Chapter IV

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METHODOLOGY

Research Methodology describes various steps of the plan of attack to be adopted in solving a research problem such as the manner in which the problem is formulated, the definition of terms, the choice of subjects for investigation, the validation of data gathering tools, collection of data, analysis and interpretation of data and the process of inferences and generalizations. It is a way to systematically solve a research problem. It may be understood as a science of studying how research is done scientifically. It involves the systematic procedures by which the researcher starts from the initial identification of the problem to its logical conclusion.

Research methods are of utmost importance in a research process. A method is a way of approaching the problem. A pre-planned and well-described method will provide the researcher with a scientific and feasible plan for attacking and solving the problem under investigation. 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 research work.

4.1 METHOD ADOPTED FOR THE STUDY

The major aim of the study is to develop a Computer Based Instructional Package in Physics for the Higher Secondary School Students and to ascertain the relative effectiveness of Computer Based Instructional Package and existing Activity Oriented Method of Instruction on the achievement in Physics of higher secondary school students. So the current research study was experimental in nature.

Experimental research provides a systematic and logical method of answering the question “if this is done under carefully controlled conditions what will happen”? Experimentation provides a method of hypotheses testing. Experimentation is the most sophisticated, exact and powerful method of discovering and developing an organized body of scientific knowledge which attempts to provide a precise answer to a precise question. The purpose of experimentation is to derive verified functional relationship among phenomena under controlled conditions. From an operational point of view, it is a matter of varying the independent variable in order to study the effect of such variation on the dependent variable. In an experimental study, the
researcher manipulates at least one independent variable, controls over relevant variables and observes the effect on one or more dependent variables (Gay, 1996). An experiment involves the comparison of the effects of a particular treatment with that of a different treatment or of no treatment. In a simple conventional experiment, reference is usually made to an experimental group and to a control group. The experimental group is exposed to the influence of the factor under consideration; the control group is not. Observations are then made to determine what difference appears or what change or modification occurs in the experimental as contrasted with the control group.

The experimental research is not considered as a precise method of research in the field of education because of the complex nature of human beings and problems of controlling the extraneous variables. However, experimentation has been put to various uses in solving educational problems. It is used to determine and evaluate the adequacy and effectiveness of the educational and instructional objectives through measurement of outcomes.

4.1.1. Design Selected

“Experimental design is the blueprint of the procedures that enables the researcher to test hypotheses by reaching valid conclusions about the relationship between independent and dependent variables. Selection of a particular design is based upon the purpose of the experiment, the type of variables to be manipulated, and the conditions or limiting factors under which it is conducted” (Best, 2007). An experimental design provides the researcher an opportunity for the comparisons required by the hypotheses of the experiment and enables him to make a meaningful interpretation of the results of the study with the help of statistical analysis of the data.

In this study, the Investigator has adopted the “Pre-Test Post- Test Non-equivalent group design”. This design provides control of when and to whom the measurement is applied. The researcher has assigned experimental and control group randomly. 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, 2007). The reason for this is that in a school situation, it is practically not possible to upset class schedules, to gather subjects for obtaining a sufficiently
large sample or to recognize classes in order to employ randomization procedure for getting equivalent control and experimental groups.

The present study utilized two groups, the groups which was exposed to the Computer Based Instructional Package (CBIP) was the experimental group and the other which was exposed to existing Activity Oriented Method of Instruction (AOMI) was the control group and this permitted the comparison for the scientific investigation. The Investigator in the present study made use of two non-equivalent classroom groups, one experimental group and one control group. To compensate for the lack of equivalency between two groups, the Investigator has applied the technique of Analysis of Co-variance.

A pre-test was administrated to the two groups at first. These groups were then randomly assigned to treatments. The experimental treatment was administered to the experimental group and the control group was treated with existing Activity Oriented Method of Instruction. Then the post-test was given to the two groups. The pre and post-tests were designed to indicate student’s mastery of content before and after the application of the pre-determined instructional strategies. The differences between the pre-test and post-test scores were compared with the help of appropriate statistical techniques to ascertain the relative effectiveness of Computer Based Instructional Package and existing Activity Oriented Method of Instruction. The layout of the design is

\[
G_1O_1 \ X \ O_2 \\
G_2O_3 \ C \ O_4 
\]

In this design

\[O_1 \text{ and } O_3 \text{ are pre-tests}\]
\[O_2 \text{ and } O_4 \text{ are post - tests.}\]
\[‘X’ \text{ is the experimental Treatment}\]
\[‘C’ \text{ is the control Treatment}\]
\[G_1 \text{ is the Experimental Group}\]
\[G_2 \text{ is the Control Group}\]
The outline of the experimental procedure is given below

**STANDARD XII STUDENTS**

- EXPERIMENTAL GROUP
  - **PRE-TEST**
    - ACHIEVEMENT TEST
    - PROCESS SKILL ASSESSMENT TEST
    - SCIENTIFIC ATTITUDE SCALE
    - SCIENTIFIC CREATIVITY TEST
  - COMPUTER BASED INSTRUCTIONAL PACKAGE
  - **POST-TEST**
    - ACHIEVEMENT TEST
    - PROCESS SKILL ASSESSMENT TEST
    - SCIENTIFIC ATTITUDE SCALE
    - SCIENTIFIC CREATIVITY TEST

- CONTROL GROUP
  - **PRE-TEST**
    - ACHIEVEMENT TEST
    - PROCESS SKILL ASSESSMENT TEST
    - SCIENTIFIC ATTITUDE SCALE
    - SCIENTIFIC CREATIVITY TEST
  - ACTIVITY ORIENTED METHOD OF INSTRUCTION
  - **POST-TEST**
    - ACHIEVEMENT TEST
    - PROCESS SKILL ASSESSMENT TEST
    - SCIENTIFIC ATTITUDE SCALE
    - SCIENTIFIC CREATIVITY TEST

*Figure 4.1 Outline of the Experimental Procedure*
4.1.2 SAMPLE SELECTED

The population of the study consisted of Higher Secondary School Students of Kerala following State syllabus.

The diagrammatic representation of the sample selected for the study is given below.

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**Fig 4.2** Diagrammatic Representation of Sample Selected for the Study

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The Investigator adopted simple random sampling technique for the sample selected. 120 students from Standard XII of T.R.K.H.S.S. Vaniyamkulam, Palakkad were selected for the study. These students were divided into two groups; each consists of 60 students, based on their pre-achievement. Then one group was randomly selected as experimental group and the other as control group.

4.1.3. Variables in the Experiment

Variables are the conditions or characteristics that the experimenter manipulates, controls or observes. A variable is some aspects of a testing condition that can change or take on different characteristics with different conditions. Reducing a phenomenon to variables focuses the researcher’s attention on specific events out of the many that may be related to the phenomenon (Mc Burney, 2001). Mainly there are two important types of variables. They are:

**Independent Variable**

“The independent variables are the conditions or characteristics that the experimenter manipulates or controls in his/her attempt to ascertain their relationship to observed phenomenon” (Best, 2007). In the present study the method of treatment is the independent variable. Instruction through Computer Based Instructional Package and Activity Oriented Method of Instruction were the independent variables selected for the study.

**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, 2007). In this study the dependent variable selected was the Achievement in Physics of the higher secondary school students in different domains of testing.

The variables selected for the present study is represented diagrammatically in the following figure.
4.1.4 Materials and Tools Used in the Study

The selection of suitable tool is of vital importance for successful research as it is the sole factor in collecting sound data and in arriving at perfect conclusions about the problem or study in hand, which ultimately helps in providing suitable remedial measures to the problems concerned.

