CHAPTER III
METHODOLOGY

3.1 Introduction

Research is a systematic and scientific approach to solve a problem. Research has been defined as, the systematic and objective analysis and recording of controlled observations that may lead to the development of generalizations, principles or theories, resulting in prediction and possibly ultimate control of event (Best and Kahn, 2006).

Methodology is the procedure used by the investigator in conducting the study. It refers to the activity of collecting information in an orderly and systematic fashion. According to Barr (1960) “the machinery of methodology occupied a very important position in any kind of research”. The vehicle of research cannot perform its function without it. The success of any research depends largely upon the techniques the researcher follows to gather adequate data.

The successful outcome of the research depends upon methodology adopted. The selection of method for research work depends upon the tools and techniques that the researcher uses. There are several methods available to research workers in the matter of data collection. Taking into account the need and objectives of the research problem, the nature of the subjects involved in the study and such factors as time and cost, the final decision on the procedure is made (Siddhu, 2003).

The method selected should always be appropriate to the nature of the problem under investigation and the kind of data that the problem demands. The validity and reliability of the research findings also depend on the method adopted for the research work.

3.2 Method Adopted for the Study

The research method is a strategy of enquiry, which moves from the underlying assumptions to research design, and data collection (Myers, 2009). The present study aims to find out “The Effect of the Brain-Based Learning Strategy on the Academic Achievement and Creativity among Secondary School Students”. The investigator has adopted experimental method for the study. “A test under controlled conditions that is made to demonstrate a known truth or examine the validity of a hypothesis is experimental method” (Muijs, 2004).
3.2.1 Research Design

Outline of the experimental design followed in the present study is detailed in the flowchart (Figure 3.1).

Figure 3.1 Outline of the Research Design
3.2.2 Experimental design

Experimental design is the blueprint of the procedure that enables the researcher to test the hypotheses by reaching valid conclusions about the relationships between independent and dependent variables. The selection of a particular design depends upon such factors as the nature and the purpose of the experiment, the type of variables to be manipulated, the nature of the data and the facilities or the conditions for carrying out the experiment (Koul, 2009).

“Often in educational research, it is simply not possible for investigation to undertake true experiments” (Cohen et al., 2011). It is difficult to establish comparable experimental and control groups and is very difficult to get the exact identical groups in social sciences. True experimental design is rarely feasible with human beings as human life situations are dynamic and complex. It is possible to achieve reasonable degree of validity by adopting appropriate techniques (Krishnaswamy and Renganathan, 2006). On the basis of above justification, the investigator attempted to adopt the Quasi Experimental design in implementing Brain-Based Learning Strategy.

In this study, the investigator has adopted the “Pre test Post test Non equivalent group design”. This design is used in classroom experiments when experimental and control groups are such naturally assembled groups as intact classes, which may be similar (Best and Kahn, 2006). Hence without disturbing the natural setting of the classroom, intact class groups, which are normally non equated, were selected for the study.

The investigator in the present study made use of two non-equivalent intact classroom groups, one experimental group and one control group. The reason for this is that in a school situation it is practically not possible to upset class schedules, to gather subjects to obtain a sufficiently large sample or to reorganise classes in order to employ randomisation procedure to get equivalent experimental and control groups. To compensate for the lack of equivalency between two groups, the investigator has applied the technique of Analysis of Co-variance (ANCOVA).

A pre test was administered to the two groups at first. These groups were then randomly assigned to treatments. The experimental group was instructed through Brain-Based Learning Strategy and the control group was exposed to conventional method of
teaching. Then the post test was given to the two groups. The differences between the pre test and post test scores were compared with the help of appropriate statistical techniques to ascertain the relative effect of Brain-Based Learning Strategy and Conventional method of teaching.

The layout of the design is:

Experimental group  \( O_1 \quad X \quad O_2 \)
Control Group  \( O_3 \quad C \quad O_4 \)

where, \( O_1 \) and \( O_3 \) - Pre tests; \( O_2 \) and \( O_4 \) - Post tests. ‘X’ is the experimental group which was instructed through Brain-Based Learning Strategy and ‘C’ is the control group which was instructed through conventional method of teaching.

3.2.3. Sampling Procedure
Before gathering sample, it is important for the investigator to find out details about the population. The population from which the sample is selected consisted of all secondary school students in Tamilnadu following the state board syllabus.

- **Sample selected for the study**
  Sampling is the process by which a relatively small number of individuals, objects or events are selected and analyzed in order to find out something about the entire population or universe from which it was selected. In the present design, it is not possible to collect data from every respondent relevant to our study but only from the fractional part of respondents. The process of selecting the fractional part is called sampling (Chandra and Sharma, 2004).

The present study was carried out on a sample of 156 students of standard IX. The age range of students (IX standard) selected for the study is between 13-14 years. The sample was selected using purposive sampling method from three types of schools namely, Government, Government aided and Corporation schools in Coimbatore.

