CHAPTER IV

METHODOLOGY

4.1 Method adopted for the study
4.2 Design selected
4.3 Variables in the experiment
4.4 Sample selected
4.5 Tools and materials employed in the study
4.6 Data collection procedures
4.7 Statistical techniques employed
METHODOLOGY

The methodology occupies a key position in any research process; the researcher in every step feels its relevance. It guides the researcher and keeps him on track from the initial selection and identification of the problem to the final conclusion. A researcher who is aware of the strength, limitation, applicability and appropriateness of the methodology can only succeed in his attempt.

Educational research like any other social science research uses different methods for studying different kinds of educational phenomena. A pre-planned, well-described and well-designed method can only provide the researcher a scientific and feasible plan for attacking and solving the problem under investigation. Methodology outlines the entire research design.

4.1 METHOD ADOPTED FOR THE STUDY

The major objective of the present study is to test the effectiveness of reflective thinking strategy of teaching over conventional method of direct instruction, in secondary school students of Kerala, with special emphasis on certain cognitive and affective variables. After considering the different methods of research, the investigator felt that experimental method is
suitable for conducting the study. Experimental method is a systematic and logical method of hypothesis testing under carefully controlled conditions. An experiment involves the comparison of the effects of a particular treatment with that of a different treatment or of no treatment (Best & Kahn, 2005).

Experiment is the only one means for settling disputes regarding educational practice, the only way of verifying educational improvements, and the only way of establishing a cumulative tradition in which improvement can be introduced without the danger of a faddish discard of old wisdom in favour of inferior novelties. It helps to find out whether one method of teaching is more effective than the other or not. Hence, experimental method was found to be most appropriate for the study and was adopted to compare the effectiveness of reflective thinking strategy of teaching with the conventional method of direct instruction.

4.2 DESIGN SELECTED

Research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure. In fact, the research design is the conceptual structure within which
research is conducted; it constitutes the blueprint for the collection, measurement and analysis of data (Hasounah, 2003).

Research design refers to the plan and structure of the investigation used to obtain evidence to answer research questions. The design describes the procedures for conducting the study, including when, from whom, and under what conditions the data will be obtained. In other words, design indicates how the research is set up: what happens to the subjects and what methods of data collection are used (McMillan & Schumacher, 1989 p.30).

Of the various experimental designs, the pre test – post test non-equivalent group design was found appropriate for the present study and the investigator adopted the same. In the non-equivalent pre test – post test design, subjects were assigned to experimental and control groups by random procedures. A pre test is administered to these two groups as a measure of the dependent variable. After introducing the treatment to the experimental group and maintaining the control group under normal conditions for a specified period of time, both the groups are subjected to the post test to measure the same dependent variable. The difference between the mean pre
test scores and post test scores are found for each group and the significance of the difference of the means is checked with the help of appropriate statistical procedures in order to ascertain whether the experimental treatment produced a noticeable effect. Classroom experiments often use this design where experimental and control groups are intact classroom groups.

In the present school situation, it is practically impossible to upset class schedule to gather subjects for obtaining sufficiently large sample or to reorganise classes in order to employ randomisation procedures for getting equivalent experimental and control groups. Hence, without disturbing the school schedule, intact classroom groups, which are normally non-equated, were selected for the study. To compensate for the lack of equivalence among the groups the investigator applied appropriate statistical techniques.

4.3 VARIABLES IN THE EXPERIMENT

A variable is an event, category, behaviour, or an attribute that expresses a construct and has different values, depending on how it is used in a particular study (McMillan & Schumacher, 1989). Events that can change in value and can be measured are termed as variables. It can be aspects or characteristics; in an
In the present study, the effect of reflective thinking strategy of teaching and conventional method of direct instruction on certain cognitive and affective variables is assessed. Therefore, reflective thinking strategy of teaching and conventional method of direct instruction are referred to as, the independent variables in the present study. In addition, the selected cognitive and affective variables are the dependent variables. ‘Achievement in chemistry’ and ‘metacognitive awareness’ were considered under the head of cognitive variables and ‘innovative attitude’ and ‘fear of success’ were considered under the head affective variables.

The investigator for the present study employed a ‘test on creativity’ to find out whether reflective thinking strategy of teaching is equally effective for students with different levels of creativity. Hence, in the present study creativity is also considered as, an independent variable.

The independent and dependent variables involved in the study are given in table 4.1.
Methodology

Table 4.1
Variables of the study

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Dependent variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reflective thinking strategy of teaching</td>
<td>1. Cognitive variables</td>
</tr>
<tr>
<td>2. Conventional method of direct instruction</td>
<td>a) Achievement</td>
</tr>
<tr>
<td>3. Creativity</td>
<td>b) Metacognitive awareness</td>
</tr>
</tbody>
</table>

2. Affective variables
a) Innovative attitude
b) Fear of success

4.4 SAMPLE SELECTED

A sample is a relatively small subset of a population that is selected to represent or stand in for the population (Heiman, 1995). The population for the study consisted of secondary school students of Kerala following the state syllabus. The investigator decided to adopt random sampling technique. Three VIII standard classes each from (1) Kuriakose Elias English Medium School, Mannanam, Kottayam, (2) St. Dominics High School, Palluruthy, Ernakulam, and (3) Thirumala Devaswom High School, Mattanchery, Ernakulam were selected randomly for the study. Among the six classes (divisions) selected, one each from all the three schools was selected as experimental groups and the other three as control groups. The sample selected was
random and representative of the population. A group of 263 secondary school students selected from the six classes were treated as sample for the study. Due to absence of some students either in the pre test or post test, the sample size had to be reduced to 212. Distribution of the samples selected for the study is given in Table 4.2

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of school</th>
<th>No. of pupils</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Kuriakose Elias English Medium School, Mannanam, Kottayam</td>
<td>46</td>
</tr>
<tr>
<td>2.</td>
<td>St. Dominics High School, Palluruthy, Ernakulam</td>
<td>50</td>
</tr>
<tr>
<td>3.</td>
<td>Thirumala Devaswom High School, Mattanchery, Ernakulam</td>
<td>116</td>
</tr>
</tbody>
</table>

