CHAPTER IV
METHODOLOGY

4.1 Method Adopted
4.2 Variables of the Study
4.3 Population of the Study
4.4 Tools used for the Study
4.5 Experimental Procedure
4.6 Statistical Techniques Used
METHODOLOGY

4.0 INTRODUCTION

Methodology lightens the way in which the formal research is to be carried out, and outlines the details of the description of the research variables and procedures. A suitable research method helps the researcher to explore the various dimensions of the study. The reliability and validity of the findings also depends up on the method adopted and hence methodology occupies a very important place in the field of any research.

This chapter is presented under the following sections.

4.1 Method Adopted

4.2 Variables of the Study

4.3 Population of the Study

4.4 Tools used for the Study

4.5 Experimental Procedure

4.6 Statistical Techniques Used

4.1 METHOD ADOPTED

Since the study was intended to find out the effectiveness of 5E Learning Cycle Model on Scientific Creativity, Scientific Interest and Achievement in Physics of students at secondary level, experimental method was adopted.

The most powerful research method is undoubtedly the controlled experimentation and is capable of providing firm evidence regarding cause and effect relationships, which no other research method can provide. The defining features of the experimental method are manipulation and control. The experimenter manipulates the conjectured causal factor (called
independent variable because it is manipulated independently of other variables) and examines its effects on a suitable measure of the behavior of interest, called dependent variable. Thus a precise well controlled experiment eliminates the alternative explanation of result.

4.1.1 Design Selected

Experimental design attempts to ensure valid causal inferences from randomized experiments conducted within practical constraints of available resources and time. “Experimental design is the blue print of the procedures that enables the researcher to test hypothesis by reaching valid conclusion about the relationship between independent and dependent variables” (Best & Kahn, 2004).

Since it is not practical to get one to one equalized groups for experimentation, classroom intact groups were selected for the study. So the design selected in the present study was ‘pre-test post-test non-equivalent group design’. This design is often used in classroom experiments, when Experimental and Control groups are such naturally assembled groups as intact classes, which may be similar (Best & Kahn, 2004).

4.2 VARIABLES OF THE STUDY

Something that can change in value and can be measured is a variable. It is an aspect of experimental situation that changes with individuals. For an experimental study, there are independent variables, dependent variables and extraneous variables.

4.2.1 Independent variables

The variable, which is manipulated by the experimenter or the variable which is suspected of being the cause in the experimentation is called independent variable. “It is under the direct control of the experimenter who may vary it in any direction” (Sax, 1979).
In the present study, teaching methods are the independent variables. The 5E Learning Cycle Model of teaching and the Prevailing Activity Oriented Method of teaching are the two independent variables adopted in the study.

4.2.2 Dependent variables

The dependent variable is the condition or the characteristics that appears, disappears or changes as the experimenter introduces, removes or changes the independent variable.

For the present study, Scientific Creativity, Scientific Interest, and Achievement in Physics are selected as the dependent variables.

4.2.3 Extraneous variables

There is every chance of other variables to affect the experiment. Among them learning style, previous achievement, general mental ability, age, class, time of instruction etc. are considered as the major extraneous variables affecting the present study.

4.3 POPULATION OF THE STUDY

Population is any group of individuals who have one or more characteristics in common that are of interest to the researcher. In this study, the population consists of all the students studying at secondary school level in Kerala.

4.3.1 Sample selected for the study

The investigator decided to adopt purposive random sampling keeping in view of the experimental nature of the study.

The initial sample consists of 335 students, from selected schools of Idukki and Ernakulam districts, studying in Standard IX of Kerala State syllabus. After removing absentees in pre-test and post-test, the total number of students included in the study was 312, out of which 156 students were
coming under the Experimental group and other 156 students under the Control group. Breakup of the sample is given in the table given below.

Table 4.1

Break up of the sample for the study

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Name of the school</th>
<th>Boys/Girls/Co-edn</th>
<th>Type of school</th>
<th>Number of students</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>St. George H.S.S., Vazhathope</td>
<td>Co-edn</td>
<td>Aided</td>
<td>Experimental 42</td>
<td>Control 42</td>
</tr>
<tr>
<td>2</td>
<td>G.V.H.S.S, Vanchikavala</td>
<td>Co-edn</td>
<td>Govt</td>
<td>Experimental 36</td>
<td>Control 36</td>
</tr>
<tr>
<td>3</td>
<td>Nirmala H.S S Muvattupuzha</td>
<td>Co-edn</td>
<td>Aided</td>
<td>Experimental 40</td>
<td>Control 40</td>
</tr>
<tr>
<td>4</td>
<td>G.H.S, Muvattupuzha</td>
<td>Co-edn</td>
<td>Govt</td>
<td>Experimental 38</td>
<td>Control 38</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>156</td>
<td>156</td>
</tr>
</tbody>
</table>

4.4 TOOLS USED FOR THE STUDY

The tools employ distinctive ways of describing and quantifying data and are particularly appropriate for certain source of data, yielding information of the kind and in the form that can be used more effectively.

The tools used in this present study are

4.4.1 Lesson transcripts based on 5E Learning Cycle Model

4.4.2 Lesson transcripts based on Activity Oriented Method

4.4.3 Kolb’s Learning Style Inventory (Adapted version)

4.4.4 Raven’s Standard Progressive Matrices

4.4.5 Scientific Creativity Test (Prepared and Standardized by the Investigator)
4.4.6 Scientific Interest Inventory (Prepared and Standardized by the Investigator)

4.4.7 Achievement test in Physics (Prepared and Standardized by the Investigator)

The descriptions of the various tools used in the study are given below.

4.4.1 Lesson transcripts based on 5E Learning Cycle Model

5E Learning Cycle describes a teaching sequence that helps students to build their own understanding from their experiences and new ideas. As a very frequently used model in constructivist learning approach, 5E learning cycle model’s name comes from the number of its phases and the initials of each phase. These five phases are:

- Engage
- Explore
- Explain
- Elaborate
- Evaluate

1. Engage:

The purposes of the ‘Engage’ stage is to peak student’s interest and get them personally involved in the lesson, while pre-assessing prior understanding. To ‘engage’ means to excite and to draw the student's curiosity. It means to wow them in a way that catches their attention. It is not forcing children to learn but inviting them to engage. This is how lessons are introduced and it does not have to be difficult or overly detailed but just interesting enough to open student's minds for the learning process to begin. Using technology to engage student learning makes planning very easy for teachers in today's classrooms. Using Smart board technology, videos, illustrations, asking questions, reading a great book, acting out a character or even introducing a game are ways to engage students at the beginning of a
lesson. The learner and teacher behavior in this stage is given in the table given below