Giving equal representation to rural and urban area, four schools were selected, two from each area. One corporation school and one Government aided school were selected under urban area. Similarly, one Government school and one Government aided school were selected from rural area. From these four schools, two classes of IX standard from each school were considered for the study. Among the 8 classes selected, the sample was divided into two by stratified random sampling method with 78 students each in the
experimental group and the control group giving equal representation to gender and type of school.

After removing the absentees either in the pre test or the post test, the final sample consisted of 156 students of standard IX.

The distribution of the total sample for the study is presented in the Table 3.1

<table>
<thead>
<tr>
<th>Table 3.1 Distribution of the Total Sample for the Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td><strong>Type of school</strong></td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>Experimental Group</td>
</tr>
<tr>
<td>Control Group</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

3.3 Variables

Variables are the conditions or characteristics that the experimenter manipulates controls or observes (Kothari, 2006). In the present study the following independent and dependent variables have been considered.

**Independent Variable**

“The independent variables are the conditions or characteristics that the experimenter manipulates or controls in his or her attempt to ascertain their relationship to observed phenomena” (Best and Kahn, 2006). In this study the **Brain-Based Learning Strategy** was considered as the independent variable.

**Dependent Variable**

“The dependent variables are the conditions or characteristics that appear, disappear or change as the experimenter introduces, removes, or changes independent variables” (Best and Kahn, 2006). Dependent variables are one that the outcome of which is used to compare the independent variables in an experiment. In this study the main
dependent variables selected were Academic Achievement and Creativity. It is to be tested whether the independent variable Brain-Based Learning Strategy would have an effect on the academic achievement and creativity among secondary school students.

3.4 Tools Used for the Study

Selection of suitable instruments or tools is also of vital importance in every research study. Data gathering tools may vary in their complexity, design, administration and interpretation. Each tool is suitable for the collection of certain type of information. One has to select from the available tools, those that will provide data that seeks for testing hypothesis.

For the purpose of the present study, the investigator prepared the following materials and tools.

**Description of tools used in the study**

- Lesson transcripts based on Brain-Based Learning (prepared and validated by the investigator).
- Achievement Test (prepared and validated by the investigator).
- Test of Creativity for secondary school students (prepared and validated by the investigator).

The descriptions of the tools used for this study are given below:

3.4.1. Construction and Validation of Brain-Based Learning Lesson Transcripts

The content for the Brain-Based Learning Strategy was selected from the IX standard Tamilnadu State Board Science Textbook. The content selected was a unit on ‘Addiction and Healthy Lifestyle’. The unit was designed to enhance academic achievement and creativity in that particular topic. The investigator selected this particular unit because awareness of addiction and healthy lifestyle is the need of the hour. The unit focuses on personal, realistic day to-day life situations. The content analysis was done considering the objectives required to be fulfilled for standard IX.

A thorough and systematic examination of all the related area of content on topic ‘Addiction and Healthy Lifestyle’ was analysed from secondary school textbooks. Reference books and net resources also helped the investigator in the preparation of the content.
In contrast to memorization, the emphasis was laid on constructing knowledge. The instructional activities were introduced in such a way so to activate the brain functioning of the students. Throughout the unit the students were given worksheets for helping them to learn. Where ever possible the investigator had taken the students to real life experiences. Activities were given in order to make them judge their awareness about addiction and healthy lifestyle.

In the present study the investigator has made an attempt to integrate the components of brain-based learning in the preparation of Brain-Based Learning lesson transcripts for secondary school students.

**Lesson Transcripts based on Brain-Based Learning Strategy**

Lesson transcripts were planned for the unit “Addiction and Healthy Lifestyle” from Science in which different brain-based learning strategies were used. The content in the lesson were organised based on the background knowledge and experience of the students following the principles of Brain-Based Learning. The construction of the Brain-Based Learning lesson transcripts was a very challenging, highly dynamic and time consuming exercise. The investigator prepared lesson transcripts based on the 7 Stage Brain-Based Learning Lesson Planning (Chavhan, 2012).

**The 7 Stage Brain-Based Learning Lesson Planning outline**

**The process**

The following strategies are organized in a sequence that makes sense to the brain (Jensen, 2008).

Outline of the 7 Stage Brain-Based Learning Lesson Planning is detailed in the flow chart (Figure 3.2)
Figure 3.2 Outline of the 7 Stage Brain-Based Learning Lesson Planning

- **Stage 1: Pre Exposure**
  - This phase provides the brain with an overview of the new learning before really digging into the concept. Pre exposure helps the brain develop better conceptual maps.

- **Stage 2: Preparation**
  - This is the phase where you create the curiosity or the excitement. It is similar to the “Anticipatory Set” but goes farther in preparing the learner.

- **Stage 3: Initiation and Acquisition**
  - This stage provides the immersion. Flood with content! Provide an initial virtual overload of ideas, details, complexity, and meanings. Allow a sense of temporary overwhelm to occur in learners. This will be followed by anticipation, curiosity, and a determination to discover meaning for oneself. Over time it all gets sorted out by the learner. It is like the real world outside the classroom.

- **Stage 4: Elaboration**
  - This is the process stage. It requires genuine thinking on the part of the learner. This is the time to make intellectual sense of the learning.