**Total** 212

4.5 **TOOLS AND MATERIALS EMPLOYED IN THE STUDY**

A measuring tool is an instrument that has general acceptance, used for taking measurement in acceptable units (Soman, 2006). The tools and materials employed for the present study are the following:

1. Pre tests –
Methodology

a) Achievement Test in Chemistry

b) Metacognitive Awareness Inventory

c) Test on Innovative Attitude

d) Test on Fear of Success

2. Lesson Transcripts

3. Teaching Materials

4. Reflective Thinking Tool

5. Post tests -

   a) Achievement Test in Chemistry

   b) Metacognitive Awareness Inventory

   c) Test on Innovative Attitude

   d) Test on Fear of Success

6. Test on Creativity

Description of the Tools and Materials

In the present study the investigator prepared most of the tools and materials in consultation with experts, (List of experts is given in Appendix – K) and the research guide. ‘Metacognitive awareness inventory’, ‘test on innovative attitude’, ‘test on fear of success’ and ‘test on creativity’ were adopted by the investigator from reliable sources. The details of the tools and devices are presented below.
1. Pre Tests

The following pre tests were employed by the investigator to assess the entry behaviour of the sample of students regarding dependent variables of the study.

a) Achievement Test in Chemistry

To assess the previous knowledge of the students about the selected topics – ‘solutions’ and ‘acids and bases’ – a standardised achievement test was prepared by the investigator based on these topics of standard VIII of Kerala state syllabus. Before finalising the test items in the achievement test, a draft test was prepared by the investigator.

i) Preparation and Standardisation of Achievement Test

A draft achievement test was prepared by the investigator including, double the number of items intended to be given in the final standardised test. The steps involved in the preparation of the draft test and standardisation procedure is detailed below.
1. Planning of the Test

The first step in the construction of any achievement test is the planning. While planning the test, the main points to be kept in mind are weightage to content, weightage to educational objectives, weightage to form of items, weightage to item difficulty. This was ensured in the preparation of the test by taking the following steps.

i. Preparation of content outline based on analysis of content
ii. Making outline of the educational objectives to be measured
iii. Deciding the type of questions to be used in the test
iv. Determining difficulty level of the test
v. Preparing blueprint based on weightage assigned to content, objectives, and type of items.

Weightage to Contents

Two major units ‘solutions’ and ‘acids and bases’ of standard VIII chemistry, the former assigned to teach in the second term and the latter to the third term of the academic year were selected and analysed. The weightages given to various topics included in the draft test is given in Appendix – L.
**Weightage to Objectives**

Objectives are the main goals and are stated in terms of changes in pupil behaviour. Four objectives – knowledge, understanding, application and skill were tested in the achievement test. Weightages given to objectives in the draft test is given in Appendix – M.

**Weightage to Form of Questions**

In an achievement test, generally three types of items are possible, objective type, short answer type and essay type. In the present study investigator, adopted objective type and short answer type questions. The short answer type questions were sub divided into very short answer type and short answer type. This was to make the test more objective and at the same time allow students freedom of expression. Weightages given to form of questions in the draft test is given in Appendix – N.

**Weightage to Difficulty Levels**

While planning the test the range of difficulty of items had to be measured. The items should be neither too easy nor too difficult, so that the average, below average and above average can go through it. The weightages given to difficulty level in the draft test is given Appendix-O.
Blue Print of the Test

The blue print is a document, which gives a complete functional picture of the test. Blue print of the test indicates weightages for objectives, content, and form of questions. The blue print of the draft test constructed is given in Appendix – P.

2. Preparation of Items for the Draft Test

The items in the test were prepared on the basis of blue print. In preparing the items, opinions of experts and experienced teachers were sought. The prepared test consisted of two sections. First section was based on the topic – ‘solutions’ and the other on – ‘acids and bases’. The test consisted of ‘objective type’, ‘very short answer type’ and ‘short answer type’ questions on both sections. Objective type questions were of three categories – ‘fill in the blank’ (8 items), ‘multiple choice’ (8 items) and ‘match the following’ (10 items) types – each carrying one mark. It also consisted of ‘very short answer questions’ (8 items) carrying one mark and ‘short answer questions’ (8 items) carrying two marks each. Thus, both the sections of the achievement test consisted of 42 questions related to the selected topics. The total marks for each section was 50 and the time allotted for answering each section was 90 minutes.
were no options for answering and all the questions were compulsory. Separate instructions, and details regarding marks were given at the beginning of each part of the question paper. The draft form of achievement test is given in Appendix – Q.

3. Scheme of Evaluation

In order to maintain objectivity in the scoring procedure a scheme of evaluation was made by the investigator. This includes a scoring key for objective type test items and a marking scheme for the short answer type questions. The scoring key and marking scheme for the draft test, showing the number of items and correct answers are given in Appendix – R.

ii) Administration of the Draft Achievement Test

The investigator administered the draft achievement test in order to check the appropriateness of the items in the test. According to Ebel (1966) advance announcement and description of a good test is likely to do more to encourage effective study than the surprise administration of a test.

The investigator selected St. Jude High School, Mukhathala, Kollam for the pilot study. After getting permission from the school
authorities, the investigator with the help of subject teacher administered the test to 200 VIII standard students who have already learned the topics. The two sections of the test were administered separately. The response sheets were collected and scored strictly in accordance with the pre-designed evaluation scheme.

iii) Item Analysis

Item analysis is one of the most important stages in test construction. It indicates items, which discriminate clearly the better and poorer examinees. Item analysis of achievement test usually concentrates on two factors – difficulty index and discriminating power.

The collected answer sheets were arranged in descending order of the total scores. The responses of the high scoring 27 percent and low scoring 27 percent students were used for item analysis. These two groups of students form the criterion groups for item analysis. Selecting criterion groups of “twenty seven percent provides the best compromise between two desirable but inconsistent aims: (1) to make the extreme groups as large as possible and (2) to make the extreme groups as different from one another as possible” (Ebel & Frisbie, 1991, p. 227).