Table 4.2
*Learner and Teacher behavior of ‘Engage’ phase*

<table>
<thead>
<tr>
<th>Learner</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Calls up prior knowledge</td>
<td>- Poses problems</td>
</tr>
<tr>
<td>- Has interest</td>
<td>- Asks questions</td>
</tr>
<tr>
<td>- Experience doubt or disequilibrium</td>
<td>- Reveals discrepancies</td>
</tr>
<tr>
<td>- Has a question(s)</td>
<td>- Causes disequilibrium or doubt</td>
</tr>
<tr>
<td>- Identifies problems to solve, decisions to be made, conflicts to be resolved</td>
<td>- Assess prior knowledge</td>
</tr>
<tr>
<td>- Writes questions, problems, etc.</td>
<td></td>
</tr>
<tr>
<td>- Develops a need to know</td>
<td></td>
</tr>
<tr>
<td>- Self reflects and evaluate</td>
<td></td>
</tr>
</tbody>
</table>

**Evaluation of ‘Engagement’**

This stage revolves around the pre-assessment. The teacher finds out what the students already know about the topic in this stage.

2. **Explore**

The purpose of the ‘*Explore*’ stage is to get students involved in the topic, providing them with a chance to build their own understanding. The students have an opportunity to get directly involved with phenomenon and materials. As they work together in teams, students build a set of common experiences which prompts sharing and communicating. The most effective explorations allow for mistakes or trial and error. It is looking at a concept before discussing all the details, with a hope that students will discover answers to possible questions through exploration. The teacher acts as a
facilitator, providing materials and guiding the students’ focus. The learner and teacher behavior in this stage is given in the table given below.

Table 4.3

*Learner and Teacher behavior of ‘Explore’ phase*

<table>
<thead>
<tr>
<th>Learner</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothesizes and predicts</td>
<td>Questions and probes</td>
</tr>
<tr>
<td>Explores resources and materials</td>
<td>Models when needed</td>
</tr>
<tr>
<td>Designs and plans</td>
<td>Makes open suggestions</td>
</tr>
<tr>
<td>Collects data</td>
<td>Provides resources</td>
</tr>
<tr>
<td>Builds models</td>
<td>Provides feedback</td>
</tr>
<tr>
<td>Seeks possibilities</td>
<td>Assesses understanding and processes</td>
</tr>
<tr>
<td>Self reflects and evaluates</td>
<td></td>
</tr>
</tbody>
</table>

**Evaluation of Exploration**

The evaluation of this stage should focus on the process of the data collected by the students rather than the product of the data collection. Teachers ask themselves questions such as

- How well are the students collecting data?
- Are they carrying out the procedures correctly?
- How do they record data?
- Is it in a logical form or is it haphazard?

**3. Explain**

Students now have an opportunity to hear from their educator. The teacher's role so far has been to facilitate learning, now they can use their expertise to answer questions. They also may pose questions to the students to see what they are able to explain about what they have experienced.
Checking for misunderstandings helps the teacher to observe what objectives need to be clarified or taught. The teacher is reinforced by what the students have seen from their exploration. The learner and teacher behavior in this stage is given in the table given below.

Table 4.4
Learner and teacher behavior of ‘Explain’ phase

<table>
<thead>
<tr>
<th>Learner</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Clarifies understanding</td>
<td>• Provides feedback</td>
</tr>
<tr>
<td>• Shares understandings for feedback</td>
<td>• Asks questions, poses new problems and issues</td>
</tr>
<tr>
<td>• Forms generalizations</td>
<td>• Models or suggests possible modes</td>
</tr>
<tr>
<td>• Reflects on plausibility</td>
<td>• Offers alternative explanations</td>
</tr>
<tr>
<td>• Seeks new explanations</td>
<td>• Enhances or clarifies explanations</td>
</tr>
<tr>
<td>• Employs various modes for explanation</td>
<td>• Evaluates explanations</td>
</tr>
</tbody>
</table>

Evaluation of Explanation

This stage focusses on the process the students are using how well can students use the information they have collected, and what they already knew to come up with new ideas?. Using questions the teacher can assess the student’s comprehension of the new vocabulary and new concepts.

4. Elaborate

Here the students can participate in an extension, or a different activity that teaches more details about the concept being taught. Here differentiation can be used. A student of above average level will need an elaboration that extends or enriches the lesson. A student of below average level will need
perhaps a repeat of the same explore activity with more teacher input to guide students to correct misunderstandings. The learner and teacher behavior in this stage is given in the table given below.

Table 4.5
Learner and teacher behavior of ‘Elaborate’ phase

<table>
<thead>
<tr>
<th>Learner</th>
<th>Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Applies new knowledge</td>
<td>• Asks questions</td>
</tr>
<tr>
<td>• Solves problems</td>
<td>• Provides feedback</td>
</tr>
<tr>
<td>• Makes decisions</td>
<td>• Provides resources</td>
</tr>
<tr>
<td>• Performs new related tasks</td>
<td>• Makes open suggestions</td>
</tr>
<tr>
<td>• Resolves conflicts</td>
<td>• Models when necessary</td>
</tr>
<tr>
<td>• Plans and carries out new</td>
<td>• Evaluates</td>
</tr>
<tr>
<td>project</td>
<td></td>
</tr>
<tr>
<td>• Asks new questions</td>
<td></td>
</tr>
<tr>
<td>• Seeks further clarification</td>
<td></td>
</tr>
</tbody>
</table>

Evaluation of Elaboration

In this stage teachers equate evaluation with the test at the end of the chapter. When a teacher gives application problems as a part of elaboration, it can be treated as an evaluation.

5. Evaluate

Finally, after the objectives are taught, it is the time to assess. What have students effectively learned? What do they not understand? What should be done to help them? Assessments do not have to be the traditional quiz or essay. It can be a reflection, a project, book report, or a model. Using a rubric (here an Activity Assessment Sheet), the teacher or parent can now easily grade or make assessment of what is learned and of what needs to be retaught.
Two major units from the Physics textbook of Standard IX were selected for the experimentation. The units were “Work, Power and Energy” and “Refraction of light” of Standard IX of Kerala State syllabus. The concepts to be developed, the principles to be formulated, the procedure adopted for developing rules, equation and diagrams, and the processes leading to problem solving were carefully identified.

The sample lesson transcripts based on 5E Learning Cycle Model was prepared by the investigator. After the preparation, the lesson transcripts were given to experts in the field of science education and teacher education. The draft lesson transcripts were modified by the investigator based on the suggestions of the experts. Then five lesson transcripts were given for try out to students in a division of Standard IX (of St. George H.S.S Vazhathope, Idukki). After the try out, the lesson transcripts were modified and restructured based on the actual feedback, the investigator experienced. Thus 24 lesson transcripts were prepared based on the 5E Learning Cycle Model. Sample lesson transcripts (English & Malayalam) are given as Appendices I A and I B

4.4.2 Lesson Transcripts based on Activity Oriented Method

Activity Oriented method of teaching aids the implementation of the continuous evaluation system including seminars, projects, assignments, library sessions and practical sessions along with regular classes. Experts have identified many activities which can be given in the classroom situation. The activities listed below can easily be provided in one form or combined form.

