
<td></td>
<td>or multiple group survey criterion measure</td>
</tr>
</tbody>
</table>

---

The use of the above table in the present case leads to the choice of multiple group experimental design. Since there are four independent variables each of two levels a factorial design is called for.

5.2.4 ANOVA: Factorial Design:

According to Kerlinger\(^{9}\) (1978), "Factorial Design is the structure of research in which two or more independent variables are juxtaposed in order to study their independent and interactive effects on a dependent variable."

In the present experiment the independent variables are treatment (A), sex (B), I.Q (C), Parental Education (D). Each is at 2 levels. It is a \(2^4\) Factorial Experiment.

Factorial Analysis of variance has several advantages. It enables the researcher to manipulate and control two or more variable. Secondly, variables like sex, parental education etc., that cannot be manipulated can also be controlled. Factorial analysis is more precise than the one-way analysis, it is the third advantage. Finally the interactive effects could be studied. This is important from a scientific point of view.

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5.2.5 **Statistical technique in ANOVA:**

Here treatment (A), Sex (B), I.Q (C), and Parental education (D) are the independent variables each at two levels. In all there are sixteen blocks. They are shown in the table 5.5.

The F-test is based on the following assumptions:

(i) an equal unit scale is assumed for the measurement of the dependent variable.

(ii) Homogeneity of variance.

The ANOVA summary shown in table 5.4 helps in testing whether the group means differ or not.

**TABLE 5.4**

**ANOVA SUMMARY**

**BETWEEN THE GROUPS AND WITHIN THE GROUPS**

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean SS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between the groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within the groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The 0.05 and 0.01 confidence levels were taken to test for significance.

Factorial design for data analysis is shown in table 5.5.
Table 5.5.

$2^4$ Factorial design for data analysis

<table>
<thead>
<tr>
<th></th>
<th>$A_1$</th>
<th></th>
<th>$A_2$</th>
<th></th>
<th>$A_1$</th>
<th></th>
<th>$A_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$B_1$</td>
<td></td>
<td>$B_2$</td>
<td></td>
<td>$B_1$</td>
<td></td>
<td>$B_2$</td>
</tr>
<tr>
<td></td>
<td>$C_1$</td>
<td></td>
<td>$C_2$</td>
<td></td>
<td>$C_1$</td>
<td></td>
<td>$C_2$</td>
</tr>
<tr>
<td>$D_1$</td>
<td>1111</td>
<td>$D_2$</td>
<td>2111</td>
<td>$D_1$</td>
<td>1211</td>
<td>$D_2$</td>
<td>2211</td>
</tr>
<tr>
<td>$D_1$</td>
<td>2112</td>
<td></td>
<td></td>
<td>$D_1$</td>
<td>1221</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$D_2$</td>
<td>2212</td>
<td></td>
<td></td>
<td>$D_2$</td>
<td>1122</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$D_2$</td>
<td>2122</td>
<td></td>
<td></td>
<td></td>
<td>1222</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$D_2$</td>
<td>2222</td>
<td></td>
<td></td>
<td></td>
<td>2222</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
To test the Main effects and Interaction effects complete ANOVA is used with the help of orthogonal system. The full form is shown in the table 5.6.

**TABLE 5.6**

**SUMMARY OF FOUR WAY ANOVA**

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>SS</th>
<th>df</th>
<th>MSS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BxC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BxD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CxD</td>
<td></td>
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<td>Error</td>
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</table>

The values of F are obtained by dividing each of the mean sum of square (MSS) by error variance, i.e. within
groups mean square. The level of significance at 0.05 and 0.01 levels of confidence has been accepted to study the main effect and interaction effect on the dependent variable. Thus, the hypothesis could be tested for acceptance or rejection.

5.3 **Execution of the experiment:**

There were two groups under experiment. One was experimental group and other was control group. Treatment was given to the experimental group. LIP was administered to the experimental group. Control group was taught by traditional method. Both the groups were treated in the usual manner. The general instructions were given to both the groups. They were asked to be punctual, regular and neat in their work. Regular and continuous effort will yield good results and better learning takes place.

5.3.1 **Instructions to experimental group:**

Whatever necessary treatment is required to the experimental group was provided by the investigator himself. In the beginning the investigator provided the instructions given in programme booklet, Appendix 1 to motivate the pupils to response warmly.