1. Difficulty Index

The difficulty index of each item in the draft test was calculated using the formula;

\[ \text{Difficulty index} = \frac{U + L}{2N} \]
Methodology

2. Discriminating Power

The discriminating power was calculated using the formula

\[
\text{Discriminating power} = \frac{U - L}{N}
\]

Where,

\[U = \text{the number of examinees getting the same item correct in the high group}\]

\[L = \text{the number of examinees getting the same item correct in the low group and}\]

\[N = \text{the number of students in each group (here } N = 54).\]

Items having difficulty index between .25 and .75 and discriminating power above .30 were taken for the final test. The difficulty index and discriminating power of each item are presented in Appendix – S.

iv) Description of the Final Form of Achievement Test

The achievement test prepared gives due weightage to content, objectives, form of questions and difficulty level.

Weightage to Contents

The weightages given to various topics included in the achievement test – ‘solutions’ and ‘acids and bases’ and various sub units are presented in table 4.3.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Units – Topics</th>
<th>Marks</th>
<th>Percentage of marks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Methodology

<table>
<thead>
<tr>
<th></th>
<th>Solutions</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I. Diffusion, Solubility of substances in water, Solute and solvent</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>2.</td>
<td>II. Different states of solutions</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>3.</td>
<td>III. Types of solutions, Solubility</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>4.</td>
<td>IV. Factors influencing solubility</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>5.</td>
<td>V. True solution, suspension and colloid</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td><strong>Solutions - Sub Total</strong></td>
<td><strong>25</strong></td>
<td><strong>50</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Acids and Bases</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6.</td>
<td>I. Neutralisation, Salt formation</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>7.</td>
<td>II. Acids</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>8.</td>
<td>III. Alkalies</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>9.</td>
<td>IV. Bases</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>10.</td>
<td>V. Theories on acids and bases</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>11.</td>
<td>VI. Radicals</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td><strong>Acids and Bases - Sub Total</strong></td>
<td><strong>25</strong></td>
<td><strong>50</strong></td>
</tr>
</tbody>
</table>

|   | **Grand Total** | 50 | 100 |

### Weightage to Objectives

The weightages given to objectives in the achievement test – knowledge, understanding, application and skill are given in table 4.4.
Table 4.4
Weightage to Objectives

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Objectives</th>
<th>Marks</th>
<th>Total marks</th>
<th>Percentage of marks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Solutions</td>
<td>Acids and Bases</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Knowledge</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>2.</td>
<td>Understanding</td>
<td>12</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>3.</td>
<td>Application</td>
<td>6</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>4.</td>
<td>Skill</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>25</strong></td>
<td><strong>25</strong></td>
<td><strong>50</strong></td>
</tr>
</tbody>
</table>

Weightage to Form of Questions

The weightages given to form of questions – objective type, very short answer type and short answer type – in the achievement test are given in table 4.5.

Table 4.5
Weightage to Form of Questions

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Form of Questions</th>
<th>Marks</th>
<th>Total marks</th>
<th>Percentage of marks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Solutions</td>
<td>Acids and Bases</td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Objective type</td>
<td>13</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>2.</td>
<td>Very Short Answer Type</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>3.</td>
<td>Short Answer Type</td>
<td>8</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>25</strong></td>
<td><strong>25</strong></td>
<td><strong>50</strong></td>
</tr>
</tbody>
</table>
Weightage to Difficulty Level

The items having difficulty index in between .25 and .75 were included in the test. The weightages given to easy, average and difficult questions are shown in table 4.6.

Table 4.6
Weightage to Difficulty Level

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Difficulty Level</th>
<th>Marks</th>
<th>Total</th>
<th>Percentage of marks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Solutions</td>
<td>Acids and Bases</td>
<td>Total marks</td>
</tr>
<tr>
<td>1. Easy</td>
<td></td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>2. Average</td>
<td></td>
<td>15</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>3. Difficult</td>
<td></td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>25</td>
<td>25</td>
<td>50</td>
</tr>
</tbody>
</table>

Blue Print of the test

The blue print which gives a complete picture of the final form of the achievement test constructed is given in table 4.7.
Table 4.7

Blue print of the Achievement Test in Chemistry

<table>
<thead>
<tr>
<th>Content</th>
<th>Form of Question</th>
<th>Knowledge</th>
<th>Understanding</th>
<th>Application</th>
<th>Skill</th>
<th>Sub Total</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>V</td>
<td>S</td>
<td>O</td>
<td>V</td>
<td>S</td>
</tr>
<tr>
<td>I</td>
<td>(1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(19)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(2)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(20)</td>
</tr>
<tr>
<td>II</td>
<td>(10)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(16)</td>
</tr>
<tr>
<td></td>
<td>(12)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(15)</td>
</tr>
<tr>
<td>III</td>
<td>(9)</td>
<td>-</td>
<td>(3)</td>
<td>-</td>
<td>(4)</td>
<td>(5)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(11)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sub Total</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>12</td>
<td>6</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acids and Bases</td>
<td>I</td>
<td>(1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(13)</td>
<td>(17)</td>
</tr>
<tr>
<td></td>
<td>(9)</td>
<td>-</td>
<td>(2)</td>
<td>-</td>
<td>(6)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(10)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(5)</td>
<td>(19)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(11)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(3)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(12)</td>
<td>-</td>
<td>-</td>
<td>(4)</td>
<td>(16)</td>
<td>-</td>
<td>(7)</td>
</tr>
<tr>
<td></td>
<td>(13)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(18)</td>
<td>(8)</td>
</tr>
<tr>
<td>Sub Total</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>12</td>
<td>6</td>
<td>2</td>
<td></td>
<td></td>
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<td>24</td>
<td>12</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The abbreviations and notations used in the blue print are explained below.

(#)* Number inside the bracket (#) denotes item number and the number outside the bracket ( )* denotes mark for the item.
Methodology

O – Objective type questions;

V – Very short answer type question

S – Short answer type question

Solutions

I – Diffusion, Solubility of substances in water, Solute and solvent

II – Different states of solutions

III – Types of solutions, Solubility

IV – Factors influencing solubility

V – True solution, suspension and colloid

Acids and bases

I – Neutralisation, Salt formation

II – Acids

III – Alkalies

IV – Bases

V – Theories on acids and bases

VI – Radicals

Thus, the final form of the achievement test used in the present study consisted of two sections with 21 items in each. The maximum score for each section is 25 marks and the time for the test was fixed as 40 minutes for each section. The final form of
the achievement test is given in Appendix – C and scoring key and marking scheme are given in Appendix – D.