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

1. Questionnaire for Students on Computer Awareness & Learning Difficulties (Developed by the Investigator)
2. Computer Based Interactive Learning Package (Developed by the Investigator)
3. Rating Scale to Teachers for Assessing the Effectiveness of the Computer Based Instructional Package (Developed and Standardized by the Investigator)
4. Lesson Transcripts and Learning Materials Based on Activity Oriented Method of Instruction (Developed by the Investigator).
5. Achievement Test in Physics (Developed and Standardized by the Investigator).
6. Process Skill Assessment Test (Developed and Standardized by the Investigator).
7. Scale of Scientific Attitude (Developed and Standardized by the Investigator).
8. Scientific Creativity Test (Adapted version of the Test Developed and Standardized by Hu and Adey (2002)).
9. Intelligence Test (Raven’s Progressive Matrices Test)

4.2 DESCRIPTION OF MATERIALS AND TOOLS USED IN THE STUDY

The description of construction and administration of various tools and materials used in the present study is given below.

4.2.1 Questionnaire for Students on Computer Awareness and Learning Difficulties for Higher Secondary School Students

In educational research when tools are considered, the inquiry forms are the most important and the most popular. The Investigator used a questionnaire to collect data regarding the difficulties experienced by the higher secondary school students in learning science and about their computer awareness.

Barr (1960) defines questionnaire as a systematic compilation of questions that are submitted to the sample of population from which the information is derived. Questionnaire is one of the most flexible tools, which possess unique advantages over other kinds of tools in collecting both qualitative and quantitative information (Best, 2007). It permits wide coverage for a minimum expense both in money and effort. This greater coverage ensures greater validity in the result through prompting the selection of a large and more representative sample.

Steps involved in the construction of the questionnaire are as follows.

1. Planning of the questionnaire
2. Preparation of the questionnaire
3. Pilot testing
4. Finalization of the questionnaire
5. Establishing reliability and validity of the questionnaire
1. **Planning of the questionnaire**

Since the present study was intended to prepare a Computer Based Instructional Package in Physics at higher secondary school level the Investigator thought that it was beneficial to know about the drawbacks of the existing practices in science education, learning difficulties experienced by the higher secondary school students in their science classrooms and their awareness in using computers. In order to measure these factors, the Investigator decided to construct a questionnaire.

During the planning stage, the Investigator conducted a review of available tools in similar areas and various aspects of preparation of questionnaires from books, journals, handbooks and published papers, related to higher secondary school science education. Before preparing the questionnaire, the Investigator also made thorough discussion and consultation with the experts, higher secondary school physics teachers, higher secondary school science students and physical science teacher educators who were actively involved in the teaching-learning process. Based on these reviews and discussions, the Investigator decided to prepare a preliminary draft of the questionnaire consisting items under five major dimensions. The dimensions chosen were

i. Modern / innovative approaches used by the teacher

ii. Attitude of the learner towards innovative approaches

iii. Individualized instruction

iv. Awareness / use of computer for general purpose by the learner

v. Use of computer in education by the learner

2. **Preparation of the questionnaire**

After consultation with the experts and reviewing related literature, the Investigator prepared a preliminary draft of the questionnaire based on the plan. The Investigator prepared 36 questions for the draft tool. The questions were arranged in such a way that the respondent could go through it easily and could get the idea contained in the question in single reading. The objectives of the study and the intention of the Investigator were mentioned in the covering letter of the questionnaire. Directions for the respondent were also given at the beginning. The
Details of the questionnaire prepared on the basis of the dimensions are given below in Table 4.1

Table 4.1

*Dimension-wise Distribution of the Questions in the Draft Questionnaire*

<table>
<thead>
<tr>
<th>SI.No.</th>
<th>Dimensions</th>
<th>Question No.</th>
<th>No. of Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Modern / innovative approaches used by the teacher</td>
<td>1, 5, 6, 7, 23, 31</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Attitude of learner towards innovative approaches</td>
<td>14, 17, 22, 26, 27, 28, 29, 30, 33</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>Individualized instruction</td>
<td>2, 3, 4, 8, 9, 18, 24, 25, 32</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>Awareness or use of computer for general purpose by the learner</td>
<td>10, 11, 12, 15, 16, 19, 34, 35</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>Use of computer in education by the learner</td>
<td>13, 20, 21, 36</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>36</strong></td>
<td></td>
</tr>
</tbody>
</table>

3. **Pilot Testing**

The prepared draft questionnaire was administered on a small group consisting of 40 higher secondary science students with a view in getting feedback so that necessary corrections and restructuring of the items could be made. The students were asked to read the statements carefully and mark their responses against the corresponding statement by putting tick (✓) mark in the appropriate boxes Yes/No.

4. **Finalization of the Questionnaire**

On the basis of the consultation with the experts and feedback from pilot testing, two questions were avoided and changes in the language and structure of certain items were made. Then 34 questions out of 36 questions were selected for the
final questionnaire. The dimension wise distribution of questions in the final form of questionnaire is given below in Table 4.2

Table 4.2

**Dimension-wise Distribution of the Questions in the Final Questionnaire**

<table>
<thead>
<tr>
<th>SI.No.</th>
<th>Dimensions</th>
<th>Question No.</th>
<th>No. of Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Modern / innovative approaches used by the teacher</td>
<td>1,5,6,7,23,31</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Attitude of learner towards innovative approaches</td>
<td>14,17,22,25,26,27,28,29</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Individualized instruction</td>
<td>2,3,4,8,9,18,24,31</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Awareness or use of computer for general purpose by the learner</td>
<td>10,11,12,15,16,19,32,33</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>Use of computer in education by the learner</td>
<td>13,20,21,34</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>34</strong></td>
</tr>
</tbody>
</table>

The draft and final forms of the questionnaire are given in appendix II A, and II B respectively.

5. **Establishing Reliability and Validity of the Questionnaire**

Reliability

Reliability and validity are the two essential characteristics of a measuring instrument; hence this part presents the details of establishing these two. Reliability refers to the consistency of scores obtained by the same person when re-examined.
with the same test on different occasions (stability) or with different sets of equivalent items (equivalence). Since all types of reliability are concerned with degrees of consistency or between independently desired sets of scores, they can all be expressed in terms of Correlation Co-efficient.

Reliability of the questionnaire was established by the Split-Half method. The test is first divided into two equivalent “halves” and the correlation is found for each of these half-tests. The procedure is generating two sets of scores by taking alternate items in the test. That is first set of scores represents the performance of odd numbered items and the second set of score represents the performance of even numbered items. From the self correlation of the half tests, the reliability coefficient of the whole test may be estimated from the Spearman-Brown Prophecy formula. The reliability coefficient of the present tool was found to be 0.751.

**Validity**

The process of measurement in psychology is generally consistent with the ascription of numbers to attributes according to a rule (Stevens, 1946). As was the case for reliability described above, validity is not a property that can be ascribed to a test. Many approaches to the assessment of validity have been devised over the years, the most common of which are face validity, content validity, factorial validity, predictive validity and concurrent validity.

The validity of the present tool was established in two different ways. By subjecting the test items for expert criticism, content validity of the test was ensured. As per the evaluation of the experts, the tool agrees with the components verbally and comprehensively. Face validity of the tool was also established in the conventional way. Intrinsic validity is also established for the two as it can be calculated as the square root of reliability and it was found to be 0.866.