5.3.2 **Time Schedule for the Execution of programme:**

The following time schedule was used applying the
Each lesson idea programme required one hour.

<table>
<thead>
<tr>
<th>Month</th>
<th>Lesson Idea Programme No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>1, 2, 3, 4,</td>
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<tr>
<td>August</td>
<td>5, 6, 7, 8</td>
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<tr>
<td>September</td>
<td>9, 10</td>
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<td>October</td>
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<tr>
<td>November</td>
<td>11, 12, 13, 14</td>
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<tr>
<td>December</td>
<td>15, 16, 17, 18</td>
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<tr>
<td>January</td>
<td>19, 20, 21, 22</td>
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<tr>
<td>February</td>
<td>23, 24, 25</td>
</tr>
<tr>
<td>March</td>
<td>Examination</td>
</tr>
</tbody>
</table>

After completion of the programme the achievement test in mathematics, Affective behaviour rating scale and Attitude test were administered to both the groups under experiment.

5.3.3 Execution of LIP:

The teacher had chosen the strategies selected by him for each lesson idea programme and through the content tried to develop the appropriate cognitive and affective behaviours in the pupils. The normal classroom activities
Like questioning, home work, seat work, explanation at the blackboard were supplemented and enriched by the ideas.

Whenever some material is needed, it was prepared and kept ready well in advance. It was distributed to the pupils at the time of use. For example LIP 9 needed the graph paper. The graph paper of suitable size was provided, the coordinate axes were drawn and kept ready.

Every pupil was provided the note book to write their responses during the programme.

5.3.4 Observations:

During the implementation of LIP the investigator found the appropriate behaviour developed through the strategies specially chosen using mathematics as content. They were recorded at the time of the experiment. The following description contains them in all detail.

Lesson Idea Programme 1:

In this lesson idea programme teacher compare one thing with others and tries to get answer of the asked question. Teacher tries to develop pupils' original thinking by asking provocative questions. Pupils think deeply or with complexity to frame a new various examples as provided form of example.

Pupils think originally to frame a new example.
While selling any item when the person will be in profit or loss? The answer of this question by the pupils will be that if the selling price exceeds the actual price, the person will be in profit and if the selling price falls short of the actual price, then the person will be in loss.

A few pupils may be able to think in the form-

"Profit = Selling price - Actual price"
"Loss = Actual price - selling price"

Ramesh sold a bat at a loss of 20%. If he had bought it for Rs. 50, for how many rupees did he sell it?

By the calculation pupils may answer 40. A few pupils may answer 30. After this answer teacher will guide them for the meaning of 20% loss and lead them to the correct answer. With a small changes in the above example the pupils were able to frame various new examples.

Pupils develop their original thinking by writing 60, 70, 100, 86, 81, 61.50, 40\frac{1}{2}, 60\frac{3}{4}, 1050 etc. by replacing the number 50. Thus, they could change the numerical form.

In place of 20% pupils may replace it by 10%, 5%, 2%, 1.5% \frac{1}{2}%, etc.

Pupils try to write different names of boys and girls in the replacement of 'Ramesh' in verbal form.

Pupils convert the word bat by table, chair,
bicycle, scooter, buffaloes, quantity of grain etc. A few pupils use the word profit instead of loss.

Thus, by changing the form of examples pupils could solve the examples. Pupils were enthusiasm because they got the first time opportunity to do the work by this way.

Lesson idea programme 2:

In this lesson idea programme teacher tries to develop pupils original thinking and imagination by the strategies Discrepancies and Skill of Search. Teacher tries to teach compound interest on the basis of simple interest. Pupils could understand the difference between simple interest and compound interest and would be able to say that when interest is calculated on interest also it is called compound interest.

To find the simple interest on Rs. 1000 at 10% for 2 years, pupils were able to calculate this example. Then after interest calculated yearly. Calculate first year interest and add into the principal. That figure would be counted as principal for the second year and on the figure of this pupils calculate the interest. Pupils put first year's interest and second year's interest and summate it.

Pupils could know clearly, that the interest calculated by the second method may get more instead of first
method and explained the reason for it.

By framing such above examples, pupils might solve the example. Pupils were able to frame the examples by their original thinking.

Teacher provided an opportunity to develop imagination of the pupil to get the examples in numerical and verbal form.

One pupil asked the teacher, Sir, whether the rate of interest would be 0% any where?