Reliability of Achievement Test

Test reliability refers to “the consistency of scores obtained by the same person when retested on different occasions or with an equivalent form of the test” (Deighton, 1971, p. 393). Reliability of the test is usually expressed by the coefficient of correlation which is called reliability coefficient. Here, the reliability of the test was established by using split-half method. A sample of 100 students was used for the purpose. Here all the even numbered items in the answer sheets were treated as one half of the test and all the odd numbered items were treated as the second half and scored separately. The total scores for the even numbered and odd numbered items in the test were computed separately for each student. The two sets of scores obtained were correlated and the reliability of the half test was found to be .64, from this, the reliability of the whole test was found out using Spearman Brown Prophecy formula.

That is \( R = \frac{2r}{1+r} \), where \( R \) is the reliability of the test and \( r \) is the reliability of the half test.

Thus reliability of the test \( = \frac{2 \times .64}{1+.64} = .78 \).
Validity of the Achievement test

The content validity and empirical validity of the test was established.

Content Validity

Content validity involves the systematic examination of the test content to determine whether it covers a representative sample of the behaviour domain to be measured. The test was framed by the investigator keeping in view the weightages given for content and objectives on one hand and suggestions and opinions of experts on the other. Thus, the content validity of the test was presumed to be established.

Empirical Validity

The empirical validity of the test was calculated by correlating the test scores of 100 students with their marks of a recently conducted test obtained from the school. The coefficient of correlation obtained was .72. This value establishes the empirical validity of the test.

b) Metacognitive Awareness Inventory (MAI)

For the present study to assess the metacognitive awareness of students at the entry level, the investigator adopted a ‘metacognitive awareness inventory’ (given in Appendix – E) prepared and standardised by Schraw and Dennison (1994). The details of the MAI are given below.
Description of Metacognitive Awareness Inventory

This MAI consisted 52 items to assess students’ metacognitive awareness. The two main components of metacognition, ‘knowledge about cognition’ and ‘regulation of cognition’ are studied using the inventory. Seventeen items are related to ‘knowledge about cognition’ and 35 items are related to ‘regulation of cognition’. Items regarding various aspects of the first component knowledge about cognition, such as declarative knowledge (8 questions), procedural knowledge (4 questions) and conditional knowledge (5 questions) were included in the inventory. Items based on the various aspects of the second component regulation of cognition – planning (7 questions), information management strategies (10 questions), comprehension monitoring (7 questions), debugging strategies (5 questions) and evaluation (6 questions) are also included in the inventory. The distribution of items in the inventory are presented in Table 4.8.
Table 4.8

Distribution of Items in the Metacognitive Awareness Inventory

<table>
<thead>
<tr>
<th>Component</th>
<th>Aspect</th>
<th>Item Nos.</th>
<th>No. of items</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge about cognition</td>
<td>Declarative knowledge</td>
<td>5,10,12,16,17,20, 32,46</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Procedural knowledge</td>
<td>3,14,27,33</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Conditional knowledge</td>
<td>15,18,26,29,35</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Regulation of cognition</td>
<td>Planning</td>
<td>4,6,8,22,23,42,45</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Information management</td>
<td>9,13,30,31,37,39, 41,43,47,48</td>
<td>10</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Comprehension monitoring</td>
<td>1,2,11,21,28,34,49</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Debugging strategies</td>
<td>25,40,44,51,52</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluation</td>
<td>7,18,24,36,38,49</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Grand total</td>
<td></td>
<td></td>
<td></td>
<td>52</td>
</tr>
</tbody>
</table>

Scoring of Metacognitive Awareness Inventory

The items of MAI are statement type, the responses of which are to be entered on a seven-point scale. The response – ‘not at all true of me’ is given a score of 1 and the response – ‘very true of me’ is given a score of 7. If the response lie in between these two ranges it can be given scores 2, 3, 4, 5, 6
Methodology

accordingly. The maximum score that can be attained by an individual for MAI is 364 (52 x 7) and the minimum score is 52 (52 x 1).

Reliability of Metacognitive Awareness Inventory

Reliability refers to the degree to which observations of a study are repeatable. The Cronbach alpha reliability coefficient of the Metacognitive Awareness Inventory devised by Schraw and Dennison (1994) is .90 as given in the test manual.

Validity of Metacognitive Awareness Inventory

The concept of test validity pertains to “what the test measures and how well it does so” (Deighton, 1971, p. 393). The manual of the tool makes it vivid that the content validity of the test was ensured. In other words validity refers to the degree to which content is measured accurately that reflects the concept it is intended to measure.

c) Test on Innovative Attitude

Innovative attitude is an important affective variable which is inevitable for the present day learner as education is considered as the generation of knowledge. In this process, the learner has to device his own ways and means for knowledge
construction; the learner has to know how to learn. Innovative attitude is an index of the learners’ potential to involve and contribute to the construction of knowledge by him/her. To quantify the innovate attitude of students, a test on innovative attitude prepared and standardised by Sanghi (2002) was adopted for the present study. It consists of 10 items to assess one’s receptivity to innovation. The test on innovative attitude used in the present study is given in Appendix – F.

Scoring of Test on Innovative Attitude

The test on innovative attitude uses a 5-point Attitude scale. Scores 5, 4, 3, 2 and 1 are given to the responses – ‘Always’, ‘Often’, ‘Do not know’, ‘Seldom’ and ‘Never’. Thus the maximum score one can obtain is fifty (5 x 10) and minimum score is ten (1 x 10). The total scores obtained for the ten statements indicate one’s degree of innovative attitude.

Reliability of the Test on Innovative Attitude

The reliability of the test on innovative attitude was found out using split half method. The test was administered to a sample of 100 students and the responses were collected. The
total scores for the even numbered and odd numbered items in
the test were computed separately for each sample. Thus two
lists of scores were obtained and the Pearson correlation
coefficient for these scores was calculated. This corresponds to
the reliability of the half test and found to be .77. From this, the
reliability of the whole test was found out using Spearman-Brown
prophecy formula.

That is $R = \frac{2r}{1+r}$, where $R$ is the reliability of the test and
$r$ is the reliability of the half test. Thus reliability of the test =
$2 \times .77/1+.77 = .87$ (Sanghi, 2002).