After eliminating the rejected questions, the percentage analysis of each question was made and is given in Appendix III C. The explanation of percentage analysis of the questionnaire is given in chapter 5 namely Analysis and Interpretation of data.
4.2.2 Development of Computer Based Instructional Package

Developing Computer Based Instructional material or software for use in a range of school subjects is a highly volatile activity. Software development is an expensive and time consuming activity and requires expertise.

The strategy chosen to develop courseware depends on the content in which the application will be used and the resource that are available to develop the application. The most important resources are the experts with their educational and multimedia expertise. The expertise may come from one individual or the expertise of many experts may be combined.

Mainly there are three approaches for the development of courseware. They are:-

1. **Individual Approach**

   In individual approach, one person in the role of a teacher develops the courseware alone. In this case, the teacher must have knowledge in the user interface component, the subject matter component, the pedagogical component and the student model component.

2. **Team Approach**

   Since it is difficult to find out teachers who are experts in all areas, to develop a high quality courseware an organized approach in which several experts provide the required expertise are used. In general, the team approach has a better chance of delivering high quality courseware products.

3. **Organizational Approach**

   In organizational approach, a large project organization where all required disciplines are available on an expert level. The courseware project may be divided into sub-projects. For each of the component in the development of the courseware, multiple experts may work for each specific field or discipline on the project team.

   Here, the Investigator adopted a ‘team approach’ for the development of the educational software. Hussain (2010) suggested five major stages or steps for

The following figure gives the design steps in the development of Educational Software.

![Diagram of design steps]

Figure 4.4 Design Steps in the Development of Educational Software.

1. **The Idea**

   Idea is the key ‘brain storming’ session of software development. Soundness of initial ground work in this stage is important, however, the nature and character of the software may change during development. The activities at this stage include:

   - Identification of teacher, curriculum or content, software developers and host institution for the formation of a new working group.
   - Introductory sessions on computer based instruction awareness to include looking at computer based learning materials in various subjects.
   - Discussion on the curriculum, areas of teaching/learning difficulties and features to be included while developing the computer based learning material to solve the teaching/learning difficulties.
Methodology

- Following a pathway through the programme; what do we want the learners to do and in what sort of sequence? A further look at variety of styles of user interface.
- Initial attempts at designing the screen layout; drawing up a comic script with specific learning objectives in behavioural terms.
- Some initial coding and feasibility of certain aspects of execution. Consultation by the programmer with the central team on the overall plans and on exploration of various methods of execution.
- Producing a clear specification for the programmer on the basis of which the groups agree on the point that is sufficiently sound to produce.

In this phase the Investigator constituted a working group in which physical science teacher educators, higher secondary physics teachers, computer program developers and subject experts were included. The list of the experts is given in Appendix I. After discussion with the members of the working group, the Investigator decided to fix ‘Ray Optics and Optical Instruments’ of class XII physics for the development of Computer Based Instructional Material.

Then the group analyzed Computer Based Instructional Materials already developed in various subjects and prepared an outline of the nature and features of the software to be prepared. This involves how to prepare the software, what the learner wants to do, the sequential order, and variety of styles of presenting the learning activities so that the learner can construct the knowledge by performing the activities individually or in small groups. Also initial attempts at designing the screen layout and drawing up a comic script were made in this stage.

2. Design

The next step is to form a design group. The design group consists of the subject experts, instructional designer, graphic designer and computer programmer.

The main activities of the design group will be:

- Writing the objectives of the lesson to be prepared.
- Discuss and decide the teaching-learning strategy to be incorporated in the lesson.
• Identify the target group that would use the package.
• Identify the areas of curriculum that the courseware would cover.
• Identify the student activities during learning with the package.
• Identify the role of the teacher in the software usage.
• Identify the control system on the student’s activities and interaction with the computer.
• Identify the methods and techniques for the presentation of the content.
• Develop and finalize the complete script.

In this phase a design for the Computer Based Learning Material to be developed is prepared by the Investigator. With constant consultation with the working group, the Investigator split the unit into 15 meaningful topics. Objectives and learning materials required for each topic were fixed and the teaching-learning strategies for realizing these objectives were also decided.

Interesting, interactive and innovative learning activities were carefully selected so that the learner can construct knowledge by performing each activity individually or in small groups, following the instruction given through the Computer based learning material.

The script for the software was prepared for each topic in which objectives, learning materials required, learning activities to be performed, illustration and explanation required for each concept, etc. were mentioned. Provisions were given for the self evaluation or feedback for the learner at the end of each topic. Also additional activities for the gifted children were selected and are included at the end of the package as ‘Learn more’ session. The sample scripts of two capsules are given in Appendix III.

3. Development

Development is really exciting, creative and the most fruitful part of the whole operation.

The main activities of the stage are:

• Main coding of key modules in the specification takes place; draft screen designs are produced and thus, initial user interface mapped out.
Methodology

- The groups respond to the initial execution of the idea. This often results in quite major revisions of their specifications as intention become clearer. Occasionally the execution spins off further ideas that move away from the original intention.
- The model being used is tested for robustness and appropriateness. At this stage fundamental problems or a lack of balance, within the model can be exposed through the testing of the outward variable limits.
- The group debates in greater detail to the educational objectives in order to clarify the aims of software and help to solve some of the modeling problems.
- Draft notes begin to emerge from the working group. It helps to overcome and nurture the confidence among subject teacher to give the write-up on which the computer based instructional package is to be developed. Editing help is provided by the CBI programme developer.
- Trial evaluation sheets are written with a particular emphasis on a section covering the particular subject and learning aims intended by the developers. Sometimes an author will do a dummy run of the software in their own classroom to explore some of the questions which may be included in the trials.
- Programme and notes need to be welded together by cross referring; screen dumps are taken for incorporation into notes.
- The authors determine style and wording of error messages and check their occurrence.
- The programmer has to decide early about any particular machine constraints to avoid during development and accordingly consult with others in the central team.
- The next step involves developing the final script on the computer. The programmer now develops the critical sections and the broad outline of the software developed is reviewed again. The subject expert is associated throughout the development stage for periodical review till the package is developed finally.
In this phase, at first the package was developed only for some key concepts based on the design. Then the effectiveness of the developed software was discussed among the working group.

The models developed for the key concepts were tested by giving them to some higher secondary school physics teachers and students. Based on their feedback, the working group made a debate in greater detail. Then modifications were done in the script wherever necessary. Based on the modified script the entire package was developed. The working group was associated throughout the development stage for periodical review till the package was developed finally.

4. Trials

This is a stage for both satisfaction and apprehension. In all creative work, it is very positive to have a physical product that is both robust and formal with properly produced notes and artwork ready for trials. The teachers are able to use something in their own schools to test out their own ideas in reality.

The main activities of this stage are:

- The trial programmes and notes forming the complete unit are sent out to the trial school accompanied with a detailed questionnaire.
- Copies are also sent to all members of the working group.
- During trials in the schools, teachers begin noting down problems and bugs in the unit and contacting the programmer directly about them.
- The trials have to run for quite a few months so that as far as possible, a unit can be trailed at the point in the curriculum that the teacher would normally cover the topic. This can influence the pace of work and projected trial date. The design team, peer group and selected target group, also review the software. The feedback from the reviewers helps in modifying the software.

In this phase the developed package was reviewed by the members of the working group. The feedback and suggestions from the members were collected by the Investigator. Also the copies of the package were given to five physics teachers of different higher secondary schools. The teachers were requested to administer the package to their classrooms and note down the difficulties from the part of the teachers and learners while administering the package. The suggestions from the
teachers were collected. The feedback from the reviewers, teachers, and learners helped in modifying the software.