1. **Oral Activities**: such as inviting questions and answers, narrating experiences and participating in general class discussions.

2. **Written Experiences**: such as selecting and copying relevant material from books and journals, seeking information, making summaries, writing short book review, taking notes, and drawing diagrams.

3. **Visual Activities**: these include reading and interpreting charts, diagrams and graphs, studying specimens, apparatuses and pictures, seeing films and
film strips and gathering information from bulletin boards.

4. Practical Activities: such as setting up experiments in the laboratory, science fairs and exhibitions, constructing and improvising apparatuses, preparing charts and diagrams and finding matter for the bulletin boards etc.

Twenty four Lesson transcripts based on Activity Oriented Method were prepared by the investigator for the same topic selected for the preparation of lesson transcripts based on 5E Learning Cycle Model. Sample lesson transcripts based on Activity Oriented Method (English & Malayalam) are given as Appendices II A and II B.

4.4.3 Kolb’s Learning Style Inventory

The Kolb Learning Style Inventory (KLSI) is designed to understand how one learns best in educational settings and everyday life. It differs from other tests of learning style and personality used in education, being based on the comprehensive theory of experiential learning. David A. Kolb (1971, 1984) published 5 versions of Learning Style Inventory over the last four decades.

The investigator adapted the 5th version of the Kolb’s Learning Style Inventory (Version 3.1, 2005), after making minor modifications suited to Indian condition. The four learning styles described in the Kolb’s Learning Style Inventory are

- Assimilating style: Combines the Reflective Observation and Abstract Conceptualization phases (RO & AC).
- Accommodating style: It combines Active Experimentation and Concrete Experience phases (AE & CE).
- Converging style: Combines the Abstract Conceptualization and Active Experimentation phases (AC & AE).
- Diverging style: Combines the Concrete Experience and Reflective Observation phases (CE & RO).
The items in the inventory are reworded much carefully, in consultation with experts in the field of education. The modified adapted version of KLSI 3.1 was given to experts. After expert validation, the adapted version of Kolb’s Learning Style Inventory was given for try out and then it is again modified based on the feedback.

**Administration and Scoring**

Kolb’s learning style inventory (adapted version) consists of 12 questions about the ways in which one learns best. Each question has 4 answers which are to be ranked by the order of preference in terms of best fit on a scale of 1 - 4 (4-most like, 3 –next like, 2-moderately like, 1-least like). Responses are organized based on the preferences and the scores are summarized and are categorized as Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC), and Active Experimentation (AE). Scores of CE, RO, AC and AE are plotted on a learning style grid. Based on the plots on the grid the learning style of each student was identified.

English and Malayalam versions of the Kolb’s Learning Style Inventory, Response Sheet for Kolb’s Learning Style Inventory and Scoring key are given as Appendices - III A, III B, III C, and III D.

**Reliability and Validity**

The reliability of Kolb’s Learning Style Inventory was found by test re-test method. The reliability coefficient of AC-CE and AE-RO is found to be 0.73 and 0.80 respectively. This is in conformity with the value obtained at the time of standardization by Kayes (2005) which were 0.77 and 0.84 respectively and for Cheriyan (2010) which were 0.71 and 0.78 respectively.

**4.4.4 Raven’s Standard Progressive Matrices**

The investigator decided to use Raven’s Standard Progressive Matrices to measure the General Mental Ability of students. Raven’s Progressive Matrices are widely used non-verbal intelligence tests. Standard
Progressive Matrices (SPM) was designed to measure a person’s ability to form perceptual relations and to reason by analogy, independent of the language and formal schooling. And it may be used with person ranging in age from 6 years to adult. The matrices measure two complementary components of general intelligence: the ability to think clearly and make sense of complex data, which is known as educative ability; and the ability to score and reproduce information known as reproductive ability.

**Administration and Scoring**

Raven’s Progressive Matrices are multiple choice tests of abstract reasoning. SPM consists of 60 items arranged in five sets (A, B, C, D & E) of 12 items each. Each item contains a figure with a missing piece. Below the figure are either six (sets A & B) or eight (sets C through E) alternative pieces to complete the figure, only one of which is correct. Each set involves a different principle or ‘theme’ for obtaining the missing piece, and within a set the items are roughly arranged in the increasing order of difficulty. All items are presented in black ink on a white background. In each set, the first problem is the easiest one and the consecutive problems became gradually difficult.

The scores of SPM were used to compare the General Mental Ability of the students. The response sheet of the Raven’s Standard Progressive Matrices is given as Appendix IV.

**4.4.5 Scientific Creativity Test**

The explosion and rapid advancement of knowledge have focused the attention of educators, psychologists, planners and leaders in various walks of life on values of creative potential in promoting technological progress with a view to raise the status of common people.

Scientific Creativity may be considered as specific creative expression, unique production in science and technology, it may be a unique scientific process responsible for some creative contribution in the field of science, technology or otherwise.
Scientific Creativity may be considered from the following points of view:

1. Scientific Creativity deals with the unusual and original excellence in the field of science or scientific productivity.

2. Scientific Creativity can also be thought as scientific method or scientific process primarily involved in the production of unusual and original scientific contribution.

3. The unusual scientific thinking abilities characterized by systematic approach for all contents whether from science or humanities or otherwise could be considered as the basic attributes of Scientific Creativity.

An apt tool for measuring the Scientific Creativity of Secondary School students was not available. So the investigator decided to prepare a Scientific Creativity test. The present test has been developed on the concept as specified in the third alternative of the concepts of Scientific Creativity as the unusual scientific thinking abilities characterized by systematic approach for all contents whether from science or humanities.

**4.4.5.1 Construction of the test**

The platform selected for the preparation of the present test was the Creativity test of Guilford and Minnesota Test of Creativity. According to Guilford’s structure of Intellect model, creativity has 120 S-I factors. Guilford (1957) visualized that out of 120 S-I factors, 28 S-I factors may contribute significantly to Scientific Creativity. From such a line of thinking it could be inferred that ‘Scientific Creativity’ may be some extent different from General Creativity as conceptualized by Torrance and Barren (Guilford, 1959).