Teacher answered that the meaning of the 0% interest is that the person has given money without any interest so there is no need of calculate the interest. See, the imagination of the pupils, they would think about the rate of interest at 0%.

**Lesson Idea Programme 3:**

Through this lesson idea programme the teacher has tried to develop the original thinking and Imagination of the students with the help of strategies, discrepancies and skill of search, using various examples of Compound Interest.

The teacher put the question before the pupils, why the bank is calculating the interest at every six months? The pupils have tried to answer the above question using their originality and imagination. Some pupils answered that bank motivate the people to deposit their money in the bank, some pupils answered that the amount will become big so the calculation of the interest will be difficult
and there are possibilities of mistakes in calculating the interest at the end of the year. Some pupils answered that the calculation of interest at every six months will provide the work to the bank staff throughout the year. The pupils have participated in the discussion of various given answers of above questions.

Students were able to divide the given period if the interest is to be calculated at every six months. Pupils were able to solve the given example correctly. At that time one pupil asked the question with his imagination. Sir, is it possible to solve the example using the formula?

Pupils were able to differentiate the compound interest and the simple interest. The teacher asked the pupils to frame various examples making necessary numerical and verbal changes in given example. They were able to make numerical and verbal changes with their original thinking. Moreover they were able to frame various examples, pupils found much more interested in framing new examples, than the solution of the given examples. The teacher has tried to bring variety in framing the examples. Instead of 5000 various numerical figures like 3000, 2000, 1500, 1625, 1810, 1525 etc. were used by the pupils. Instead of 12% various numerical changes were made i.e. 8%, 9%, 10%, 20% etc., were taken up as a rate of interest. Some of the pupils were able to think about the highest rate of interest. Teacher asked pupils to answer the questions using
their imagination. They were not found to consider the period more than five years in calculating interest.

Lesson Idea Programme 4:

Through this lesson idea programme teacher used Evaluate situation and Visualization skill strategies to encourage Elaborative thinking and Risk taking of the pupils.

Pupils were asked to draw a rectangle according to their choice. Pupils could draw rectangles using various measures. Some pupils could draw rectangles selecting different measures, e.g. (3.8 \times 4.2) \text{ cm}, (5.6 \times 3.3) \text{ cm}, (6 \times 9) \text{ cm} etc., with risk taking.

Pupils could frame two triangles from a single rectangle. Most of the pupils could answer that the area of the triangles would be equal.

Pupils could answer the relation between area of one triangle and the area of the rectangle. Using Elaborative thinking pupils could give the following formula for area of triangle.

\[
\text{Area of triangle} = \frac{1}{2} \times \text{base} \times \text{altitude} = \frac{1}{2} \cdot bh
\]

Pupils could draw the triangle according to their choice and could calculate the area of the triangle. Teacher used visualization skill to draw altitude on the
different sides of the triangle. Teacher asked the pupils to calculate the area of different types of triangle.

**Lesson Idea Programme 5:**

Pupils could divide the circle into 32 equal parts, and could answer that each section contains the shape of triangle. Pupils could answer that the measure of base of one triangle = \( \frac{1}{32} \times \text{circumference of the circle} \) using their complexity. Pupils could verify that the area of the triangle = \( \frac{\pi r^2}{32} \) where \( r \) is the radius of the circle.

Pupils could answer that 32 triangles will be required to complete the circle. Pupils could verify the formula.

\[
\text{Area of the circle} = \pi r^2.
\]

Pupils could calculate the example given by the teacher. Pupils could think in which situation one can take the value of \( \pi \) either \( \frac{22}{7} \) or 3.14.

**Lesson Idea Programme 6:**

Pupils could explain the definition of same centred circle. With the help of their Elaborative thinking pupils could say that one can draw numerous circle from a single circle. Pupils could draw the figure of same centred circle.
Pupils could explain the area of circular path and could decide the relationship by their visualization that $R > r$ where $R$ is the radius of larger circle and $r$ is the radius of smaller circle. Pupils could get the formula for the area of a circular path i.e. the area of the circular path is

$$\text{area of the larger circle} - \text{area of the smaller circle}$$

$$= \pi R^2 - \pi r^2$$

Pupils could derive the formula for area of the circular path in the form of $\pi (R+r)(R-r)$. This formula is very easy in calculation of the area of a circular path. They could frame various examples and could calculate the area. They were able to apply their imagination to frame various examples.