- **Stage 5: Incubation and Memory Encoding**
  - This phase emphasizes the importance of down time and review time. The brain learns most effectively over time, not all at once.

- **Stage 6: Verification and Confidence Check**
  - This phase is not just for the benefit of the teacher. Learners need to confirm their learning for themselves, as well. Learning is best remembered when the student possesses a model or metaphor regarding the new concepts or materials.

- **Stage 7: Celebration and Integration**
  - In the celebration phase it is critical to engage emotions. Make it fun, light, and joyful. This step instills the important love of learning. It must never be missed.
Worksheets

As an evidence for assessment of students learning, worksheets for each activity were prepared. While planning the worksheets, objectives of the session were considered as well as due care was taken that it should not become monotonous. Variation in the worksheets was brought by changing the nature of each worksheet. Various issues and problems relating to the topic ‘addiction and healthy lifestyle’ were presented through worksheets. Students were given ample scope for developing their thinking through those worksheets. The solutions provided in the worksheets provided scope for further learning.

Evaluation Rubric

Evaluation of level of learner’s mastery in drawing concept maps and graphic organizers was done by scoring their performance on evaluation rubric. The attributes/criteria of concept maps and graphic organizer were classified in evaluation rubric and each criterion was rated giving it scores as per the performance.

Reflection sheets

To evaluate the opinion of the learner and to identify the change in their learning process reflection sheets were provided at the end of each activity. Students were also told to write reflective journal entries in their reflective journals.

Validation of Lesson Transcripts Based on Brain-Based Learning Strategy

Fifteen lesson transcripts were prepared on the basis of Brain-Based Learning Strategy. The initial draft of lesson transcripts was submitted to five experts in the field of science teaching and teacher education for evaluation. Necessary corrections and modifications were made according to the suggestions and recommendations of experts. The modified lesson transcripts were administered to an initial sample of 30 students. By analyzing the response of the students, certain modifications were again made. The opinion from teachers and experts were taken as indices for ensuring the validity of the lesson transcripts.

The whole content was reviewed in the light of the suggestions and the opinions of experts for content adequacy and accuracy and finally concluded that the content prepared by the investigator possessed face and content validity.

The validity was again ensured by rectifying the technical difficulties confronted at the time of try out and taking into account the results of pilot testing. The lesson
transcripts based on Brain-Based Learning Strategy, Worksheet, Evaluation Rubrics, and Reflection sheet are given in Appendix I, II, III and IV respectively.

3.4.2 Preparation and Validation of Achievement test

Achievement test was used as the prime tool for the study to test the achievement levels of students of experimental and control group. Achievement test measure the present proficiency, mastery and understanding of general and specific areas of knowledge. Achievement tests are designed to maximize discrimination between the performances of the students and tests are constructed to provide information on the relative levels of achievement reached (Hawk and Hill, 1996). Achievement test was prepared by the investigator to evaluate the performance of students in science.

Construction of Achievement Test

In the present study to measure the performance of the students before and after the experiment, an achievement test was constructed by the investigator on the topic, ‘Addiction and Healthy Lifestyle’. The test items used were of multiple choice questions. The test was designed to assess the students’ Knowledge, Understanding and Application levels related to the topic, which was of 45 minutes duration; each question carries one mark with a maximum weightage of 35 marks. The same test was used as pre test and post test. The procedure of the test development process included the following steps.

The steps followed in the Achievement Test Development and Validation

The preparation and standardization of the achievement test consisted of four major phases such as Planning, Construction, Evaluation and Validation (Pathak, 2011). Each of the phases has several steps.

Phase 1: Planning

Test development requires a test plan that operationalizes the test objective that specifies the characteristics of the test, including an operational definition of the construct and content to be measured (the testing universe), the format of the questions, and the administration and scoring of the test. The major steps included in this phase are:

1. Defining test universe, target audience and purpose

The test universe is the body of knowledge or behaviour that the test represents, the target audience is the group of individuals who will take test, and the purpose of the test is the information that the test will provide to the test user.
To define the test universe, the investigator identified what the students should learn from the unit of instruction. Then the investigator selected teaching objectives from a list of teaching objectives of subject teaching which have to be made the basis for test construction.

While defining the target audience, the investigator made a list of characteristics of the persons who will take the test. Here the target audience was secondary school students of Coimbatore.

Defining the test purpose includes not only what the test will measure but also how the test users will use the test scores. In the present study, the purpose of the test was to compare the test takers i.e., a normative approach.

2. Defining the construct and content to be measured

After reviewing the literature about the construct and available tests, the investigator wrote a concise definition of the construct which includes operationalizing the construct in terms of specifications. In the present study the investigator selected the cognitive domain as the major construct.

Selection of teaching objectives for measurement

The test was designed to assess the achievement of students in the Cognitive Domain. The objectives selected by the investigator for the test construction were of Knowledge, Understanding and Application level.