**Validity of the Test on Innovative Attitude**

The test manual gives the validity of the test on innovative
attitude as .81.

d) **Test on Fear of Success**

To be a winner in the present day, a learner has to be free
from anxiety about his/her accomplishment. That is he or she
should possess low level of fear of success. To assess the fear of
success of students, a ‘test on fear of success’ prepared and
standardised by Sanghi (2002) was adopted by the investigator
for the present study. The test consists of 10 items to assess
one’s subconscious fear of success. The test on fear of success employed in the present study is given as Appendix – G.

**Scoring of Test on Fear of Success**

The test consists of ten statements. The respondents have to indicate their agreement towards each of the statements by giving responses agree, between /do not know and disagree. The scoring key for the test on fear of success is given as Appendix – H.

The total score for the test on fear of success is obtained by adding the scores for all the statements. Thus, a respondent can obtain a maximum score of 15 and a minimum score of −11. High total scores for the test indicate low fear of success.

**Reliability of the Test on Fear of Success**

The reliability of the ‘test on fear of success’ was found out employing split half method. The test was administered to a sample of 100 students and the responses were collected. The total scores for the even numbered and odd numbered items in the test were computed separately for each sample. Thus, two lists of scores were obtained and the Pearson’s correlation coefficient for these scores was calculated. This corresponds to
the reliability of the half test and found to be .76. From this, the reliability of the whole test was found out using Spearman-Brown prophecy formula.

That is \( R = \frac{2r}{1+r} \), where \( R \) is the reliability of the test and \( r \) is the reliability of the half test. Thus reliability of the test = \( 2 \times .76 / 1 + .76 = .86 \) (Sanghi, 2002).

**Validity of the Test on Fear of Success**

The test manual gives the validity of the test on fear of success as .79.

2. Lesson Transcripts

a) **Lesson Transcripts for Reflective Thinking Strategy of Teaching**

The experimental group was taught through reflective thinking strategy of teaching. The investigator prepared lesson transcripts for conducting classes in the experimental group by reflective thinking strategy of teaching. Two chapters from the standard VIII science text book of Kerala ‘solutions’ and ‘acids and bases’ were selected for the preparation of lesson transcripts. Ten lesson transcripts were prepared for the first unit ‘solutions’ and twelve lesson transcripts for the second unit ‘Acids and Bases’.
Lesson transcripts for the reflective thinking strategy of teaching was prepared in consultation with experts in the field. The valuable suggestions from the expert educationists helped a lot in preparing the lesson transcripts. The lesson transcripts used in the present study are given in Appendix – A.

**Pilot Study**

A pilot study was conducted not only by preparing lesson transcripts on the topic ‘water’ which is included just before the unit ‘solutions’ of VIII standard chemistry but also by teaching the students with the help of that lessons. This pilot study was conducted for the same students to whom experimental treatment is to be given, thus the experimental group students of the three schools were pilot tested. This was done to find out and avoid the technical difficulties that may arise while administering this particular strategy, as well as to make the students familiar with the strategy well before the actual experiment and also to find out how the students respond to this strategy.

Suggestions from experts, as well as those of students who participated in the pilot study were made use of in preparing lesson transcripts on the topics ‘solutions’ and ‘acids and bases’ for experimentation. The pilot study gave the investigator insight on the need for a longer treatment and it was realised by taking two consecutive topics of VIII standard chemistry that belonged to the
second and third terms of the years study. The pilot study helped the investigator experience the need for taking up small content areas for a day’s lesson and this was accomplished by dividing the units into small manageable topics. Thus from the insights and experiences gained in the light of the pilot study the investigator prepared a total of twenty two lesson transcripts from two units of study ten from ‘solutions’ and twelve from ‘acids and bases’ for this study.

**Description of Lesson Transcripts Prepared**

Lesson transcripts were prepared based on reflective thinking strategy of teaching following the concept shared by John Dewey on reflective thinking. According to Dewey the role of reflection is to regulate the dialectic relationship between knowing and acting, and reflective thinking is a tool for problem resolution and operates through the progressive cycle of inquiry.

Dewey (1933) postulated five phases of reflective thinking that might vary in duration with the type of inquiry and can overlap in time. The five phases suggested were problem recognition; enumeration of possibilities of new actions or beliefs; evaluation of the possibilities through consulting memory, questioning, or experimenting; revision of possibilities; decision-making on next appropriate actions. Dewey again
characterised reflection as comprising five phases that need not necessarily occur in any particular order but should fit together to form the process of reflective thinking. The five phases were suggestions, problem, hypothesis, reasoning and testing.

The investigator designed the lesson transcripts keeping in view these concepts proposed by Dewey about reflection. The general format of the lesson plans prepared for the study is presented below.

A) General information: details about the grade, subject, unit, topic and duration.

B) Content overview: gives an overview of the day’s lesson

C) Objectives: specify the objectives of the day’s class

D) Strategy employed: outlines the teaching learning strategy adopted for the day’s lesson

E) Resources or materials: presents the resources and materials needed for the day’s practices

F) Activities and procedures: details the flow of action of teaching learning process under four heads. They are:

➢ **Getting started**: (Problem, or problem recognition) - this is the introductory stage; it helps learner begin the day's work – it may be by way of a puzzling activity, a demonstration, a story,
an anecdote or something that makes the child’s mind inquiring. An example taken from one of the lesson transcript is given below:

Teacher begins the class by asking students – Have you seen cautions on sacks and cartons saying protect from water? – What do you infer from this?

➢ **Reflective thinking session**: (hypothesis, reasoning, or enumeration of possibilities of new actions or beliefs) – helps the learner reflect on the problem recognised. The pupil at this stage gets involved in reflective activities individual, group, cooperative or teacher initiated, depending on the content dealt in the day’s lesson. Individual activities include – think aloud/journaling or log. Group activities include – group discussion/ experimentation/brainstorming/buzz session. Cooperative activities include – team pair solo/think pair share. Teacher initiated activities include – demonstration/probing question/puzzling experience. Examples for all the above-mentioned activities from various lessons are presented below.

 ✓ **Individual Activities**: Here reflections takes place by ones own thought processes – stress is on individual reflections.
**Methodology**

**Think Aloud:** Students are asked or allowed to think individually and find out things that are to be protected from water, they are asked to find out substances other than water that is made use of in our life to dissolve things.