Lesson Idea Programme 7:

Pupils were able to say about three surfaces of the wooden cylinder. From three surfaces they could say that it is very difficult to measure the area of curved surface. Moreover they were able to know that if a cylinder is cut vertically, one can get a rectangular shape when spread on a plane. Thus, the area of the curved surface of a cylinder

$= \text{Area of the rectangle (The rectangle framed from the curved surface of a cylinder)}$.

Pupils could derive the formula for the total sur-
face area of a close cylinder. They were able to say that if a cylinder open at the top and having a bottom, possesses a circular bottom and curved surface then the total surface area of such a cylinder = 2 \pi rh + \pi r^2.

Through above derived formula teacher could encourage the pupils to develop their complexity.

To encourage the original thinking of the pupils, teacher provided one example and asked them to frame various examples using verbal and numerical changes.

Pupils could take the measure of height as 3.0 metre, 4.5 metre, 6\frac{1}{2} metre etc. Some of the pupils could use centimeter unit instead of meter. Pupils could give the example of three types of cylinder.

Lesson Idea Programme 8:

Pupil could derive the formula of volume of a cylinder with the help of volume of the cuboid.

Pupils could answer that if the radius of the cylinder is one unit and height is one unit then the volume of a cylinder is equal to 3.14 cubic unit in decimal system.

Pupils could tell that if the radius of a cylinder is 'r' and height is one unit then the volume of a cylinder is equal to 3.14 \times r^2.

They could calculate the given example. To encourage the flexible thinking, teacher provided the task of
framing various types of examples. They could frame
various types of examples.

Lesson Idea Programme 9:

Pupils could answer the questions observing the
type of other questions observing the histogram.
1. How many marks would have Manu got in Gujarati
   subject?
2. In which subject has Manu got less marks than
   social studies?
3. In which subject has Manu got 60 marks?
4. In which two subjects there is difference of
   5 marks?

Pupils could draw the histogram with the help of
the result of their previous annual examination and could
guess some possible inferences.

Lesson Idea Programme 10:

Pupils could verify the statement
\((x + y) + z = x + (y + z)\) by taking \(x, y, z\) as rational
numbers.

The teacher tried to encourage pupils for fluent
thinking by providing the abovementioned activity.

Pupils could think that the neutral number of
addition for a rational number is 0. Pupils could tell that the opposite number of \( \frac{3}{4} \) is \( -\frac{3}{4} \), the opposite number of \( \frac{9}{7} \) is \( \frac{9}{7} \), etc. Pupils could tell that for every rational number \( X \) there exists \( -X \) such that \( X + (-X) = 0 \) then \(-X\) is the opposite no of \( X \). Thus \( X \) and \(-X\) both are opposite number of each other.

**Lesson Idea Programme 11:**

Pupils could verify that rational numbers are closed with respect to multiplication. They could derive that the result of multiplying two rational number is independent of their order. They could verify "\((X \times Y) \times Z = X \times (Y \times Z)\)" by taking \( X, Y, Z \) as rational numbers. Pupils could tell that the above result is commutative property for multiplication. They could find 1 as a neutral number for multiplication.

**Lesson Idea Programme 12:**

Pupils could answer that the measure of breadth of both the rectangle is same. They could draw one rectangle from the two rectangles so that the breadth of that rectangle remains same. Pupils could verify that the area of this rectangle is equal to \( \frac{3}{2} \left( \frac{5}{2} + \frac{7}{2} \right) \). They could answer that the area of both the rectangles and area of a rectangle is equal. From the illustration \( \frac{3}{2} \left( \frac{5}{2} + \frac{7}{2} \right) = \frac{3}{2} \times \frac{5}{2} + \frac{3}{2} \times \frac{7}{2} \).
pupils could verify the result by placing $\frac{3}{2}$ in place of $\frac{3}{2}$. Pupils could derive the distributive property for multiplication. Pupils could verify the above property by taking different rational numbers.

**Lesson Idea Programme 13:**

Pupils could answer that the inverse number of 5 is $\frac{1}{5}$. Pupils could tell that the inverse of 6 is $\frac{1}{6}$, inverse of $\frac{3}{2}$ is $\frac{2}{3}$, inverse of $-\frac{5}{7}$ is $-\frac{7}{5}$ and inverse of $\frac{1}{10}$ is 10. Pupils could think that the inverse of 0 does not exist. Pupils could answer that the inverse of 1 and -1 is the number itself.