Weightage to content

The content was divided into 5 sub units and the marks were allotted accordingly to prepare the question paper and to give adequate coverage to content. The weightage to content was finalized after discussing with experienced science teachers of the schools. The details are given in Table 3.2.
### Table 3.2 Weightage to Content

<table>
<thead>
<tr>
<th>No.</th>
<th>Content</th>
<th>Total marks</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Addiction prevention, and general</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Alcoholism</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Smoking</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Drug Abuse</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>Healthy lifestyle</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

**Weightage to Objectives**

Out of the 50 scores, 17 scores were for Knowledge level, 16 scores were for Understanding level and 17 scores for Application level. The details are shown in Table 3.3.

### Table 3.3 Weightage to Objectives

<table>
<thead>
<tr>
<th>No.</th>
<th>Content</th>
<th>Total marks</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knowledge</td>
<td>17</td>
<td>34</td>
</tr>
<tr>
<td>2</td>
<td>Understanding</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>3</td>
<td>Application</td>
<td>17</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

**Weightage to Difficulty Level**

The questions were divided into three categories easy, average and difficult based on the results of analysis of students’ answer sheets in the pilot test. Proper weightage was given to each level. 18 questions (36 per cent) were included as average questions while 16 questions (32 per cent) were easy questions. The remaining 16 questions (32 per cent) were difficult questions. Weightage to difficulty level of the achievement test is given in Table 3.4.
Table 3.4 Weightage to Difficulty Level

<table>
<thead>
<tr>
<th>No.</th>
<th>Content</th>
<th>Total marks</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Easy</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>Average</td>
<td>18</td>
<td>36</td>
</tr>
<tr>
<td>3</td>
<td>Difficult</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

The test items were of objective type including only multiple choice questions. The test was designed to assess the Knowledge, Understanding and Application level related to the topic which was of 60 minutes duration and carried a maximum weightage of 50 marks.

3. Blueprint

Blue print prepared by the investigator was three dimensional. However a slight modification in the blue print was made by the investigator by adding the difficulty-level. Since all the questions in the achievement test were objective-type, the columns denoting objective, short answer and essay were unnecessary as far as this achievement test is concerned. So these columns were changed into easy, average and difficult to incorporate the difficulty-level of each question. The weightage given to each objective and content, the difficulty-level of each question and marks are specified in the blue print. Blue print of the draft achievement test is given in Table 3.5.
### Table 3.5 Blue print of the Draft Achievement Test

<table>
<thead>
<tr>
<th>No</th>
<th>Objectives</th>
<th>KNOWLEDGE</th>
<th>UNDERSTANDING</th>
<th>APPLICATION</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Content</td>
<td>E</td>
<td>A</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>1</td>
<td>Addiction, prevention and general</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Alcoholism</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Smoking</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Drug Abuse</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Healthy lifestyle</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Grand Total</td>
<td>16</td>
<td>17</td>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>

* The number inside the parentheses denotes the mark and the number outside the bracket denotes the number of questions.

E denotes Easy; A denotes Average; and D denotes Difficult items.

Each question carries one mark.

**Phase 2: Construction**

**4. Preparation of the test items**

The investigator selected multiple choice questions for the test because such questions can be easily and objectively graded. The multiple choice format was chosen and the investigator employed the rational and empirical approach in selecting distractors. In rational approach personal judgments are involved and in empirical one selection of the most popular incorrect responses which students tend to make when the questions are given in an open ended form.
5. Assembling the test

Fifty multiple choice test items were prepared by the investigator which were reviewed and edited by experts in teacher education and Science. Then the investigator considered the appropriateness of the length of the test for the time limits, and arranged the items on the pages of the booklet with necessary instructions. Based on the suggestions put forward by the experts the investigator developed the first draft of the achievement test.

Qualitative Evaluation of items by Experts

The prepared test items were given to a panel of experts for qualitative evaluation. The experts selected were two senior teacher educators and three experienced secondary school science teachers. The panel reviewed the draft test in terms of the content analysis and blue print to make sure that the draft test would meet the intended test specification. The investigator made necessary corrections and modifications in the test items based on the suggestions from the review panel and prepared the final draft of the achievement test consisting of 50 multiple choice items. The selected test items were arranged in a random order and 60 minutes were allotted for 50 test items. There were no options for answering; all questions were compulsory and answer booklets were provided with each question paper.

Scheme of Evaluation

A scheme of evaluation includes a scoring key for the draft test, showing the number of items and correct answers. One mark was assigned for each correct answer and zero score for every incorrect answer.

Phase 3: Quantitative Evaluation

7. Pilot testing: Item try out

At this stage the initial format of the test was administered on a small representative sample. Hence the investigator administered the draft achievement test in order to identify the appropriateness of the items in the test. The investigator selected a Government aided school for the item tryout. After getting the permission from the school authorities the investigator with the help of the subject teacher administered the draft achievement test to 100 students of IX standard.
Brief instructions for completion of the test were clearly and prominently indicated. The participant had to circle the letter (a, b, c, or d) preceding the appropriate answer on the achievement test to indicate their choice. Enough time was given to the students so as to enable them to complete the test. The response sheets were collected and scored strictly in accordance with the prepared scheme of evaluation.