It is a test of Scientific Creativity and contents in general as well as from scientific thinking in terms of process-orientedness have been included in this test. Only three factors i.e. Fluency, Flexibility and Originality of Scientific Creativity have been taken in the evaluation of the Scientific Creativity.
4.4.5.2 Description of the draft test

The test of Scientific Creativity consists of four sub tests namely (1) Consequences test (2) Unusual Uses test (3) New Relationship test (4) Just Think Why test.

1. The Consequences test

The consequences test is designed on the test patterns of Guilford (1952) and Torrance (1962). In this test the familiar things are presented in the form of a hypothetical situation. The subject has to visualize a large number of possibilities to a hypothetical happening. This applies to cause-consequence relationship. The subject has to think the effects of consequence whether usual or unusual, logical or illogical.

The consequences test consists of hypothetical situations arising from fundamentals of science, such as.

i) What would happen if there is no earth in the world?

ii) What would happen if there are no bones in human body?

The situations are the hypothetical ones hence the experience is minimized. An example is given in the test booklet to make the students familiar with the test. The time allotted for this subtest is fifteen minutes.

2. Unusual Uses test

The test of unusual uses has been designed on the lines of Guilford's (1952) Brick Uses Test and Torrance's (1962) Tin Can Uses Test. The present test of Scientific Creativity includes the names of the common objects. For example, the leaves of plants and trees which can be used for numerous purposes. All these items are very common objects from the fields of physical and biological sciences. They do not require in any way the knowledge and skills in science; however, vertical scientific thinking is an essential requirement for attaining high on this test.
The students are requested to write as many novel, interesting and unusual uses of these objects as they may think. One practice item is given in the booklet to acquaint the pupil with nature of activity that has to do. Time allotted to complete this subtest is fifteen minutes.

### 3. New Relationships Test

The New Relationship Test has been designed on the pattern of Mednick’s (1962) Remote association test. In this activity, the articles of daily use with which the students are familiar are taken so that he may think more naturally. All the articles of this test are scientifically belonging to the same group. This new relationships test consists of pairs of words, namely i) Sugar and Salt, ii) Oil and Water. Each pair of words was similar to certain extent in some of their physical, chemical or biological properties.

Student has to think as many new and novel similarities between these pairs of familiar objects from physical and biological sciences. This permits the students, an opportunity of free play for their imagination in the production of novel, original and unusual responses. One example is given in the test booklet for practice and time allotted is fifteen minutes.

### 4. ‘Just Think, Why’ test

The Just Think Why test of Scientific Creativity consists of common events based on cause-effect relationship. The effect of some particular events is given under this task and the students are asked to think various causes of the events.

The sample items are given as an example,

i) Under what conditions palpitation of heart shoots up?

ii) What are the reasons for non-germination of the seed?

The students have given ample opportunity to imagine, and to produce novel and original ideas. The time allotted to complete this sub-test is fifteen minutes.
4.4.5.3 Administration of the tool

The Scientific Creativity was given to experts for validation. After expert validation, the test was given for try out and then it is again modified based on the feedback. The test booklet contains general instructions as well as instructions for each activity. The test includes four subtests and each subtest consists of 5 items and thus a total of 20 items. Time allotted to each activity is fifteen minutes which should be strictly adhered to. A draft test of Scientific Creativity (English & Malayalam) is given as Appendices VA and V B.

The total time required to administer the whole test is one hour, in addition to 20 minutes time for general instructions and practice items. The students are asked to give responses on Scientific Creativity Test Booklet supplied to them.

Emotional climate of the class is of much significance when a creativity tool is administered. Students would express their imaginative ideas freely if a friendly atmosphere is present there. A non-threatening, relaxed and game like environment was created in the classroom. The students are properly motivated to take the test, since it takes more than one period.

The following steps were followed for administering the test,

1. Distribution of the test booklets to the subjects
2. Explaining the general instructions in the booklet
3. Distribution of answer sheets with necessary instructions
4. Making the students familiar with the examples given and directing them to answer all the items accordingly
5. Provide enough time to complete the test
6. Clearing the doubts of subjects
7. Collecting back the booklets and response sheets
4.4.5.4 Scoring Technique

While scoring, it is to be kept in mind that each item is to be scored for Fluency, Flexibility and Originality.

i) Fluency has been scored in terms of total number of responses related to the object.

ii) Flexibility has been scored in terms of total number of categories of responses. Each category has been assigned one score.

ii) Originality has been scored in terms of weights assigned in accordance with their degree of unusualness. The unusual responses have been defined as that response which has a probability of occurrence to the extent of 5%. The scoring procedure for originality is presented in the following table.

<table>
<thead>
<tr>
<th>Percentage of response</th>
<th>Marks given</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1% - 1.0%</td>
<td>5</td>
</tr>
<tr>
<td>1.1% - 2.0%</td>
<td>4</td>
</tr>
<tr>
<td>2.1% - 3.0%</td>
<td>3</td>
</tr>
<tr>
<td>3.1% - 4.0%</td>
<td>2</td>
</tr>
<tr>
<td>4.1% - 5.0%</td>
<td>1</td>
</tr>
<tr>
<td>Beyond 5.0</td>
<td>0</td>
</tr>
</tbody>
</table>

4.4.5.5 Item analysis

Hundred representative pupils were randomly selected from different schools for the purpose of item analysis. General instructions were given to them and then administered the draft Scientific Creativity test to them. The responses were scored for Fluency, Flexibility and Originality dimensions of
Scientific Creativity. The sum of the scores of Fluency, Flexibility and Originality gives the total Scientific Creativity score.

In the construction of the present test of Scientific Creativity, item difficulty cannot be determined in the conventional way because the items in the test of Scientific Creativity demanded responses of divergent nature. So the method suggested by Edward (1969) was followed for item analysis.

The responses were scored using scoring scheme. The score obtained for each item and total scores of each individual were marked. On the basis of total scores obtained, the response sheets were arranged in the descending order of marks. The top 27% and bottom 27% were identified as upper and lower criterion groups. The ‘t’ value calculated using the formula

\[ t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\frac{\sum (X_H - \bar{X}_H)^2 + \sum (X_L - \bar{X}_L)^2}{n(n-1)}}} \]

Where
\( X_H \) = Scores of items for the higher group  
\( X_L \) = Scores of items for the lower group  
\( n \) = Total number of students in each group

Those items for which t value equal to or above 1.85 were noticed and were selected for the final test. Table of t values for the Items are given in the Appendix V C.

4.4.5.6 Final Form of Scientific Creativity test

Based on the item analysis, the good items with higher ‘t’ values were retained in the final form of the Scientific Creativity test and other items were discarded. In the final form of Scientific Creativity test, four subtests namely the Consequences test, Unusual Uses test, New Relationship test and Just Think Why test were included. In each subtest three items were retained and thus a total of 12 items were included in the final form. Final form of Scientific Creativity test (English & Malayalam), Scientific Creativity booklet (English &
Malayalam) and the scoring guide are given as Appendices - V D, V E, V F, VG and V H.