5. Modification

The modification stage was a difficult one. The programmer may be asked to re-do or re-arrange, scrape or start new code, all of which are time consuming and frustrating when the trials’ version may have seemed to work perfectly well. New ideas with regard to screen design and user interface may need to be incorporated. The main activities of this stage include:

- Trial questionnaire forms are analyzed with respect to programme performance, usefulness of the notes, subject considerations and the general acceptance or rejection of the unit in terms of its value to the programme trial teacher.
- Programmer produces version of the programme on one machine, in the light of trial modifications. Colour combination of screen display chosen.
- Front page designed, using some artwork from within the programme.
- Modified notes were typed, revised and edited.

In this phase, based on the obtained feedback, appropriate modifications were made in the script. Modified notes were typed, revised and edited in the developed package. Also modifications in the pictures, graphics and animations wherever necessary were made with the help of the programmer. Proper style, size and lay out was decided and finally the modified fair package was emerged.

6. Documentation and Publication

The last and important phase is documentation and publication. The user manuals are developed indicating the pre-requisites for using the package, the different ways in which the software can be integrated into teaching, the ways in which the student can use the package and the methods in which the teacher can modify the material, if required. Finally the fully documented package is published.

In this stage the instructions for using the computer based instructional package and the method of using the package were prepared by the Investigator and
attached at the beginning of the developed package. Finally the fully documented package was published.

**Features of the Developed Computer Based Instructional Package**

1. **Providing individualized instruction**

   In this Computer Based Instructional Package, materials that meet different goals employ different methods and have different levels of difficulty are included so that every student can learn at their own pace based on their potentialities. Learners can move as slowly or as quickly as they like while utilizing this package. If they want to repeat some tasks or review some material again, they can do so as many times as they choose. Learners can skip over a topic if information is already known, making the learning process time effective and more efficient. That is this package is presented with exactly the same sequence of exercises, each student can work on them at a slightly different learning rate. By using this package each student can work at his own pace of learning to the desired level of learning. It also requires that students should take their own responsibility of their learning. Also supplementary information is provided at the end of the package for all capsules as ‘Learn More’ session. Here additional information likes biographies of scientists, solved problems, etc. is given.

**Some examples from the ‘learn more’ sessions**

(a) One of the biographies of the scientists given at the ‘Learn more’ session is that of Issac Newton which is given below

**Isaac Newton (1642-1727)**

Issac Newton was one of the greatest scientists of all time. He is best known for his discovery of the law of universal gravitation and the laws of motion. Much of modern science is based on the understanding and use of his laws. Newton was born on Christmas day 1642 in the small English town of Woolstrove.
In 1665 when Newton was only 22 years old, he worked out a basic formula in mathematics that has been used ever since. Today it is called Binomial theorem. While at Woolsthope, Newton began experimenting with light. He succeeded in showing that a beam of sunlight is made up of bands of colours from red to violet, as in a rainbow. He called these bands the spectrum. Newton continued working on light and colour. This work led him to the discovery of the reflecting telescope. In recognition of his work in mathematics and optics Newton was appointed Professor of mathematics at Trinity College in 1669. Early in 1672 he was elected a member of the Royal Society.

Although Newton experimented mostly with optics during these years at Trinity College, his mind always returned to the problem of gravitation. He was trying to calculate the exact amount of force that objects exert on each other. Finally he completed the mathematics of the law of gravitation. Using this law, Newton in 1682 proved mathematically one of the laws of planetary motion. This law had been figured out by the German astronomer Johannes Kepler in the early 1600’s. Kepler’s law stated that a planet’s orbit around the sun had to be in the shape of an ellipse. But he had not been able to show mathematical proof of this.

Newton’s book ‘The Mathematical Principles of Natural Philosophy’ appeared in 1687. It was written in Latin. Newton’s book is usually called the ‘Principia’ after its Latin title. Many scientists think it is the most important scientific book ever written. During later years Newton served his country in Parliament, as well as in
other ways. In 1703 he was elected President of the Royal society, and in 1705 he was knighted by the Queen Anne.

Issac newton died in 1727. He was buried in Westminster Abbey, among the great men of England. His statue stands today in the hall of Trinity College, Cambridge University.

(b) Some additional information given for capsule 14 is given below

1. Who invented the compound microscope?
   Galileo

2. An object is first seen in blue light and then in red light through a simple microscope. Compare its magnifying power.
   For a simple microscope \( M = \frac{1 + D/f}{f} \)
   Since \( f_R > f_B \)
   \[ \therefore M_B > M_R \]
   Thus, magnifying power is more in blue light.

3. Compound microscope has an objective lens of focal length 2cm and an eye lens of focal length 5cm. If an object is placed 3 cm from the objective and final image is formed at the least distance of distinct vision (=25cm), find the magnification produced.
Methodology

\[ u_0 = -3.0\text{cm}, \quad f_o = 2\text{cm}, \quad f_e = 5\text{cm} \]

Applying lens formula to objective lens, formula

\[ \frac{1}{f} = \frac{1}{v} - \frac{1}{u} \]

Or

\[ \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{2} \cdot \frac{1}{5} \]

\[ = \frac{1}{c} \quad \text{or} \quad v_c = 6\text{cm} \]

Also,

\[ M = -\frac{v}{u} \left(1 + \frac{D}{fE}\right) \]

\[ = \frac{v_e}{u_e} \left(1 + \frac{D}{fE}\right) \]

\[ = -\frac{6}{3} \left(1 + \frac{25}{3}\right) \]

\[ \therefore M = -12 \]

ii. Provision for feedback

The package provide for systematic and continuous monitoring of student performance as instruction and evaluation are closely interlinked. Therefore, while using this package, students can evaluate themselves on whatever they have learned.

In this package, the feedback is provided mainly in two ways. At the end of each capsule certain questions related to the topics discussed are given at the evaluation session. Students can write their responses and can be checked whether their answers are correct or not by comparing the correct responses given in the feedback session.

(a) Some examples from the evaluation and feedback sessions given at the end of capsule 4 are given below.

Evaluation questions

1. What is refraction?
2. State the laws of refraction.
3. Define Optical density.

Feedback

1. What is refraction?

Whenever a beam of light enters from one medium to another obliquely, a bending or change in direction of the beam occurs at the surface of separation of two media. This phenomenon is called Refraction.

2. State the laws of refraction.

The laws of refractions can be stated as

(a) The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane.

(b) The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant.

\[ \frac{\sin \theta_1}{\sin \theta_2} = n_{21}. \]

\( n_{21} \) is called the refractive index of the second medium with respect to the first medium.

3. Define Optical density.

Optical density is the resistance offered by the medium to the flow of light through it.

Or, Optical density is the rate of the speed of light in two media.

(b) Evaluation at the end of each activity

At the end of each activity, students get the chance to draw their inference or conclusion and provision is made to record their conclusions in the space provided in the package itself.
For example, an activity to introduce reflection of light is given in the package as below. Here after performing the activity learner is given the chance to record their inference and then verify it with the explanations and illustrations given.

**Activity**

You might have studied some of the properties of light. It is very much interesting to learn more about various phenomena of light.

To learn about one such an interesting phenomenon you can perform an activity.

Place a plane mirror on the top of a table and a beam of light from a torch is allowed to incident on it as shown in figure.

![Activity Diagram](image)

What happened to the light ray from the torch?