8. Item analysis

According to Oosterhof (1990) item analysis procedure includes two level of analysis of items namely, the level of item difficulty index and the level of item discriminating power. Item analysis is a technique by which the test items are selected or rejected. Item analysis is thus the integral part of both reliability and validity of the test.

For the present study 100 samples were selected and their answers were scored. The item analysis was carried out based on the guidelines of Ebel and Frisbie (1991). The total score was calculated and were arranged in descending order of the magnitude of scores. The scores obtained by the upper 27 students (27 per cent) and the lower 27 students (27 per cent) were taken as the upper group and lower group respectively. The marks of each item of the upper group and lower group were recorded separately. Based on these values the difficulty index (DI) and discriminating power (DP) for each item were calculated.

**Difficulty Index**

In item analysis, the first step is to find out the difficulty value of an item. The proportion or percentage of the subjects or individuals who answer the item correctly is called the difficulty value of an item.

The difficulty index was calculated by using the formula

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

Where,

- \( U \) = Number of correct responses in the upper group
- \( L \) = Number of correct responses in the lower group
- \( N \) = Number of students in each group.
**Discriminating power**

An important aspect in item analysis is the determination of the index of discrimination. It is the degree to which the single item separates the superior from the inferior individuals in the trait or group of traits being measured (Bean, 1953).

The discriminating power was calculated by using the formula

$$\text{Discriminating Power} = \frac{U - L}{N}$$

Where,
- $U$ = Number of correct responses in the upper group
- $L$ = Number of correct responses in the lower group
- $N$ = Number of students in each group

The item difficulty values and item discrimination values of high group and low group were calculated. The items having difficulty index between 0.4 and 0.6 and discriminating power more than 0.4 were selected as the final test. The item analysis for achievement test is given in *Appendix V*.

**Assembling the final test**

Those items that met the item analysis criteria formed the final test. The final test contained 35 multiple choice items with a maximum score of 35 and time for the test was 45 minutes. The blue print and the question paper (English version) of the final achievement test are given in appendices -VI and VII respectively.

**Phase 4 Validation – Reliability and Validity of Achievement Test**

**Reliability of the Test**

Reliability is the accuracy or precision of measuring an instrument. According to Best and Kahn (2006), a test is reliable to the extent that it measures accurately and consistently one another. Reliability of the test is usually expressed by a coefficient of correlation which is called reliability coefficient. The reliability of the achievement test was established using test- retest method.

The test–retest method involves repetition of a test on the same group immediately or after a lapse of time. Computation of correlations between the first and second sets of scores was calculated separately by using the product moment method of correlation. The correlation coefficient thus obtained indicates the extent or magnitude of the agreement between the two sets of scores and is often called the coefficient of stability (Kothari,
The reliability coefficient of the achievement test was 0.82. Reliability of achievement test was very high and hence the test is internally consistent.

**Validity of the test**

Validity is the efficiency with which a test measures what it intends to measure. “Validity is that quality of a data gathering instrument or procedure that enables it to measure what it supposed to measure” (Best and Khan, 2006). Validity is a relative term and has reference to a particular purpose of situation (Aggarwal, 2004).

The preparation of test items was preceded by a thorough and systematic examination of all the areas of the content in the textbook. Content validity was established by evaluating the relevance of the test item individually as a whole (Cohen et al., 2007). The content validity of the test was established by seeking the opinion of four experts including two teacher educators and two science teachers. The face validity and content validity of the test was assured by the experts while preparing the blue print and giving adequate weightages to content and objectives.

### 3.4.2 Preparation and Validation of Test of Creativity

The review of literature gave information on measurement of creativity and various tools available for measuring. The standardised tools serve as a benchmark for judging the validity of other creativity tests and for evaluating the effectiveness for the development of creativity.

However, an apt tool for measuring the creativity of secondary school students with due weightage to verbal and figural creativity was not available and were not satisfying the nature and purpose of the study. Therefore, it was decided to construct a validated test of creativity for secondary school students. So, in order to measure the creativity among the secondary school students, the investigator in the present study developed and attempted to validate an instrument designed to enable teachers to assess students’ creativity.
Construction of Test of Creativity (TOC)

In order to measure the creativity, the investigator developed a test entitled, ‘Test of Creativity for Secondary School Students (TOC)’, and a multi step process that consists of

Phase 1 – Define the test purpose
Phase 2 – Develop a test plan
Phase 3 – Compose test items
Phase 4 – Pilot testing
Phase 5 – Item analysis
Phase 6 – Revision
Phase 7 – Test Validation
Phase 8 – Compiling test manual

Phase 1 – Define Test Purpose, Target Groups and Test Universe

First phase is the description of the purpose of the test in scientific terms. For this, the investigator reviewed the theoretical part of books and journals in Science, Psychology, Education, Evaluation and Research Methodology and other such materials to find out details regarding test construction and thoroughly analyzed creativity test of Guilford and the Torrance's Minnesota test of creativity.