Pupils could define the inverse number. They could derive the following observations by taking different rational number.

1. If X is nonzero rational number then the inverse of X is $\frac{1}{X}$.

2. If $\frac{p}{q}$ is a non zero rational number then the inverse of $\frac{p}{q}$ is $\frac{q}{p}$.

3. One can get the inverse number for every rational number except zero.

**Lesson Idea Programme 14:**

Through this Lesson Idea Programme teacher has explained the unit of power and Index to the pupils.
Teacher has tried to develop their Elaborative thinking and curiosity. The teacher has made them to recognise the Power and Index. First of all Positive Integer was taken up as a base, then teacher provided the chance to the pupils to find out base and Index in \((\frac{3}{2})^6\). To develop Elaborative thinking teacher asked such similar illustrations. Pupils could provide \((\frac{3}{2})^2\), \((\frac{4}{3})^4\), \((-\frac{2}{3})^6\) such examples.

Pupils could get the value of \((-2)^4\) easily. To develop the curiosity teacher has asked them to conclude by taking \(-2\) as base and with different even and odd numbers as Index. Some of the pupils could conclude as below:

1. The value of an odd integral power of a negative number is negative.

2. The value of an even integral power of a negative number is positive.

Pupils could develop their Elaborative thinking for the above conclusions.

With the help of \(2^4 = 16\) pupils could get the result of \(2^0 = 1\).

Thus, they could derive the wonderful result that the zero power of any number is equal to one.
Lesson Idea Programme 15:

Through this lesson idea programme pupils could derive the law of power of a product for positive integer that $a^m \times a^n = a^{m+n}$.

To develop the Flexible thinking teacher has provided the activity for the formation of the various examples and to calculate their values themselves. Pupils could take the value of $m$ and $n$ by their own imagination.

Pupils could develop their flexible thinking by taking various values of 'a' as base.

Lesson Idea Programme 16:

Some of the pupils could derive the following law with the help of Elaborative thinking.

If $X$ is any none zero number and $m < n$ then,

$$X^m \div X^n = \frac{1}{n - m}$$

Pupils could derive the general rule with the combination of three sub rules.

With the help of the abovementioned rule pupils could provide a few examples by using their Elaborative thinking.

e.g. (1) $(\frac{-3}{4})^3 \div (\frac{-3}{4})^2$

(2) $(\frac{1}{2})^3 \div (\frac{1}{2})^3$

(3) $(\frac{6}{7})^5 \div (\frac{6}{7})^7$
Lesson Idea Programme 17:

Some of the pupils could provide the following law of power of a power.

If $X$ is any rational number and $m, n$ positive integer then $(x^m)^n = x^{mn}$

To develop Flexible Thinking teacher has provided the activity to calculate the value of index number by taking different negative numbers as base value.

To develop the curiosity of the pupils teacher has provided the following activity. Pupils were asked to find out the value of index number which any body has not taken for the use of the law of power of a power.

By this way pupils deviate to the Flexible thinking and imagine which type of numbers pupils might have taken for this.

Lesson Idea Programme 18:

Some of the pupil could conclude the law of power of a product as below:

If $X$ and $Y$ are any rational numbers and $m$ is positive integer then,

$$(XY)^m = x^m y^m$$

Pupils could develop their Flexible Thinking by framing different illustrations with taken up negative numbers as a base.
Lesson Idea Programme 19:

Some of the pupils could conclude the law of power of quotient as below:

If \( X \) and \( Y \) are any rational numbers and \( m \) is positive integer then,

\[
\left( \frac{X}{Y} \right)^m = \frac{X^m}{Y^m}, \quad (Y \neq 0)
\]

With the use of abovementioned rule pupils could frame various illustrations as below:

1. \( \left( \frac{2}{3} \right)^3 \), 2. \( \left( -\frac{5}{3} \right)^3 \), 3. \( \left( \frac{5}{6} \right)^2 \), 4. \( \left( \frac{3}{4} \right)^4 \), 5. \( \left( \frac{x}{y} \right)^5 \)

Pupils could take risk of taking negative number as a base.

Lesson Idea Programme 20:

Some of the pupils could get the squares of 0 to 10.