**Journaling or Log:** Students are asked to think individually and write down in their science diary the preparation of any one of the solutions they have made.

**Group Activities:** Here reflections takes place by interactions with group members – stress is on group reflections.

**Group Discussion:** Teacher invites attention of students to acids that are familiar to them and ask them to discuss in groups about their common properties.

**Experimentation:** Students are provided with 2ml of milk and oil, they are asked to prepare solutions of both in 20ml water; students are now asked to observe the solutions for a few minutes and note down the properties of the prepared solutions.

**Brain Storming:** Teacher invites attention of students towards a rusted iron nail, teacher asks one or two students to come forward and clean it using lemon and watch out what happens! A brain storming session held based on the above experience helps
students understand that reactions take place between metal oxides and acids.

**Buzz Session**: Students are grouped and they are supplied with materials and are asked to prepare solutions with the supplied materials. Now the students are asked to discuss in their buzz groups and find out the essential constituents in a solution and the quantity of the constituents.

✓ **Cooperative Activities**: Here reflections takes place by cooperative efforts – stress is on shift of reflection from group to individual.

**Team Pair Solo**: Students by team pair solo activity are asked to interpret the graph and prepare a note on the nature of change they observe in solubility with temperature for different substances.

**Think Pair Share**: Students are asked to think individually, then discuss in pair the significance of getting things dissolved and on the reason for solubility and insolubility of substances. The ideas gained are then shared with other members of the class.
Teacher Initiated Activities: Here reflections are facilitated by the effort of teacher – stress is on the role of teacher in helping students reflect.

Demonstration: Teacher demonstrates neutralisation reaction and helps students understand the process of neutralisation.

Probing question: Students you might have said a hundred times ‘Oh! Ma…… you have spoiled this curry….. you should be careful while adding salt’ – why or what makes you say this? If it is less then also you will call out ..........

Puzzling experience: Teacher invites attention of students to a dancing egg in a glass jar, teacher helps students find the reason behind the flotation of egg.

Assessment: (testing or evaluation of the possibilities through consulting memory, questioning, or experimenting) – this stage give importance for classroom interactions as well as silence. Classroom interactions include pupil - pupil interactions, teacher - pupil interactions or teacher - group interactions. Silence gives pupils chance to have individual reflections by one’s own thought processes or by putting thoughts in paper by journaling. An example taken from one of the lesson transcripts is given below:
Teacher by way of questions like - from where and how does the fish in water get oxygen? - helps students to focus their attention on substances that dissolve things and substances that gets dissolved and help them realise the importance of this phenomena in our life.

➢ **Tying it all together**: (suggestions, or revision of possibilities) - this study at the final stage employs a reflective thinking tool and, help learners have deliberate and systematic individual reflections on the lesson. An example taken from one of the lesson transcript is given below.

Students at this stage with reflective thinking tool systematically and individually reflect on, objectives of the days lesson, their understanding, application of their learning, skill acquired on the day, classroom interactions, their feeling and motivation, necessary changes they want in the next class etc.

**b) Lesson Transcripts for Conventional Method of Direct Instruction**

The control group was taught through conventional method of direct instruction. The investigator took classes in the chalk and talk mode in the control groups. Lesson transcripts were devised for this mode of teaching on the topics ‘solutions’ and
‘acids and bases’ of standard VIII chemistry selected for experimentation. Teaching of control groups by conventional method of direct instruction was done for the same span of time parallel to the teaching done in the experimental group.

3. Teaching Materials:

Reflective thinking strategy of teaching made use of different kinds of teaching materials for the smooth conduct of the classes. The teaching materials used for each lesson is given in the lesson transcripts under the head – resources/materials. The materials used were classified into three: Apparatus, consumables and improvised aids.

An example for resources/materials used for the topic true solution, suspension and colloid

Apparatus: Test tubes (10ml, 20 Nos.); Wash bottle (5 Nos.); Test tube stand (5 Nos.); Funnel (5 Nos.); Beaker (100ml, 5 Nos.).

Consumables: Filter paper, water – 1 Litre, NaCl - 100g starch powder - 100g; CaSO₄ - 100g, talcum powder, milk powder, sugar, tooth paste.

Improvised aids: Chart to help pupil enumerate the properties of true solution, colloid and suspension.
4. Reflective Thinking Tool

A reflective thinking tool (Appendix – B) developed by the investigator to prompt students think reflectively was made use of in the present study. The tool developed supported classroom instructions in reflective thinking strategy of teaching. The tool was developed based on the perspectives of previous research works (King, 1991; Schraw, 1998; Sternberg, 1998; White & Frederiksen, 1998; Lin & Lehan, 1999; Moon, 1999) on reflective thinking and learning strategies for enhancing knowledge and skills. The investigator also sought consultation and help from experts to formulate the tool.

Try Out

The reflective thinking tool developed was tried out along with the pilot study conducted using the topic ‘water’. The investigator carefully monitored the opinion and responses of students. The responses of the students confirmed its effectiveness. The tool devised was used as such for the experimental study to facilitate a deliberate and systematic student reflection about each topic dealt in the class.
Description of the tool

At the beginning of the tool information such as, name of student, roll number, name of school, standard, division, topic of the day and date are sought. The tool consisted of ten major questions and eight question prompts based on the seven targets for reflection – learning objectives, understanding, application, skill, classroom interaction, feeling and motivation, change. The targets and its aspects are explained in table 4.9.

Table 4.9

Targets for Reflection in Reflective Thinking Tool

<table>
<thead>
<tr>
<th>Targets</th>
<th>Aspect for reflection</th>
<th>Item No.</th>
<th>Type of items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning objectives</td>
<td>Objectives of the days lesson</td>
<td>1.</td>
<td>Open ended 3 point scale</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.</td>
<td>Open ended</td>
</tr>
<tr>
<td>Understanding</td>
<td>What was learned on the days lesson</td>
<td>3.</td>
<td>Open ended 3 point scale</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.</td>
<td>Open ended</td>
</tr>
<tr>
<td>Application</td>
<td>Possibility of applying the concept/idea gained on the day in new situations</td>
<td>5.</td>
<td>3 point scale</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Open ended</td>
</tr>
<tr>
<td>Skill</td>
<td>Activities of the day that helped in skill development</td>
<td>6.</td>
<td>Choice type</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Open ended</td>
</tr>
<tr>
<td>Class room interaction</td>
<td>Interaction with peers and teachers</td>
<td>7.</td>
<td>3 point scale</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.</td>
<td>Open ended</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 point</td>
</tr>
</tbody>
</table>
The tool intended to focus students attention on the topic they learned and help them reflect. It employs a self-assessment and question prompt format.