Note your observation and try to explain the reason for that.

**Inference**

(Inference can be written in the box provided and can be verified by observing the following illustrations)

Illustration-

When light beam from the torch incident on the surface of a plane mirror as shown in the diagram, you can observe a luminous spot on the top of the roof.
This is due to the reflection of light rays coming from the torch by the surface of the mirror.

**iii. On-demand training**

This means that the learner can learn whenever he is motivated by the relevance of information to their current needs. This advantage is a key factor of this Computer Based Instructional Package because the learner can use this package whenever he is motivated to learn without the help of a teacher.

**iv. Interactive learning environment**

This Computer based instructional package provides an interactive learning environment where in he is an active learner and charters his own path, which enhance intuitive thinking besides helping the student in quick understanding and increased retention. The interaction is made possible by allowing the student to perform activities following the instruction given through the package and by providing the opportunities for simulation.

_An example for interactive learning environment provided in the Computer Based Instructional Package is given below._

In order to find out the relationship between the angle of incidence and angle of reflection, in addition to the real activities a simulated activity is also given as described below.

*Activity*

Change the angle of incidence by changing the value of (i) in the following animated figure.
Note down the value of angle of reflection ($r$) corresponding to each value of angle of incidence ($i$) and are recorded in a table as given below.

<table>
<thead>
<tr>
<th>ANGLE OF INCIDENCE</th>
<th>ANGLE OF REFLECTION</th>
</tr>
</thead>
</table>

Analyze the table and try to draw some conclusions.

Here the learner can vary the angle of incidence in the given package and the corresponding angle of reflection in each can be determined. From this simulated activity learner can arrive at the conclusion that angle of incidence is always equal to the angle of reflection.

v. **Innovative learning activities**

This Computer based instructional package is developed in such a way that learner is provided with innovative learning activities so that he can use multi-senses in the learning process. The more senses through which the learner receives information, the easier is to remember it. The retention of the knowledge increases with adds on their senses by the learners in the learning process.
In this package the learning activities are provided through the computer, which can exercise various senses and present information in a variety of modes such as diagrams, figures, pictures, graphics, animations, simulations and activities that enhance the learning. Computers encourage learning as they provide stimulating environment and promote enthusiasm even among the reticent students.

One of the examples of certain innovative activities provided through the Computer Based Instructional Package is given below.

In Capsule 8, the idea of image formation by a combination of lenses is presented though a series of activities. At first the experimental set up for the formation of image by a combination of lenses is explained so that learner can perform the experiment by following the instruction provided through the package. Then how the image is formed is illustrated through a series of animations and along with, how the formulae for the focal length and power of the combination of lenses are deduced is described, which are given below.

You have seen the image formation by a lens and derived the formulae for the magnification and power of a lens.

Then consider the case of the combination of lenses.

What will be the focal length and power, if two or more lenses combined together? To know about this, you can perform an activity.

Activity 1

Take two convex lenses and find out their focal length by distant object method. For that, the first lens is mounted vertically on a stand, facing towards a distant object as shown in figure.
An image of the object is formed on a screen by adjusting the position of the screen. When the clear image is obtained, the distance between the lens and the screen is measured as the focal length $f_1$.

Similarly, find out the focal length $f_2$ of the second lens.

Then, the two lenses are placed close to each other and mounted vertically on the stand as shown in figure.
Find out the focal length $f$ of the combination of the lenses by distant object method. Repeat the experiment two or three times and average values for $f_1$, $f_2$ and $f$ are calculated.

Try to find out some relation between the effective focal length $f$ of the combination of lenses and focal lengths of the individual lenses $f_1$ and $f_2$.

Inference—

Illustration

We can derive the relationship between the effective focal length $f$ of the combination of lenses and focal lengths of the individual lenses $f_1$ and $f_2$.

For that, consider two lenses A and B of focal length ‘$f_1$’ and ‘$f_2$’ placed in contact with each other.
Let the object be placed at ‘O’ beyond the focus of the first lens A, at a distance ‘u’ from the combination of lenses.

In the absence of the second lens, the first lens alone produces an image ‘I₁’ at a distance ‘v₁’ from the combination of lenses.
If the second lens (B) is placed in contact with the first lens, the real image $I_1$ produced by the first lens serves as a virtual object for the second lens $B$ and producing the final image at $I$ at a distance $v$ from the combination of lenses.

Since the lenses are thin, we take the optic centres of the lenses to be coincident. Let this central point be denoted by $P$.

You have already derived the thin lens formula as

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \quad \text{------------- (1)}$$

Where ‘$v$’ is the distance of the image and ‘$u$’ is the distance of the object from the lens and ‘$f$’ is the focal length of the lens.

Then the lens formula for the image formed by the first lens A, becomes
where, $f_1$ is the focal length of the first lens.

The image formed by the first lens acts as a virtual object for the second lens B. Therefore the lens formula for the second lens B becomes

$$\frac{1}{v} - \frac{1}{v_1} = \frac{1}{f_2} \quad \text{------------------- (3)}$$

Where, $f_2$ is the focal length of the second lens.

Adding equations (2) and (3), we get

$$\frac{1}{v_1} - \frac{1}{u} = \frac{1}{f_2} + \frac{1}{f_2}$$

That is; $\frac{1}{v} - \frac{1}{u} = \frac{1}{f_1} + \frac{1}{f_2}$ \quad \text{------------------- (4)}
If the combination of two lenses is regarded as equivalent to a single lens of focal length \( f \) producing an image ‘I’ at a distance ‘v’ from the lens of an object ‘O’ at a distance ‘u’ from the lens.

Then the lens formula becomes

\[
\frac{1}{v} - \frac{1}{u} = \frac{1}{f}
\]

Comparing equations (4) and (5), we get

\[
\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}
\]

This derivation is valid for any number of thin lenses in contact.

If several thin lenses of focal length \( f_1, f_2, f_3 \ldots \ldots \ldots f_n \) are in contact, the effective focal length of their combination is given by

\[
\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + \ldots + \frac{1}{f_n}
\]

You have already learned that the power of a lens is the reciprocal of its focal length.

That is;

\[
P = \frac{1}{f}
\]

Therefore, in terms of power, equation (7) can be written as

\[
P = P_1 + P_2 + P_3 + \ldots + P_n
\]

Where, ‘P’ is the net power of the combination of the lenses.
That is net power of a combination of lenses is an algebraic sum of individual powers.

**vi. Interesting**

Since the developed Computer based instructional package allows new modes of learning and new ways of accomplishing the old tasks by providing variety of learning experiences in the form of simulated activities, diagrams, figures, pictures, graphics and animations, learning become more interesting than traditional methods. In this package most of the concepts are presented with colourful pictures graphics and animations that may arouse interest and curiosity among learners.

*Some of the examples of the animations developed are given below.*

i. *Total internal reflection*

![Total Internal Reflection](image)

ii. *Mirage*

![Mirage](image)
iii.  *Total reflecting prism*

![Diagram of total reflecting prism](image1)

iv.  *Optical fibres*

![Diagram of optical fibres](image2)

v.  *Dispersion of light*

![Diagram of dispersion of light](image3)
vi.  Reddish appearance of the sun during sun rise and sunset and its illustration

vii. Formation of rainbow
viii. Accommodation

ix. Short – sight and its Rectification
x. *Long sight and its rectification*

All such concepts are illustrated and explained with interesting figures, animations, and graphics.