Test purpose, Target group and Test universe

The purpose of the test was to prepare a valid and reliable test to determine the creativity among the secondary school students. The target group was IX standard students. The testing universe is the body of knowledge or behaviours that the test represents. To define the testing universe, the investigator first identified the major components of creativity and sub tests for each component. The investigator operationally defined the core components of creativity and sub tests. The investigator decided to include the major components identified by Guilford - Fluency, Flexibility, Originality, Elaboration and Redefinition and Sensitivity to Problems (Philip, 2008).
Part A - Fluency

Word Fluency: Prefixes
This is a direct adaptation of Guilford’s Word Fluency: Prefixes W-2. Here, the students have to write down as many words which begins with a specified prefix.

Word Fluency – Suffixes
This is a direct adaptation of Guilford’s Word Fluency Suffixes W-I. The students have to write as many words that end with the specified suffix. The emphasis here is on fluency (i.e., the sheer number of responses).

Ideational Fluency: Topics IF-I and Topics IF-2
This is mostly on the lines of Guilford’s Ideational Fluency: Topics IF-I and IF-2. The tasks in this test are designed to measure fluency in terms of rate of generation of ideas. Instructions emphasise sheer number of responses produced rather than their quality.

Associational Fluency: Associations
This is an adaptation of Guilford’s Associational Fluency: Associations IV, in which the students have to produce a word that could be associated with two given words. Associational fluency as measured by the test pertains to the completion of relationship in distinction with ideational fluency which involves generation of ideas. Associational fluency measures the ability of an individual to associate terms fluently.

Part B - Flexibility

Semantic Spontaneous Flexibility: Alternate Uses
This is a modification of Guilford’s Alternate Uses Test intended to measure semantic spontaneous flexibility. The students are asked to write as many usual and unusual applications of the given concept.

Figural Adaptive Flexibility: Match Problems
This is a modified form of Guilford’s Figural Adaptive Flexibility: Match Problems. This means changes of some kind -changes in the interpretation of the task, approach or strategy or in possible solution. The student must produce the shifts or changes in meaning and so come up with novel, unusual, clever or farfetched ideas. Match problems are based upon the common game forming patterns with match sticks.
The students have to form as many meaningful symbols as possible using sticks by rearranging or taking away the match sticks of the given symbol.

**Part C - Originality**

**Novelty: Remote Consequences**

It is an adaptation of Guilford’s originality. Remote consequences intended to measure a students’ originality in imagining the consequences of certain unusual situations. Each item starts with a highly improbable universal event, and the student has to imagine and then write the consequences making as many guesses as he can, of the occurrence of that event. The test is based on free play of imagination and originality.

**Novelty: Picture Completion**

This test has been taken from Torrance’s Minnesota tests. Here, the students are asked to sketch some designs by making additions to an incomplete figure given and to give suitable title to the new drawing. The sketches are expected to be original and different from one another.

**Novelty: Plot Titles**

This is a modified version of Guilford’s Plot Titles (clever). The students are asked to write clever titles for the cartoons.

**Novelty: Imaginative Stories**

This is taken from Torrance’s Minnesota Test of Creativity, Verbal Tasks using Verbal Stimuli: Imaginative Stories. Here, the students are asked to write imaginative stories on scientific topics given.

**Novelty: Just Suppose**

This is derived from Torrance’s Minnesota Test of Creativity: Just Suppose. The students are confronted with a problematic situation and they are asked to make suggestions to solve the situation.

**Multiplicity: Identification and illustration**

This task requires the students to identify the objects items given and make the appropriate illustrations. The items are presented in figural form.
Multiplicity: Suggestions
Here, the students are asked to assume that they are provided with certain objects. They have to make suggestions about procedures of actions with the available objects.

Multiplicity: Multiple Grouping
This task consists of items to test whether there is ability to produce multiple classes. The students have to group the items into categories under separate heads.

Part D - Elaboration and Redefinition

Figural Redefinition: Concealed Phenomena
This is a modified form of Guilford’s Figural Redefinition: Concealed Figures CF-1. Redefinition involves the changing of functions or uses of parts of one unit and giving them new functions or uses in some new unit. The students have to recognise the concept concealed in the given pictures and to redefine the figure.

Symbolic Redefinition: Camouflaged Words
This is a modified version of Guilford’s Symbolic Redefinition: Camouflaged Words. This is a word search puzzle. The students are asked to find the words in the given puzzle. Thus, the ability to redefine meaningless letters to meaningful terms is to be counted as creative talent.

Semantic Redefinition: Object Synthesis
This is a modified form of Guilford’s Semantic Redefinition: Object Synthesis. Redefinition means the ability to perceive in a way different from the established way. A semantic test helps the student to find new meanings for the details given. The students have to make proper alterations for the given figure to redefine into a meaningful pattern.

Semantic Elaboration: Figure Production
This task is directly taken from Guilford’s Semantic Elaboration: Figure Production. Elaboration means giving more details about a simple concept. Score is based on number of details drawn.