The self-assessment serves as a starting point for supporting student's reflection on each theme by evaluating each theme using a 3-point scale, scoring 3, 2 and 1 in terms of - How well they did?. An example for, a self-assessment in this tool asks students - 'Did your interaction with peer's help you better understand the concepts, ideas and skills in today's class?' - which gets scored 1, 2 or 3. The question prompt following the self-assessment helps students reflect deeply and assess on the response they made on the self-assessment in the targeted areas. For example, question prompt asks students - ‘Why do you think so? Give your specific reasons’.

A Frame Work of Reflective Thinking Tool
The reflective thinking tool used promoted learner reflection on the targeted areas and helped learners develop as a reflective practitioner. This tool helps learners construct new perspectives in learning by actively engaging them in reflective practices. An illustration of the tool is given in Figure 4.1.

**Figure 4.1**

*An Illustration of Reflective Thinking Tool*

5. Post Tests

The following post tests were employed by the investigator to assess the terminal behaviour of the sample of students regarding dependent variables of the study.
\textbf{Methodology}

\textit{a) Achievement Test in Chemistry}

To assess the gain in knowledge of students on the topics - ‘solutions’ and ‘acids and bases’ – of standard VIII of Kerala state syllabus the achievement test prepared and standardised by the investigator, was used. The test used here as post test is the same one that was implemented as pre test.

\textit{b) Metacognitive Awareness Inventory}

To assess the metacognitive awareness of students after the treatment the investigator applied the Metacognitive Awareness Inventory (MAI) prepared and standardised by Schraw and Dennisons (1994), as post test. This test is the same one administered as pre test in the study.

\textit{c) Test on Innovative Attitude}

To quantify the innovative attitude of students after the treatment on innovative attitude - one’s receptivity to innovation the test prepared and standardised by Sanghi (2002) was administered as post test. This test is the same one administered as pre test in the present study.

\textit{d) Test on Fear of Success}
To assess one’s subconscious fear of success after the treatment, the test prepared and standardised by Sanghi (2002) was administered by the investigator as post test. This is the same test used as pre test for the present study.

6. Test on Creativity

One of the important objectives of the present study was to establish the universal effectiveness of reflective thinking strategy of teaching on students with varying levels of creativity. Creativity is the ability of an individual for divergent thinking. To assess the level of creativity of students in the experimental group in the present study a test on creativity prepared and standardised by Sanghi (2002) was adopted and administered, by the investigator. The test on creativity adopted for the present study is given as Appendix – I.

Scoring of Test on Creativity

The test consists of fifteen statements. The respondents have to indicate their agreement towards each of the statements by giving responses agree, between/do not know and disagree. The scoring key of the test is given as Appendix – J.
The total score for the test on creativity is obtained by adding the scores for all the statements. Thus, a respondent can obtain a maximum score of 30 and a minimum score of zero. Based on the scores creativity is assessed. High total scores for the test indicate high creativity.

**Reliability of the Test on Creativity**

The reliability of the test on creativity was found out employing split half method. The test was administered to a sample of 100 students and the responses were collected. The total scores for the even numbered and odd numbered items in the test were computed separately for each sample. Thus two lists of scores were obtained and the Pearson correlation coefficient for these scores was calculated. This corresponds to the reliability of the half test and found to be .80. From this, the reliability of the whole test was found out using Spearman-Brown prophecy formula.

That is $R = \frac{2r}{1+r}$, where $R$ is the reliability of the test and $r$ is the reliability of the half test. Thus reliability of the test $= 2 \times .80 / 1 + .80 = .89$ (Sanghi, 2002).

**Validity of the Test on Creativity**
The test manual gives the validity of the test on creativity as .86.

4.6 DATA COLLECTION PROCEDURES

The study conducted aimed to experiment on the effectiveness of reflective thinking strategy of teaching over conventional method of direct instruction on certain cognitive and affective variables among secondary school students. The procedure adopted for the collection of data is given below:

4.6.1 Administration of Pre Tests

The investigator obtained the permission for the conduct of study from the authorities of the selected schools. The achievement test prepared and standardised by the investigator, related to the units - solutions and acids and bases of VIII standard chemistry was administered to the students of both the control group and experimental group in the selected schools. The test was administered in continuation with the pilot study on water and gaining necessary rapport with the students.

Similarly, all the other pre tests - metacognitive awareness inventory, test on innovative attitude and test on fear of success
were applied to the experimental and control groups in the selected schools.

The responses for all the tests were scored in accordance with the pre designed evaluation scheme. The scores obtained by the students were used for further analysis.

4.6.2 Classroom Transactions

The study comprised of two groups experimental and control. The experimental group was instructed through reflective thinking strategy of teaching. The control group was taught through conventional method of direct instruction. The treatments given to both of these groups are described below.

a) Learning by Experimental Group

After the pre test procedures, the investigator described the modus operandi of reflective thinking strategy of teaching and the way to make use of the reflective thinking tool after each class and also briefed about the contents to be studied using the new strategy.

Classroom Instructions for Reflective Thinking Practice
The investigator explained to students in the experimental group the theme of reflective thinking strategy of teaching. At the outset, the investigator discussed and explained the activities and procedures, concerning reflective practices that come in the course of the experiment. Secondly, the role of reflective thinking tool and the way to apply the tool in the classroom were explained to the students.

The investigator was cautious enough to give instructions immediately whenever he felt it needy. The investigator also paid attention to explain the activities used to promote reflection of students, whenever presented for the first time. Utmost care was taken to keep students in the track of reflective thinking strategy of teaching all through out the study.

The reflective thinking tool developed was administered immediately after each class. The tool helped students for their reflective activities, writing down their reflections and for review during the course of learning by reflective thinking strategy of teaching.