**vii. Constructivist approach**

This Computer-based instructional package provides learning by doing environment where the learner can perform the learning activities by following the instruction given through the package and thereby he can construct knowledge. Since it is an interactive package, learner can perform many activities through simulation also. Simulations are based on experimental learning and use excellent discovery learning techniques. It gives student more feeling for reality in some abstract fields of learning.
Some examples of activities given in the Computer Based Instructional Package to help the learner to construct knowledge are given below.

In capsule 4, in order to construct the knowledge regarding the concept of refraction, a series of self learning activities are given in the package as given below. After developing knowledge by the learner, the concept is made clear through proper illustrations and explanations.

Activities

Have you ever observed a tank filled with water or a pond from outside?

What about the depth of the pond when it is observed from outside?

Can you observe any difference in the depth of a tank when it is empty and when it is filled with water?

Note down your observation and try to explain the reason.

You can find the reason by performing certain activities.

Activity 1

Take a glass tumbler, half filled with water.

Insert a scale or a pen in normal position. That is scale or pen is perpendicular to the surface of water.
Repeat this activity by putting the scale or a pen in a slanting position to the surface of water.

Observe carefully these two cases and record your observation.

**Activity 2**

Put a coin in a glass tumbler and observe the coin carefully.

Then the glass is filled with water and again observes the coin.

Note you observation in both these cases.
Activity 3

Put a black spot on the surface of a plane white paper and observe it.

Then a glass slab is placed on the surface of the black spot and find out the difference in observations if any.

Analyze the observations from the above mentioned activities and try to arrive at some conclusions.

Inference-

Illustrations-
In the first activity, you can observe a bending of the scale or pen when inserted in a slanting position into water and you can notice that the bending takes place at the point where the scale or pen touches the surface of water.

But you can’t observe such a change when the scale or pen inserted to water in a normal position.

In the second case, the coin seems to be lifted from the actual position when the glass is filled with water.

In the third case the position of black spot seems to be elevated when the glass slab is placed above it.
All these changes are due to the phenomenon of refraction of light rays.

That is whenever a beam of light enters from one medium to another obliquely, a bending or change in direction of the beam occurs at the surface of separation of two media. This phenomenon is called Refraction.

**Viii. Easy to handle**

The package is simple enough for the student to operate and for the teacher to enable them. At the home page, a provision for ‘Help’ is included which simply explains the details of how this package can be used by a learner. That is this package requires little effort to use.

The CD of the developed Computer Based Instructional Package is attached at the end as Appendix X and the sample scripts of two capsules prepared for the development of the package are given in Appendix III.

**4.2.3 Rating Scale to Teachers for Assessing the Effectiveness of the Computer Based Instructional Package**

The Investigator selected Rating scale as the most suitable tool for collecting opinion from the higher secondary school physics teachers for evaluating the developed Computer Based Instructional Package in physics. In the words of Barr et al. (1960), “Rating scale is a term applied to expression of opinions or judgment regarding some situation, object or character. Opinions are usually expressed on a scale of values”. Therefore a rating scale for evaluating the Computer Based Instructional Package is developed and standardized by the Investigator.
Before preparing the rating scale, the Investigator collected the idea of evaluation of learning materials in science in general and software packages in particular by reading relevant literature and went through various Performa for evaluation of learning materials already developed. The Investigator also made consultations with experts and discussed with science teachers especially physics teachers who are working in higher secondary schools. After these discussions, consultations and reference five major dimensions were selected for the construction of the rating scale for evaluating the developed Computer Based Instructional Package. The dimensions selected were

i. Content
ii. Instructor use
iii. Student use
iv. Presentation
v. Package documentation

The components that can be arranged under each dimension were identified and a rating scale containing 42 components under 5 dimensions was developed. The draft form of the rating scale developed is given in Appendix IV A. The dimensions and their components included in the draft rating scale are given in the following table.

Table 4.3
Dimensions-wise Distribution of Components in the Draft Rating Scale

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>SI. No</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTENT</td>
<td>1</td>
<td>Based on existing curriculum</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Breadth of the content</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Depth of the content</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Accuracy of the content</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Proper structuring of the content</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Appropriate for the content</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Useful for divergent group of learners</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Presented to multiple learning intelligence</td>
</tr>
<tr>
<td>INSTRUCTOR USE</td>
<td>Student Use</td>
<td>PRESENTATION</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td>9 10 11 12 13 14</td>
<td>15 16 17 18 19 20 21 22 23 24 25 26</td>
<td>27 28 29 30 31 32 33 34 35 36 37</td>
</tr>
<tr>
<td>Objectives are clearly stated</td>
<td>Requires not much computer knowledge</td>
<td>Program free of technical problems</td>
</tr>
<tr>
<td>Objectives are educationally valuable</td>
<td>User can learn even in the absence of instructor</td>
<td>Clear instructions</td>
</tr>
<tr>
<td>Documentation clear and comprehensive</td>
<td>Does not require student to reference manuals</td>
<td>Materials logically presented and well organized</td>
</tr>
<tr>
<td>Can monitor student use</td>
<td>High student involvement</td>
<td>Realistic simulation of events</td>
</tr>
<tr>
<td>Teacher friendly</td>
<td>Student control over the rate of presentation</td>
<td>Enhance instruction through figures, colours, animations etc.</td>
</tr>
<tr>
<td>Mentioned appropriate learning aids</td>
<td>Useful for students with different learning styles</td>
<td>Accomplished stated objectives</td>
</tr>
<tr>
<td></td>
<td>User friendly</td>
<td>Resourceful/appropriate activities</td>
</tr>
<tr>
<td></td>
<td>Provision for feedback</td>
<td>Style of presentation</td>
</tr>
<tr>
<td></td>
<td>Promoting self learning</td>
<td>Richness and variety of experiences</td>
</tr>
<tr>
<td></td>
<td>Scope for constructing knowledge</td>
<td>Appropriate linkage</td>
</tr>
<tr>
<td></td>
<td>Arouse interest and curiosity</td>
<td>Clear illustrations</td>
</tr>
</tbody>
</table>
**Methodology**

**Scoring Procedure**

The rating scale consists of 42 features or components expected to be present in the developed Computer Based Instructional Package under the five dimensions can be rated in any of the following ways like

i. Good/High/Strongly Agree

ii. Average/Medium/Agree

iii. Poor/Low/Disagree

The components which is rated as Good/High/Strongly Agree is given a score of 3 (three), the component which is rated as Average/Medium/Agree is given a score of 2 (two), and the component which is rated as Poor/Low/Disagree is given a score of 1(one).

The subjects are requested to enter a tick (√) mark in one of the three points shown above corresponding to each component to express their opinion.

**Try out**

The test was tried out on a sample of 100 higher secondary school physics teachers from six districts of Kerala. Investigator informed the teachers the need for collecting their opinion and given the rating scale along with a CD of the developed Computer Based Instructional Package. The teachers were given enough time (two weeks) to review the given package and record their observations in the rating scale. After the stipulated time, the CDs and the rating scales were collected back. Scoring was done as per the scoring scheme and the scores were tabulated on a consolidated data sheet for analysis. The district-wise breakup of the sample is given in the following table.
Table 4.4

_District-wise Breakup of the Sample of Higher Secondary School Physics Teachers_

<table>
<thead>
<tr>
<th>SI.No.</th>
<th>District</th>
<th>Number of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>Kollam</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>Alappuzha</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>Pathanamthitta</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>Thrissur</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>Palakkad</td>
</tr>
<tr>
<td>6</td>
<td>17</td>
<td>Malappuram</td>
</tr>
</tbody>
</table>

The try out was done to find out the difficulty level and discriminating nature of each component and select the components for the final rating scale. For that the test scores were subjected to item analysis and the components for the final rating scale were selected on the basis of their t-value.