4.4.5.7 Reliability and Validity of the Test

The co-efficient of stability as an index of reliability on various components of Scientific Creativity as well as on the whole test has been estimated by test-retest method. The test-retest reliability coefficient was found to be 0.78. The value of ‘r’ shows that the test is a reliable one.

This test has been validated against B. Mehdi’s Verbal Test of Scientific Creative Thinking, prepared by Dr. U.P. Sharma and Dr. J.P. Shukla (2005). Since the test has sufficient validity and reliability, the prepared tool is apt for measuring Scientific Creativity of Secondary School students.

4.4.6 Scientific Interest Inventory

Interest is an enduring attitude that engages the individual’s attention to make it selective towards the object of interest (Atkinson, Berene & Woodworth, 1998).

According to Crow & Crow (1973), interest may refer to the motivating force that impels us to attend a person, a thing or an activity or may be the effective experience that has been simulated by the activity itself. In other words interest can be the cause of an activity and the results of participation in that activity.

An interest inventory is a self-assessment tool, used to assess one’s likes and dislikes of a variety of activities, objects and types of persons. The investigator prepared a Scientific Interest Inventory for the purpose of measuring science interest of secondary school students.

4.4.6.1 Preparation of draft form

The draft form of Scientific Interest Inventory was prepared by the investigator, after a thorough review of relevant literature and also with expert consultation. Each item of the inventory consists of a stem and three options
(a, b, c). Among the three options one is related to science. Other two options are general in nature. If the student gives the option related to science as the response to the stem, then it is considered the right response to the Scientific Interest Inventory.

64 preliminary items were prepared and it was given to a group of experts for comments and suggestions. After receiving the comments and suggestions of experts, some of the items were modified and some were discarded. After editing, the Scientific Interest Inventory consisting of 60 items was taken for the preliminary testing. Scientific Interest Inventory draft form (English and Malayalam) are given as Appendices - VI A and VI B.

4.4.6.2 Administration and scoring of the Scientific Interest inventory

The inventory was administered to 380 students studying in Standard IX mentioned in Table 4.7. The test forms were given to students and they were asked to write suitable alphabets (a, b, c) corresponding to each item in the appropriate space provided. The scores of all the items were summated to obtain the Scientific Interest inventory score of the individual.

Table 4.7
Distribution of the sample for tryout of Scientific Interest inventory

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Name of the school</th>
<th>Type of management</th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S.S.H.S.S., Nedumkandam</td>
<td>Aided</td>
<td>102</td>
</tr>
<tr>
<td>2</td>
<td>G.V.H.S.S., Nedumkandam</td>
<td>Govt.</td>
<td>86</td>
</tr>
<tr>
<td>3</td>
<td>S.M. H.S., Murickassery</td>
<td>Aided</td>
<td>104</td>
</tr>
<tr>
<td>4</td>
<td>G.H.S.S, Mundiyeruma</td>
<td>Govt.</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>380</td>
</tr>
</tbody>
</table>
4.4.6.3 Item analysis

After removing the absentees, response sheets of 370 students, were arranged in the descending order of their total scores. The response sheets of highest 27% and lowest 27% were treated as the extreme groups for the item analysis. Using the extreme group scores, discriminating power of the inventory was found out.

Discriminating power = (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 pupil in each group

4.4.6.4 Preparation of final form of Scientific Interest Inventory

The statements for the final form of Scientific Interest Inventory were selected based on the Discriminating Power. Items having discriminating power in between 0.35 and 0.70 were selected for the final form of Scientific Interest Inventory. Table showing the discriminating power of each item is given in Appendix VI C.

Final form of Scientific Interest Inventory consists 30 items. One score was given, if a subject selects the statement which shows inclination to science. The respondent could get a maximum of 30 scores in the inventory. The final form of Scientific Interest Inventory (English & Malayalam), the scoring key and response sheet of the final form are given as Appendices - VI D, VI E, VI F and VI G.

4.4.6.5 Reliability and Validity

Using split half method, reliability of the Scientific Interest Inventory was found out. The reliability coefficient of the interest inventory was found to
be 0.81. This high value gives a clear indication of the reliability of the Scientific Interest Inventory.

The procedure adopted for the preparation of the inventory is the clear indication of the validity of the tool. The science teachers of the concerned classes were requested to rate their students based on their interest in science. The rating scores obtained from teachers and the scores obtained by students on Scientific Interest Inventory were correlated and it was found to be 0.76. It also reveals the validity of the Scientific Interest Inventory.

4.4.7 Achievement test in Physics

According to Anastassi (1961) the principle objective of achievement test is to appraise the effects of a course of instruction or training.

The investigator developed and standardized an Achievement test in Physics for two units of standard IX of the Kerala State syllabus according to the objectives formulated by McCormack and Yager (1989) and strictly following the stages of preparation of Achievement test proposed by Anastassi (1961).

4.4.7.1 Deciding the instructional objectives

Objectives occupy a central position in teaching – learning, and hence the determination of objectives and their weightages play a crucial role in any Achievement test construction.

Here the investigator selected the instructional objectives proposed by McCormack and Yager (1989), and it consists of five categories of objectives for classifying cognitive behaviors - Knowledge, Process, Attitude, Creativity and Application.
4.4.7.2 Preparation of the draft test

Two units (units 7 & 8) from the text book of Physics of standard IX were selected for the achievement test and these units are ‘Work, Energy & Power’ and ‘Refraction of light’.

4.4.7.2.1 Type of questions

The multiple choice items are adaptable to the measurement of most important outcomes of knowledge, understanding and judgment ability to solve problems, to recommend appropriate action, to make predictions. Keeping this in mind the investigator selected objective type multiple choice questions only, for the Achievement test in Physics.

4.4.7.2.2 Draft test

With the support and concern of the supervising teacher, experts and experienced teachers in Physics, the investigator prepared achievement test with multiple choice items in the content area selected.