From the observation of the calculative squares of 0 to 10, pupils could develop their curiosity and found a mathematical symmetry shown as below:
Lesson Idea Programme 21:

Some of the pupils could get the expansion of 
(a + b)² is equal to a² + 2ab + b² by their Elaborative thinking.

The pupils could explain this matter in verbal form as below:

\[
(\text{First term} + \text{Second term})^2 = (\text{First term})^2 + 2(\text{First term})(\text{Second term}) + (\text{Second term})^2
\]

To develop the complexity of the pupils the teacher

| 0² | 0 |
| 1² | 1 |
| 2² | 4 |
| 3² | 9 |
| 4² | 16 |
| 5² | 25 |
| 6² | 36 |
| 7² | 49 |
| 8² | 64 |
| 9² | 81 |
| 10² | 100 |
has provided the activity, as to divide the square with length of 5 cm. in 4:1 each side.

Pupils could verify the expansion of \((a+b)^2\) using above activity.

Some of the pupils could derive the expansions of \((a-b)^2 = a^2 - 2ab + b^2\) with the help of expansion of \((a+b)^2\).

**Lesson Idea Programme 22:**

To develop the fluent thinking the teacher has asked them to take \(a=5x\) and \(b=4y\) in \((a+b)^2\). By this way pupils could frame the various examples.

With the help of the formula to calculate the square of 12, pupils could explain 10+2 is the more suitable expression form of 12.

Thus, pupils could express \((102)^2 = (100+2)^2\) and \((99)^2 = (100-1)^2\), pupils could frame such type of various illustrations as \((88)^2\), \((101)^2\), \((64)^2\), \((19)^2\), \((603)^2\) etc.

**Lesson Idea Programme 23:**

Some of the pupils could compare the terms of \((a+b)\) and \((a-b)\).

Pupils could get \((a+b)(a-b)\) as a factor of \(a^2 - b^2\).

Pupils could give the verbal form of \(a^2 - b^2\) as below:

\[
(\text{First term})^2 - (\text{Second term})^2 = (\text{First term} + \text{second term}) (\text{First term} - \text{second term})
\]
To develop the flexible thinking of the pupils, the teacher has asked them to frame various examples of the form \(a^2 - b^2\) and ask them to make factorisation.

Some of the pupils could frame the following types of examples.

1. \((5x - 3y)^2 - (5x + 3y)^2\)
2. \(m^2 - n^2\)
3. \(25^2 - 10^2\)
4. \(16 - y^2\)
5. \(100a^2b^2 - 49\)
6. \(a^2 - b^2c^2\)
7. \(-121x^2 - 16y^2\)
8. \(8^2 - 3^2\)
9. \((9y)^2 - (4x)^2\)

Lesson Idea Programme 24:

Some of the pupils could explain that "If we add 8 in x it becomes 21". This statement was explained in mathematical terms i.e. \(x + 8 = 21\).

Pupils could frame following types of equations as

1. \(a - 12 = 20\)
2. \(7 + x = 15\)
3. \(x + 35 = 5\)
4. \(x - 15 = (-15)\) etc.

To develop the Elaborative thinking, the teacher has asked them to frame various problems. Some of the pupils
could frame problems themselves.

1. If 5 added to one-third of a certain number gives 17, find the number.

2. Find four consecutive natural numbers whose sum is 82.

3. In \( \Delta xyz \), the measures of angles \( \angle x \), \( \angle y \) and \( \angle z \) are \( x \), \( 2x \) and \( 3x \) respectively. Find the measures of all the three angles.

Lesson Idea Programme 25:

The pupils could find out the error from given example by the teacher that Father's age is always greater than son's age.

By using the Elaborative Thinking pupils could frame various problem themselves and could get the solutions.

1. Mahesh's age is seven times Sunil's age. If the sum of their ages is 40 years, find the respective age of both.

2. Father's age is five times his daughter's. If the sum of their age is 48 years, find the age of each of them.

3. Gita's age is more than 15 years than Nita. If the sum of their age is 105 years, find out the age each of them.
This experiment was conducted with a two group design. There were four independent variables each of two levels. $2^4$ factorial design was used. The time schedule and execution of the programme were described in this chapter. The experiences of the investigator, the reactions of the pupils and how the teacher strategies worked were described in detail for each lesson idea programme. The whole programme was completed smoothly and the pupils expressed satisfaction of the teaching.