**Item analysis**

Item analysis is a set of procedures that is applied to know the indices for the truthfulness or validity of items or it is a technique through which those items which are valid are selected and rest are eliminated or modified to suit the purpose. Here the components were selected for the final rating scale on the basis of item analysis. The method followed for item analysis was as follows.

As per the scoring procedure the total scores of each component was calculated. The scored answer sheets were organized in the ascending order of the scores and the top 27 and bottom 27 response sheets were taken as high group and low group respectively. For each item the mean and standard deviation of the scores were then found out. The t-value of each component was calculated using the formula
\[
    t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\frac{\sum (X_H - \bar{X}_H)^2 + \sum (X_L - \bar{X}_L)^2}{N(N-1)}}}
\]

(Edward, 1957)

\(\bar{X}_H\) - the mean score on a given statement for the high group

\(\bar{X}_L\) - the mean score on the same statement for the low group

\(X_H\) - the score of a given individual for a given statement in the high group

\(X_L\) - the score of a given individual for a given statement in the low group

The difference between means is said to be significant when the \(t\)-value exceeds 1.96 and **2.58** at 0.05 and 0.01 level of significance respectively. The obtained \(t\)-value for all the 42 items are given in the Appendix IV B. The components which have \(t\)-value greater than or equal to 1.96 were selected for the final rating scale.

Here 38 components out of 42 were selected for the final form of the rating scale. The final form of the rating scale is given in Appendix IV C. The dimension wise distribution of the components in the final form of the rating scale is given below.

Table 4.5

*Dimension-wise Distribution of the Components in the Final Rating Scale*

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>SI. No</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTENT</td>
<td>1</td>
<td>Based on existing curriculum</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Breadth of the content</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Depth of the content</td>
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<tr>
<td></td>
<td>4</td>
<td>Accuracy of the content</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Proper structuring of the content</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Appropriate for the content</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Useful for divergent group of learners</td>
</tr>
<tr>
<td>Methodology</td>
<td>8</td>
<td>Objectives are clearly stated</td>
</tr>
<tr>
<td>:-----------</td>
<td>---</td>
<td>--------------------------------</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Objectives are educationally valuable</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Can monitor student use</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Teacher friendly</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Mentioned appropriate learning aids</td>
</tr>
<tr>
<td>INSTRUCTOR USE</td>
<td>13</td>
<td>Requires not much computer knowledge</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>User can learn even in the absence of instructor</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>High student involvement</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>Student control over the rate of presentation</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>Useful for students with different learning styles</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>User friendly</td>
</tr>
<tr>
<td>STUDENT USE</td>
<td>19</td>
<td>Provision for feedback</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Promoting self learning</td>
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<tr>
<td></td>
<td>21</td>
<td>Scope for constructing knowledge</td>
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<td>23</td>
<td>Program free of technical problems</td>
</tr>
<tr>
<td>PRESENTATION</td>
<td>24</td>
<td>Clear instructions</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>Materials logically presented and well organized</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>Realistic simulation of events</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>Enhance instruction through figures, colours, animations etc.</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>Accomplished stated objectives</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>Resourceful/appropriate activities</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Style of presentation</td>
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<tr>
<td></td>
<td>31</td>
<td>Richness and variety of experiences</td>
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<tr>
<td></td>
<td>32</td>
<td>Appropriate linkage</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>Clear illustrations</td>
</tr>
<tr>
<td>PACKAGE DOCUMENTATION</td>
<td>34</td>
<td>Readability of the text</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>Audibility of the sound</td>
</tr>
<tr>
<td></td>
<td>36</td>
<td>Clearly and nicely formatted screen displays</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>Instructions can be skipped if already known</td>
</tr>
<tr>
<td></td>
<td>38</td>
<td>Use of clear language</td>
</tr>
</tbody>
</table>
Establishing Validity and Reliability

Validity is the accuracy with which the test measures what it intends to measure. To ensure the validity of the rating scale, the Investigator consulted with the experts in the field while constructing the rating scale. Also the draft scale prepared was given for expert criticism and scrutiny by experts, teacher educators and higher secondary school physics teachers. Content validity was thus ensured. The reliability of the rating scale was assessed by split half method and the reliability coefficient was found to be 0.826.

Consolidation of Final Data for Analysis

After eliminating the rejected components, the total score of each component from all the 100 response sheets were again calculated and consolidated for percentage analysis. The details of percentage analysis of the components of the rating scale is given in Appendix IV D and is explained in chapter 5 namely Analysis and Interpretation of data.

4.2.4 Lesson Transcripts and Learning Materials Based on Activity Oriented Method of Instruction

For comparing the effect of instruction through Computer Based Instructional Package over the existing Activity Oriented Method of Instruction, the control group was taught using this method. The lesson plans on the same topics on which Computer Based Instructional Package was prepared was selected for Activity Oriented Method of Instruction also. Activity Oriented Method is a student centered approach in which students are taught the objectives through discussion, observation, secondary data collection, drill and practice, notes on the board and practice problems from the text.

4.2.5 Preparation and Standardization of Achievement Test in Physics

Achievement is the accomplishment or proficiency of performance in a given skill or body of knowledge. Therefore it can be said that achievement implies the overall mastery of a pupil in a particular context. Any measuring instrument that measures the attainments or accomplishments of a pupil must be valid and reliable.
Testing is a systematic procedure for comparing the behaviour of two or more persons. Therefore an achievement test is an examination to reveal the relative standing of an individual in the group with respect to achievement. Achievement test serves four general purposes, namely summative assessment, formative assessment, placement assessment, and diagnosis (Bloom et al., 1971). Further important aspect of the use of achievement test involves measuring the distinction between performances of individual students, classes or schools systems. 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).

**Construction of the Achievement Test**

An achievement test focuses specifically on how much a person knows about a specific topic or area. If a test has to be really made valid, reliable and practical, it has to be suitably planned. For this, the following facts should be kept in view.

- It should be decided when the test to be conducted in the context of time and frequency.
- It should be determined how many questions have to be included in the test.
- It should be determined what types of questions have to be used in the test.
- Those topics should be determined from which questions have to be constructed. This decision is taken keeping in view the teaching objectives.
- The level of difficulty of questions should be decided at the beginning of the test.
- It should be determined if any corrections has to be carried out for guessing.
- The format and type of printing should be decided in advance.
- It should be determined what should be the pass score.
- In order to control the personal bias of the examiner there should be a scoring key.

Hence to measure the performance of the students before and after the experiment, an achievement test in physics was constructed by the Investigator based on the topic ‘Ray Optics and Optical Instruments’ of standard XII. The test items were of objective type consisting of only multiple choice questions. The test was
designed to assess the achievement in the Knowledge and Application domains suggested by Mc Cormack and Yager in their taxonomy of science objectives. The test was of 60 minutes duration and carried a maximum weightage of 50 marks. The same test was used as both pre-test and post-test. The procedure of the test development process included the following steps.