A draft test consisting of 50 multiple choice items was prepared with necessary directions. Due weightage is given to content, objectives, and difficulty level. Details of the draft test are in the Tables given below.
4.4.7.2.3 Design for draft test

a) Weightage to content

Table 4.8

<table>
<thead>
<tr>
<th>No</th>
<th>Sub content</th>
<th>Total Mark</th>
<th>Question Number</th>
<th>Total no of questions</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Work</td>
<td>3</td>
<td>9,42,43</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Energy</td>
<td>1</td>
<td>35</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Different forms of energy</td>
<td>11</td>
<td>10,11,14,17,</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>27,44,45,46,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>13,25,32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Energy conservation principle</td>
<td>1</td>
<td>47</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Power</td>
<td>4</td>
<td>5,15,16,33</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>Refraction</td>
<td>2</td>
<td>2,38</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>Refractive index in diff mediums</td>
<td>2</td>
<td>3,24</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>Total internal reflection</td>
<td>2</td>
<td>20,39</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>Lenses</td>
<td>4</td>
<td>4,7,26,37</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>10</td>
<td>Image formation</td>
<td>7</td>
<td>19,21,22,23,</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>29,40,41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Human eye &amp; camera</td>
<td>1</td>
<td>31</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>Power of lenses</td>
<td>4</td>
<td>8,17,34,36</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>13</td>
<td>Defects of Eye</td>
<td>5</td>
<td>1,12,48,49,50</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>14</td>
<td>General Information</td>
<td>3</td>
<td>6,18,30</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Grand Total</td>
<td>50</td>
<td>50</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
b) Weightage to Objectives

Table 4.9

Weightage to Objectives

<table>
<thead>
<tr>
<th>No</th>
<th>Objective</th>
<th>Total mark</th>
<th>Question Number</th>
<th>Total No</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knowledge</td>
<td>11</td>
<td>1,5,7,11,20,33,34,35,45,47</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Process</td>
<td>21</td>
<td>4,6,8,12,14,17,19,22,23,24,25,26,27,28,29,31,44,48,49,50</td>
<td>21</td>
<td>42</td>
</tr>
<tr>
<td>3</td>
<td>Creativity</td>
<td>4</td>
<td>13,38,40,42</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Attitude</td>
<td>3</td>
<td>18,30,31,32</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>Application</td>
<td>11</td>
<td>2,3,9,10,15,16,21,36,39,43,46</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>50</td>
<td></td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

c) Weightage to Difficulty level

Table 4.10

Weightage to Difficulty Level

<table>
<thead>
<tr>
<th>No</th>
<th>Content</th>
<th>Mark</th>
<th>Question Number</th>
<th>Total No</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Easy</td>
<td>9</td>
<td>4,5,7,12,31,33,34,35,45</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>Average</td>
<td>32</td>
<td>1,2,3,6,8,9,10,11,13,14,15,16,17,18,19,21,22,23,24,25,26,27,28,29,32,37,38,39,43,44,47,50</td>
<td>32</td>
<td>64</td>
</tr>
<tr>
<td>3</td>
<td>Difficult</td>
<td>9</td>
<td>20,30,36,40,41,42,46,48,49</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>50</td>
<td></td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

A copy of the draft test (English & Malayalam) is provided as Appendices VII A and VII B.
4.4.7.3 Try out

The try out of the draft test for item analysis was conducted on a sample of 385 students of standard IX, selected by random sampling procedure. Prior arrangements were made with authorities for the proper conduct of the test, under satisfactory examination conditions. Test was conducted in all the institutions selected under identical conditions, especially regarding instructions given to examinees, time given etc. The scoring was done according to the scoring key prepared for this purpose.

4.4.7.4 Item analysis

It is the process of discarding and selecting suitable items for the final form of the test. The quality of each item was ascertained by analyzing two important characteristics of the item namely

- Difficulty index
- Discrimination power

From the obtained answer scripts of tryout, 370 answer scripts complete in all respects were selected for the final analysis. Based on the scores obtained, the response sheets of the students were arranged in the descending order from highest to the lowest. The responses of the top scoring 27% and bottom scoring 27% were used for item analysis. For the present study the procedure and formula suggested by Ebel & Frisbie (1991) were used to calculate the difficulty index and discriminating power.

Index of item difficulty DI = (U+L) /2N

Index of discriminating power DP = (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 pupil in each group
The general maxims of item writing were also kept in mind while selecting the final items and are:

1. Each item is on specific objective
2. Do not lift statements verbally from the textbook.
3. Try to avoid ambiguity of statements
4. Avoid trick and catch items
5. In planning a set of items for a test, take care that one item does not provide clues to the answer of another item or items.

4.4.7.5 Preparation of the final test

The final test was prepared based on the discriminating power and difficulty index of each item and due weightage is given to content, objectives, difficulty level, type of questions and through distraction analysis. In this study, items having difficulty index between 0.26 and 0.77 and discriminating power above 0.25 were selected. Out of 50 items prepared for the draft, 25 items were selected for the final test. The details regarding difficulty index and discriminating power of each item given as Appendix - VII C.

The final test was prepared by giving due weightage to content, objectives and difficulty level and is given in the following tables.
### Table 4.11

*Weightage to Content*

<table>
<thead>
<tr>
<th>No</th>
<th>Sub unit</th>
<th>Total mark</th>
<th>Question Number</th>
<th>Total Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Work</td>
<td>2</td>
<td>6,22</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>Energy</td>
<td>1</td>
<td>18</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Different forms of energy</td>
<td>4</td>
<td>8,13,23,24</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>Energy conservation</td>
<td>3</td>
<td>7,12,16</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>Power</td>
<td>1</td>
<td>9</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Refraction –</td>
<td>3</td>
<td>2,3,20</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Refractive index &amp; total internal reflection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Lenses image formation</td>
<td>4</td>
<td>4,11,14,21</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>8</td>
<td>Power of lens</td>
<td>3</td>
<td>5,17,19</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>Defects of human eye</td>
<td>2</td>
<td>1,25</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>10</td>
<td>General Information</td>
<td>2</td>
<td>10,15</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>25</strong></td>
<td><strong>25</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4.12

*Weightage to Objectives*

<table>
<thead>
<tr>
<th>No</th>
<th>Objectives</th>
<th>Question Number</th>
<th>Mark</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knowledge</td>
<td>1,17,18,23</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Process</td>
<td>4,5,7,8,11,12,13,14,22,25</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>Creativity</td>
<td>10,15</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Attitude</td>
<td>16,21</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>Application</td>
<td>2,3,6,9,19,20,24</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>25</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>
Table 4.13

*Weightage to Difficulty Level*

<table>
<thead>
<tr>
<th>No</th>
<th>Difficulty level</th>
<th>Marks</th>
<th>Question Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Easy</td>
<td>4</td>
<td>1,17,18,23</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Average</td>
<td>16</td>
<td>2,4,5,6,7,8,9,10,11,12,13,14,16,19,20,22</td>
<td>64</td>
</tr>
<tr>
<td>3</td>
<td>Difficult</td>
<td>5</td>
<td>3,15,21,24,25</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>25</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

**Distraction analysis**

If the distracters are properly given, guessing can be eliminated. Questions 1-13 are given as multiple choice items, 12-13 are odd one out type items, 14-16 are completion type questions, 17-18 are match the following type questions, 19-25 are one word type and figure completion type questions.