Part E- Sensitivity to Problems
Sensitivity to Problems: Seeing Deficiencies
This is an adaptation of Guilford’s Sensitivity to Problem: Seeing Deficiencies. This task is to point out the way in which a described activity is faulty.
Sensitivity to Problems; Seeing Problems

This is directly adapted from Guilford’s Sensitivity to Problems: Seeing Problems. Here, the students have to list problems that might arise in connection with common objects.

Sensitivity to Problems: Apparatus Test

This is directly adapted from Guilford’s Sensitivity to Problems: Apparatus Test. The students are asked to suggest improvements to the common appliances. The suggestions are expected to be interesting and unusual and need not be practicable in the acceptable sense of the term.

Phase 2 - Develop a test plan

After a careful analysis of different components and sub tests the investigator prepared an initial group of items for the creativity test. The goal was to make it easy for a student to respond with a minimum of effort or generalization. An attempt was made to include 3 or 4 stub tests regarding activities representing each component of creativity.

Phase 3 - Compose Test items for the pilot test

An initial pool of 90 items was constructed for the test of creativity. These items were strictly according to the different sub tests of creativity. The preliminary list was submitted for evaluation to educational experts in order to ensure that each test item is appropriate to each component of creativity. Based on the suggestions put forward by experts the investigator made necessary modifications and constructed a draft test of creativity for secondary students, consisting of 75 items including concepts of topic in verbal and figural forms.

Since the test was also aimed to measure the divergent thinking ability, open-ended questions were also included. The medium of instruction is English. So the test was prepared in English. However, the student’s are allowed to respond in the mother tongue (Tamil) wherever they feel difficulty to answer in English.

Scoring Scheme

A scoring scheme was prepared by scoring the items for Fluency, Flexibility and Originality, Elaboration and Redefinition and Sensitivity to problems. The scoring criteria for creativity constructs are given in Table 3.6.
Table 3.6 Scoring Criteria for Creativity Constructs

<table>
<thead>
<tr>
<th>Creativity Dimensions</th>
<th>Scoring criteria</th>
<th>Score awarded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part A – Fluency</td>
<td>The number of different ideas that one produces</td>
<td>One point for each idea</td>
</tr>
<tr>
<td>Part B – Flexibility</td>
<td>The number of categories of ideas that one produces</td>
<td>One point for each category</td>
</tr>
<tr>
<td>Part C – Originality</td>
<td>The uniqueness of the ideas that one produces as compared to the whole sample</td>
<td>3 points for 100% unusual idea</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 points for 50% unusual idea</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 point for 25% unusual idea</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 point for &lt;25% unusual idea</td>
</tr>
<tr>
<td>Part D - Elaboration and Redefinition</td>
<td>The number of categories of ideas that one produces</td>
<td>One point for each category</td>
</tr>
<tr>
<td>Part E - Sensitivity to Problems</td>
<td>The number of categories of ideas that one produces and the novel response</td>
<td>Two points (1 point for each category and additional one score is assigned for novel response)</td>
</tr>
</tbody>
</table>

A score sheet was prepared for entering the scores of Fluency, Flexibility, Originality, Elaboration and redefinition, Sensitivity to problems and Total creativity. The total score on the test is obtained by summing up the scores for all the items.

**Phase 4 – Pilot testing**

During phase 4, a pilot study was conducted in order to obtain feedback from secondary school students on the clarity of directions, wording of items, and ease of completion as well as any other concerns while completing the test. The participants of the pilot study were 100 students of IX standard from a Government Aided school. Based on the feedback, the investigator modified and selected items for the draft test of creativity.
Item Analysis of the Test of Creativity

Item analysis helps the investigator to make a test valid and reliable. Validity and reliability can both be improved through the selection and revision of items. Gulliksen (2009), Guilford (1954), Garrett (2007) and Edwards (1970) have favoured employing item analysis for improving the reliability and validity of tests.

In the construction of the test of creativity, item difficulty could not be determined in the conventional way because the items in the tests of creativity demanded responses of divergent nature. So, the method suggested by Edwards (1988) was followed for item analysis.

For the validation of the test of creativity, item analysis was done by calculating the ‘t’ values. The scores obtained for each item and the total scores for each individual were marked. On the basis of the total scores obtained, the scores of 100 response sheets were arranged in the descending order of marks. Incomplete responses were rejected. Then the top 27 papers (27 per cent) and bottom 27 papers (27 per cent) were identified as papers of upper and lower criterion groups. Then t-test was calculated on the sets of scores in the upper and lower groups. The ‘t’ value is a measure of extent to which a given statement differentiates between higher and lower groups. The ‘t’ value greater than 1.96 indicates that items can be accepted for the final test. The ‘t’ value is calculated using the following formula:

\[ t = \frac{X_{hi} - X_{li}}{\sqrt{\frac{\sum (X_{hi} - \bar{X}_{hi})^2}{N(N-1)}} + \frac{\sum (X_{li} - \bar{X}_{li})^2}{N(N-1)}} \]

Where,

\( X_{hi} \) = the mean score for the higher group
\( X_{li} \) = the mean score for the lower group
\( N \) = size of the higher group or lower group

Finally 42 items with the largest ‘t’ values (t > 1.96) were selected for the final form of the test of Creativity. (Item analysis for Test of Creativity is given in Appendix VIII).