The investigator taught the experimental groups, the unit solutions of VIII standard chemistry based on the prepared lesson transcripts. During the process, the investigator made use
of various learning strategies and materials appropriate for the topic taken on each day. At the end of each class, students were enabled to make deliberate and systematic reflections on the topic dealt on the day using reflective thinking tool. Thus all the lessons in the unit – ‘solutions’ were taught to the experimental group.

As a second phase the unit – ‘acids and bases’ was taught to the experimental group following the same pattern used for the previous unit. The experiment was conducted in the second and third terms of the academic year to get adequate time for practice in the strategy.

b) Learning by Control Group

After administering all the pre tests the control group was taught the units ‘solutions’, and ‘acids and bases’ of standard VIII chemistry through conventional method of direct instruction. The time taken for conducting the teaching was same as that taken for experimental group. Equal efforts and interest were taken to complete the teaching of the control group as in the experimental group.

4.6.3 Administration of Post Test
Immediately after the completion of teaching in both the experimental and control groups, the investigator administered the post tests. The achievement test in chemistry, metacognitive awareness inventory, test on innovative attitude, and test on fear of success were administered to both the groups. The same tests used as pre tests were given here as post tests. Prior information regarding the date of conducting the tests was given and the tests were administered to both the groups on the same days under the supervision of the investigator. The responses for all the post tests were scored strictly in accordance with the pre designed evaluation scheme. The scores obtained after evaluation of the answer sheets were subjected to statistical analysis.

4.6.4 Administration of Test on Creativity

A test on creativity prepared and standardised by Sanghi (2002) was administered by the investigator to the students of the experimental group during the course of study to assess their level of creativity. The answer sheets were scored according to the scoring key and the scores of 106 students were taken for further analysis – to compare the gain in achievement scores of students having high, average and low levels of creativity.
The experimental procedure adopted for the study is diagrammatically represented in figure 4.2.

**Figure: 4.2**

**EXPERIMENTAL PROCEDURE ADOPTED FOR THE STUDY**
4.7 STATISTICAL TECHNIQUES EMPLOYED

Since the aim of the study was to test the effect of reflective thinking strategy of teaching over conventional method of direct instruction, it became necessary to find out whether there was any significant difference between the post tests scores of experimental group and control group. For this, the achievement test scores for pre tests and post tests of pupils in experimental and control groups were subjected to the following statistical techniques.

1. Mean

2. Standard Deviation

3. Critical Ratio

4. Analysis of Variance

5. Analysis of Covariance

The formulae used were:

\[ \bar{X} = \frac{\sum fx}{N} \]
Methodology

Where;

\[ \bar{X} = \text{arithmetic mean} \]

\[ \sum = \text{sum} \]

\[ f = \text{frequency of the class interval} \]

\[ x = \text{mid-value} \]

\[ N = \text{total number of Scores} \]

\[ \text{STANDARD DEVIATION} \]

\[ SD = \sqrt{\frac{\sum f d^2}{N} - \left( \frac{\sum fd}{N} \right)^2} \]

Where;

\[ c = \text{class interval} \]

\[ d = \text{deviation in terms of class interval} \]

\[ N = \text{number of scores} \]

\[ f = \text{frequency} \]

\[ \text{CRITICAL RATIO} \]

\[ CR = \frac{M_1 - M_2}{\sigma_n} \]
Methodology

Where;

\[ M_1 = \text{mean of the first sample.} \]

\[ M_2 = \text{mean of the second sample.} \]

\[ \sigma_n = \text{standard error of the difference between the means.} \]

**STANDARD ERROR (\( \sigma_n \))**

\[ \sigma_n = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}} \]

Where;

\[ \sigma_1 \text{ and } \sigma_2 = \text{standard deviation of the groups} \]

\[ N_1 \text{ and } N_2 = \text{sizes of the two samples} \]

❖ **ANALYSIS OF VARIANCE (ANOVA)**

The analysis of variance is an effective way to determine whether the means of more than two samples are too different to attribute to sampling error. It involves the calculation of ‘F’ ratio. ‘F’ is calculated as follows.

\[ F = \frac{M_{sb}}{M_{sw}} \]
Methodology

Where,

\[ \text{MS}_b = \text{mean squared between} \]

\[ \text{MS}_w = \text{mean squared within} \]

\[ \text{MS}_b = \frac{\text{SS}_b}{\text{df}_b} \]

\[ \text{SS}_b = \frac{(\sum X_1)^2}{n_1} + \frac{(\sum X_2)^2}{n_2} + \ldots - \frac{(\sum X)^2}{N} \]

Where,

\[ \text{SS}_b = \text{between groups sum of squares} \]

\[ n = \text{the number of subjects in a group} \]

\[ N = \text{the number of subjects for all the groups combined} \]

\[ \text{df}_b = K-1, \]

Where,

\[ K \] is the number of groups.

\[ \text{MS}_w = \frac{\text{SS}_w}{\text{df}_w} \]

\[ \text{SS}_w = \frac{\sum X_1^2 - (\sum X_1)^2}{n_1} + \frac{\sum X_2^2 - (\sum X_2)^2}{n_2} + \ldots + \frac{\sum X_i^2 - (\sum X_i)^2}{n_i} \]

Where,

\[ \text{SS}_w = \text{within group sum of squares} \]

\[ \text{df}_w = n_1 + n_2 + \ldots - K, \]
Where,

\[ K \] is the number of groups.

Also,

\[ SS_w = SS_t - SS_b \]

Where,

\[ SS_t = \frac{\sum X^2 - (\sum X)^2}{N} \]

(Best, & Kahn 2005)

**ANALYSIS OF CO-VARIANCE (ANCOVA)**

Since the experiment was conducted using intact, unequated classroom groups, the technique of Analysis of Co-variance was applied for analysing the data. Through Co-variance analysis one is able to effect adjustments in final or terminal scores which allow for difference in some initial variable.

ANCOVA (Analysis of Co-variance) is a powerful statistical tool for the test of significance. It represents an extension of ANOVA (Analysis of Variance) to allow for the correlation between the initial and final scores. The main objective of ANCOVA is to examine whether there is any significant difference between the class means in view of inherent variability within separate classes. ANCOVA involves nine major steps.