**Blueprint**

The weightage given to each objective and content, the difficulty level of each question and marks are specified in the blue print. The investigator prepared a blue print before preparing the final test. The blue print is given in the table given below.
Table 4.14

Blueprint of Achievement test in Physics

<table>
<thead>
<tr>
<th>Content</th>
<th>Difficulty level</th>
<th>Knowledge</th>
<th>Process</th>
<th>Creativity</th>
<th>Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>E  A  D</td>
<td>E  A  D</td>
<td>E  A  D</td>
<td>E  A  D</td>
</tr>
<tr>
<td>Work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>(1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Form of Energy</td>
<td>(1)</td>
<td></td>
<td>(1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changes in energy forms</td>
<td></td>
<td></td>
<td>(1)</td>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>Power</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refractions – Refractive index</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lenses – Image formation</td>
<td></td>
<td></td>
<td>(1)</td>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>Power of lens</td>
<td>(1)</td>
<td></td>
<td>(1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defects of Eye</td>
<td>(1)</td>
<td></td>
<td></td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>General</td>
<td></td>
<td></td>
<td></td>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>4</td>
<td>10</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

E – Easy  A – Average  D - Difficult

(The number outside the brackets shows the number of questions and the number inside the brackets indicates the marks)
Thus 25 items were selected for the final test, based on difficulty index and discriminating power of items. The time duration of the test was 40 minutes. A copy of the final Achievement test (English & Malayalam) and the scoring key of the Achievement test (English & Malayalam) are given as Appendices - VII D, VII E, VII F and VII G.

4.4.7.6 Requirements of the test

Any measuring instrument must satisfy some requirements if it is to be a useful one. The success of an evaluation programme ultimately depends on the satisfaction of the requirements. The most important requirements of the test are Reliability, Validity, Objectivity and Practicability.

Reliability

Reliability is the degree to which test consistency measures whatever the test is measuring. Using split half method, reliability of the test was established. A sample of 100 pupils studying in Standard IX was used for this purpose. Here, the odd numbered items were treated as one half of the test and scored separately and all the even numbered items were treated as another half and scored for each examinee. The scores of the halves were correlated and the reliability of the test was found to be 0.85.

The reliability coefficient of the whole test was calculated using Spearman-Brown Prophecy formula. The reliability coefficient of the whole test was calculated as 0.92. Hence the test is a reliable one.

The reliability of the test was also calculated using test retest method. The test was administered two times to the same sample (N=100), in an interval of three weeks. The scores of the individual in the two tests were calculated. The product moment coefficient of correlation between the two scores of the sample of hundred students was calculated. The value of the correlation coefficient ‘r’ (test-retest reliability) obtained is 0.76.
Validity

Validity of the test represents the extent to which a test measures what it purports to measure. As far as achievement test is concerned, content validity and criterion related validity are important.

Content Validity

Content validity is the degree to which a test measures an intended content area. Content validity is of practical importance for achievement test. A careful consideration of the subject matter will yield satisfactory validity with regard to the content. The test was constructed keeping in view the weightage given for content area with instructional objectives on one hand and experts comments and opinion on the other. So it can be treated as a valid one.

Criterion related validity

It refers to the relation between the test scores and the criterion, the latter being an independent and direct measure of that which the test is designed to predict (Anastassi, 1961).

This empirical validity of the test can be calculated by correlating the scores of the test with marks of recently conducted test obtained from the school. The coefficient of correlation ‘r’ obtained is 0.78. Hence the test can be considered as a valid one.

For more clarity, terminal examination scores also correlated with the achievement test and the correlation coefficient obtained is 0.89.

Objectivity and Practicability

In this study, objectivity was ensured by including only objective type items and by using scoring key for validation. The test was easy to administer and it was in the booklet form and necessary directions to complete the test is
given in the front sheet itself. Duration for the test is 40 minutes. The scoring of the test is also easy, hence it is practical.

4.5 EXPERIMENTAL PROCEDURE

The experiment was conducted to study the Effectiveness of 5E Learning Cycle Model on Scientific Creativity, Scientific Interest and Achievement in Physics at secondary level. For that the investigator developed and standardized the tools. After finalizing the sample and tools to be used, the investigator visited the selected schools and contacted the heads and teachers of the select schools for getting permission and co-operation for the collection of data. The investigator established rapport with the students, and explained the purpose of the study.

The investigator compared the previous achievement in Physics of the Experimental and Control groups, before starting the treatment. Then the Raven’s Standard Progressive Matrices were administered to compare the General Mental Ability of the students. After that the investigator started the treatment and the procedure adopted in the experiment is given below.

4.5.1 Administration of Pre-test

4.5.2 Learning by the Experimental group

4.5.3 Learning by the Control group

4.5.4 Administration of Post-test

4.5.5 Administration of Delayed Achievement Test

4.5.1 Administration of Pre-test

After getting permission from the heads of the schools, the investigator administered the pre-tests. An explanation of the aim and scope of the study was given to the students and their co-operation was ensured. The Scientific Creativity Test, Scientific Interest Inventory and Achievement test in Physics
were administered as pre-test to both the experimental and control groups. The rules and procedure prescribed for each test was strictly followed.

4.5.2 Learning by the Experimental group

After administering the pre-tests, the experimental group was taught Physics using 5E Learning Cycle model. The lesson transcripts were prepared based on the five phases of the 5E Learning Cycle Model. There were 24 lesson transcripts and duration of each lesson was 40 minutes.

4.5.3 Learning by the Control group

After administering the pre-test to control group, they were taught the content using the lesson transcripts based on prevailing Activity Oriented Method. There were 24 lesson transcripts and duration of each lesson was 40 minutes. There were individual and group activities in the lesson transcripts.

4.5.4 Administration of Post-test

On completion of treatment to both experimental and control groups, the post-tests were administered. The Scientific Creativity test, Scientific Interest Inventory and Achievement test in Physics were administered as post-test. The response sheets of the post-tests were collected back and were scored with the help of scoring key. The scores obtained were analyzed statistically.

4.5.5 Administration of Delayed Post-test on Achievement

After one month from the administration of the post-test, the Achievement test is again given to both the groups (Delayed post-test on Achievement) to understand whether the method of instruction is having any effect on retention of Achievement in Physics. The Achievement test (post-test) and the Delayed post-test on Achievement are similar in all respects except the order of questions. The scores of Delayed post-test on Achievement are analyzed to find out the retention of Achievement in Physics.
4.7 STATISTICAL TECHNIQUES USED

The scores obtained by the students were treated for statistical analysis. Since the aim of the study was to find the Effectiveness of 5E Learning Cycle Model on Scientific Creativity, Scientific Interest and Achievement in Physics at secondary level, it is necessary to compare it with the teaching based on Activity Oriented Method. For this, mean, median, standard deviation, kurtosis, skewness, critical ratio, Analysis of Variance and Analysis of Co-Variance and adjusted means were calculated.