The details regarding the Items in the test of Creativity (Final Test) is given in the Table 3.7.
<table>
<thead>
<tr>
<th>PART</th>
<th>Component</th>
<th>Factor</th>
<th>Tasks</th>
<th>No. of items</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Fluency</td>
<td>Word Fluency</td>
<td>Prefixes</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Suffixes</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ideational Fluency</td>
<td>Topics IF-1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Topics IF-2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Associational Fluency</td>
<td>Associations</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>Flexibility</td>
<td>Semantic Spontaneous Flexibility</td>
<td>Alternatives</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Figural Adaptive Flexibility</td>
<td>Match Problems</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>Originality</td>
<td>Novelty</td>
<td>Remote Consequences</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Picture Completion</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Plot Titles</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Imaginative Stories</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Just Suppose</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multiplicity</td>
<td>Identification and Illustration</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Suggestions</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Multiple Grouping</td>
<td>1</td>
</tr>
<tr>
<td>D</td>
<td>Elaboration and Redefinition</td>
<td>Figural Redefinition</td>
<td>Concealed Phenomena</td>
<td>2</td>
</tr>
<tr>
<td></td>
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<td>Symbolic Redefinition</td>
<td>4</td>
</tr>
<tr>
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<td></td>
<td>Semantic Redefinition</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Semantic Elaboration</td>
<td>1</td>
</tr>
<tr>
<td>E</td>
<td>Sensitivity to Problems</td>
<td>Sensitivity to Problems</td>
<td>Seeing Deficiencies</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Seeing Problems</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Apparatus Test</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td></td>
<td>42</td>
</tr>
</tbody>
</table>
Phase 6 – Revising the Test

Items with ‘t’ value greater than 1.96 were selected and final test was prepared.

Phase 7 – Test Validation

To ensure that the instrument itself is sound, it is important to review evidence of its reliability (consistency) and validity (accuracy) (McIntire and Miller, 2007).

Reliability

Reliability refers to the consistency or stability of a set of test scores (Johnson and Christensen, 2014). A reliable measure is the consistent and stable indications of the characteristic being investigated. The test-retest method was used to establish the reliability of the test of creativity. The test-retest time was conducted on the same sample within a time gap of fifteen days. The performance of students in both the test and retest were analysed for its reliability.

The coefficient of correlation of the two sets of scores was calculated using Pearson’s Product moment correlation. The test-retest reliability coefficient (r) was found to be 0.69. This value 'r' obtained shows that the test is a reliable one. Thus, it may be concluded that since the test has sufficient reliability, the prepared tool is apt for measuring creativity of secondary school students.

Validity

For establishing the face validity of the test of creativity, the test items were given to four experts including two teacher educators and two science teachers. The experts evaluated the items as capable of measuring creativity falling under five major parts mentioned.

The test possessed construct validity to a reasonably high degree due to the theory used in the development of the test, tasks included, selection of discriminating items, etc.

Phase 8 – Compiling test manual

After establishing the validity and reliability, the final form of the test was prepared. The final form of the test consisted of 42 items and the total time fixed for the final test was ninety minutes. Finally the investigator developed the test manual for the test of creativity. A copy of the final test in English version is given as Appendix IX.
3.5 Data collection procedure

The experimental study was conducted to ascertain the effect of brain-based learning strategy on academic achievement and creativity among secondary school students. The data collection was carried out in the following phases.

Pre test conducted

The investigator in the present study made use of one experimental group and control group. The investigator administered the Achievement test and Test of Creativity as pre test. The test papers were scored and the scores collected were subjected to statistical analysis.

Teaching for experimental and control group

The investigator prepared and validated an achievement test and test of creativity and used them as both pre test and post test to measure the performance of students before and after the experiment. The experimental group was exposed to brain-based learning strategy and the control group was taught through conventional method of teaching for about twenty hours. The two groups were given equal attention during the course of the experiment.

Post test conducted

Immediately after the completion of teaching, the investigator once again administered the same achievement test and test of creativity to the two groups as post test. Prior information regarding the date of the tests was given. The answers were scored and the scores thus obtained were then analyzed by using statistical techniques and the comparison of the groups was done to ascertain the effect of brain-based learning strategy on academic achievement and creativity among secondary school students.

3.6 Statistical techniques used

To study the effect of Brain-Based Learning Strategy, the investigator decided to find out whether there was any significant difference between the mean post test scores of students in the two groups. The pre test and post test scores of students in experimental and control groups were subjected to the following statistical techniques:

1. Mean
2. Median
3. Standard deviation
4 Test of significance
5 Analysis of Covariance
6 Correlation
7 Wolf’s Formula

3.7. Conclusion

This chapter deals with the methodology of the present investigation as enumerated in detail about the methods, the selection of the sample, the tools, data collection procedure and statistical techniques to be used for the study. The results obtained were analysed and given in Chapter IV.