1. Critical Ratio

\[ \text{C.R.} = \frac{(M_1 - M_2)}{\text{S.E}_D} \]

Where C.R. – Critical ratio

\( M_1 \) – Mean of first group

\( M_2 \) – Mean of second group

\( \text{S.E}_D \) – Standard Error of the difference between Mean

2. ANCOVA

ANCOVA is a statistical technique for equating groups on one or more variables when testing for statistical significance; it adjusts scores on a dependent variable for initial differences on other variables, such as pre-test performance or IQ (Fraenkel & Walen, 1993).

The pre-test and post-test scores of both the groups were consolidated for statistical analysis. Since the aim of the study was to determine the Effectiveness of 5E Learning Cycle Model on Scientific Creativity, Scientific Interest and Achievement in Physics at secondary level, it was necessary to find out whether there is significant difference between two mean scores. The technique of ‘Analysis of Covariance’ was applied. This technique was also applied to test the Effectiveness of 5E Learning Cycle Model on achievement
in Physics at Knowledge, Process, Application, Analysis and Creativity. Analysis of covariance is an extension of analysis of variance to allow for the correlation between initial and final scores.

In applying the statistical technique ANCOVA, the procedure suggested and illustrated by Garrett (2005) was followed. It includes nine major steps as follows.

Step 1

Computation of Correlation term (C):

Determine the correlation terms Cx, Cy and Cxy being correction of ‘x’ scores, ‘y’ scores and ‘x,y’ scores respectively that are required to make adjustments of the standard deviation calculated from original measures, taking zero as the assumed mean. These are calculated using the formula:

\[
\begin{align*}
C_x &= \left(\frac{\Sigma x}{N}\right)^2 \\
C_y &= \left(\frac{\Sigma y}{N}\right)^2 \\
C_{xy} &= \left(\frac{\Sigma xy}{N}\right)
\end{align*}
\]

Where,

\[
\Sigma x = \Sigma x_1 + \Sigma x_2 \\
\Sigma y = \Sigma y_1 + \Sigma y_2 \\
\Sigma xy = \Sigma x_1 y_1 + \Sigma x_2 y_2
\]

N = Number of scores of both the groups

\Sigma x_1 = Sum of the pretest scores of experimental group

\Sigma x_2 = Sum of the pretest scores of control group

\Sigma y_1 = Sum of the posttest scores of experimental group

\Sigma y_2 = Sum of the posttest scores of control group

Step 2

Computation of total sum of squares (Total SS)

In this step, the total sum of squares (total SS) for ‘x’, ‘y’ and ‘xy’ are calculated. These are calculated using the formulae:

Total SS for x, \(SS_x = \Sigma x^2 - Cx\)
Total SS for \( y \), \( SS_y = \sum y^2 - Cy \)

Total SS for \( xy \), \( SS_{xy} = \sum xy - Cxy \)

Where \( \sum x^2 = \sum x_1^2 + \sum x_2^2 \)

\( \sum y^2 = \sum y_1^2 + \sum y_2^2 \)

**Step 3**

**Computation of sum of squares (SS) among the means of the groups**

In this step, sum of squares among the group means are calculated using the following formulae:

a) \( SS \) among means for \( X = \frac{(\sum x_1)^2}{n_1} + \frac{(\sum x_2)^2}{n_2} - Cx \)

b) \( SS \) among means for \( Y = \frac{(\sum y_1)^2}{n_1} + \frac{(\sum y_2)^2}{n_2} - Cy \)

c) \( SS \) among means for \( XY = \frac{\left((\sum x_1)(\sum y_1]\right)}{n_1} + \frac{\left((\sum x_2)(\sum y_2]\right)}{n_2} - Cxy \)

Where \( n_1 = \) no. of scores in the experimental group

\( n_2 = \) no. of scores in the control group

**Step 4**

**Computation of sum of squares within groups**

Sum of squares (SS) within groups can be calculated by the formulae:-

a) Within groups \( SS \) for \( X = SSx - SS \) among-means for \( X \)

b) Within groups \( SS \) for \( Y = SSy - SS \) among-means for \( Y \)

c) Within groups \( SS \) for \( XY = SSxy - SS \) among means for \( XY \)

**Step 5**

**Analysis of Variance of \( X \) and \( Y \) scores**

In this step, analysis of variance of ‘\( x \)’ and ‘\( y \)’ scores are taken respectively. The F-test is applied to the two sets of scores using the following formulae.
**Methodology**

F_x = Mean square variance of among groups (for x)

Mean square variance of within groups

F_y = Mean square variance of among groups (for y)

Mean square variance of within groups

Where, F_x = F ratio for x scores

F_y = F ratio for y scores

**Step 6**

**Computation of adjusted sum of squares (SS for y ie, SS_yx)**

The computations carried out in this step are for the purpose of computing the final (Y) scores for differences in initial (X) scores. The equation for finding adjusted sum of squares is given below.

\[ SS_{y.x} = SS_y - \left( \frac{SS_{xy}}{SS_x} \right)^2 \]

From the adjusted sum of squares thus calculated, the variance can be computed by dividing each ‘SS’ by its degree of freedom.

Then F-test is applied to the adjusted, among and within variance to determine whether the adjusted means differ significantly.

**Step 7**

**Computation of regression coefficient for within groups**

From the SS’s in x, y and xy, it is possible to compare several coefficients of correlations. These are helpful in the interpretation of the result obtained in step 6.

The general formula used is,

\[ r = \frac{SS_{xy}}{\sqrt{SS_x \times SS_y}} \]

It may be applied to the appropriate SS’s, for total among means and within groups.
The correlation among scores and the correlation among means may be used, in a preliminary way to decide, analysis of co-variance is worthwhile.

Regression coefficients for total, among means and within groups have been calculated using the formulae.

\[ b = \frac{SS_{xy}}{SS_x} \]

\[ b \] - Within is used in the computation of the adjusted y means in step 8.

**Step 8: Calculation of adjusted Y means**

It can be calculated by the formula,

\[ My_x = My - b (Mx - GMx) \]

This step is to find which mean differences noticed in step 6 are significant.

**Step 9: Significance of differences among adjusted Y means**

For calculating this, the standard error of difference between two means is calculated using the formula \( S.E_D = \sqrt{\frac{1}{N_1} + \frac{1}{N_2}} \). Then the ‘t’ value is found from Tables and by substituting in the equation \( t = D/S.E_D \). Now we will obtain the level of significance of difference at 0.05 or 0.01 level.

The details of analysis and interpretation of data using the above mentioned statistical techniques are given in the next chapter.