The steps followed in the 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, R.P., 2011)

Phase I - Planning
Phase II - Construction
Phase III - Evaluation
Phase IV - Validation

The steps involved in each phase are shown in the following figure

**Figure 4.5** Steps Involved in each Phase of Construction of Achievement Test
Phase I: Planning

Planning is an important function in test development. It requires a test plan that operationalizes the test objectives 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,

i. Defining test universe, target audience and test purpose.
ii. Defining the construct and content to be measured.
iii. Preparing the blueprint of the achievement test.

i. 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 person who will take the test. Here the target audience was higher secondary school students of Kerala, who are learning Physics as one of their optional subjects.

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. Therefore the test follows a normative approach.
ii. **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 indicators. It also specifies what content should be excluded. In the present study the Investigator selected the knowledge domain and application domain as the major constructs in preparing the achievement test.

iii. **Selection of Teaching Objectives for Measurement**

Yager and Mc Cormack (1989) proposed that science education might be viewed in the context of five domains but later expanded these to six domains when they included the ‘nature of science’. Therefore an assessment framework for science learning and experiences to promote science literacy can be organized around six domains shown in figure 4.5

![Figure 4.6 The Six Domains of Science](image-url)

*Figure 4.6 The Six Domains of Science*

Taxonomy of science teaching introduced by Yager and Mc Cormack emphasized and promoted assessment in all six domains. Table 4.6 shows the foci of all these six domains.
Table 4.6

*What Characterizes each of the Six Domains?*

<table>
<thead>
<tr>
<th>Science Domain</th>
<th>Domain foci</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Concepts (Knowledge and understanding)</td>
<td>Scientific information- facts, concepts, laws hypotheses and theories accepted by the Scientific community.</td>
</tr>
<tr>
<td>II. Process (exploring and applying)</td>
<td>Processes of science, how scientists work and think</td>
</tr>
<tr>
<td>III. Applications (using and applying)</td>
<td>Applications of what is learned to do science, connections to everyday life; informed decision making</td>
</tr>
<tr>
<td>IV. Attitudes (feeling and valuing)</td>
<td>Attitudes, sensitivity, societal issues and impacts.</td>
</tr>
<tr>
<td>V. Creativity (imaging and creating)</td>
<td>Idea generation, designing, problem solving</td>
</tr>
<tr>
<td>VI. Nature of Science (the Scientific endeavor)</td>
<td>History and philosophy of sciences, how science progresses and science knowledge and understanding develop.</td>
</tr>
</tbody>
</table>

While considering the above mentioned domains of science teaching and domain foci, it can be decided that a conventional achievement test can be used only to evaluate the changes in the concept (knowledge) and Application domains. Therefore the Investigator decided to construct an achievement test by taking changes in Knowledge (concept) and Application domains as objectives.

**Weightage to Objectives**

The test was designed to assess the achievement of students in the Knowledge domain and the Application domain. The weightage given to these domains of objectives are given in Table – 4.7
Table 4.7

Weightage to Domains of Objectives in the Achievement test

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Domains of Objectives</th>
<th>Marks</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knowledge</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>Application</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

Weightage to Content

A content analysis provides a summary of the intentions of the curriculum expressed in content terms. The Investigator analyzed the content thoroughly and found out which content is supposed to be covered in the achievement test. Content is used as a means of realizing objectives and questions have to be constructed on its basis. There is distinction in the nature, importance and scope of each topic. Therefore the weightage should be given to those facts in view; else the test would not represent the whole subject. “The Ray Optics and Optical Instruments” formed the content area. This unit was divided into 5 sub units and the marks were allotted accordingly. The details are given in Table – 4.8

Table 4.8

Weightage to Content in the Achievement test

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Content</th>
<th>Marks</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction and Reflection</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Refraction and Total Internal Reflection</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>Refraction by spherical surfaces by lenses and through a prism</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>4</td>
<td>Dispersion , formation of Rainbow and Scattering</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>Optical Instruments</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>
Weightage to Difficulty Level

Based on the difficulty level, the items in the test were classified into easy average and difficult. Proper weightage was given to each level. The details are shown in Table 4.9

Table 4.9

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Difficulty</th>
<th>Marks</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Easy</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Average</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>Difficult</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

Blueprint of the Achievement Test

A blueprint provides a bird’s view of the entire test. In it we can see the topics, teaching objectives and type of questions, number of items and distribution of scores and their mutual relationship. A blueprint is the basis of test construction. After the content and cognitive levels have been specified, the Investigator determined the percentage of items to be assigned to each of the content areas and domain of objectives and calculated the number of items to accompany the percentages based up on the total number of test items. When deciding upon the total numbers of test items, the Investigator considered that all students should have adequate time to finish the test. Time is estimated based on the type and number of items.

A blueprint is prepared as a three dimensional chart indicating the distribution of questions - objective wise, content wise and form wise, Details are given in Table 4.10.
Table 4.10

Blueprint of the Achievement Test

<table>
<thead>
<tr>
<th>Domains of Objectives</th>
<th>Form of Questions</th>
<th>Conceptual Domain Objective</th>
<th>Application Domain Objective</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Introduction and Reflection</td>
<td></td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>2. Refraction and Total Internal Reflection</td>
<td></td>
<td>6</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>3. Refraction by spherical surfaces, by lenses and through a prism</td>
<td></td>
<td>6</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>4. Dispersion, formation of Rainbow and Scattering</td>
<td></td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>5. Optical Instruments</td>
<td></td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>25</td>
<td>25</td>
<td>50</td>
</tr>
</tbody>
</table>

PHASE 2: Construction

Preparation of Test Items

The Investigator selected multiple choice questions for the test because such questions can be easily and objectively graded. Multiple-choice items are the most versatile of all objective test items. They can be used to measure both simple and complex learning objectives at all grade levels and in all subject matter areas.

Multiple choice question is a form of assessment in which respondents are asked to select the best possible answer out of the choices from a list. Scores on multiple choice items are less affected by guessing than scores on other objective items. Furthermore, useful diagnostic information may be obtained from an analysis of the incorrect options (distracters) selected by the examiners and such items are less time consuming and easier to complete, and scoring and processing is simple (Babbie, 1975 and Gronlund, 1993). Hence the multiple choice format was chosen in the present study.
The rules for item construction were applied in drafting the items. Clarity, precision and relevance of items and avoiding double barreled items were some of the requirements that the Investigator paid much attention to. A critical factor in determining the effectiveness of multiple choice items is the selection of distracters. In the present study the Investigator employed the rational and empirical approach in selecting distracters. In rational approach personal judgments are involved and in empirical one selection of the most popular incorrect responses which students tend to make when questions are given in an open form.

**Assembling the Test**

Sixty multiple choice items were prepared by the Investigator which were reviewed and edited by experts in the field of education and physics. Based on the suggestions put forward by the experts the Investigator developed the first draft of the achievement test. Then the Investigator considered the appropriateness of the length of the test for the time limits, and arranged the items with necessary instructions.

**Qualitative Evaluation of Items by Experts**

The prepared test items were given to a panel of experts for qualitative evaluation. The experts were selected from among teacher educators and Higher Secondary School Physics teachers. The experts were requested to (a) check whether each item belongs to the specified objectives (b) point out ambiguous items (c) suggest necessary modifications if any. The review panel checked whether the task was clear in each item, the items were expressed in the simplest possible language, there were unintended clues to the correct answers, and there was a single correct or best answer for each item, the items were appropriate to specified objectives to be assessed. The panel reviewed the draft test in terms of the content analysis and test blue print to make sure that the draft test would meet the intended test specification.

This analysis helped the Investigator to avoid language difficulty, ambiguous items, multiple negatives and distracters which are not plausible. 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. There were no options for answering; all questions were compulsory and provided response sheets with each question paper.

**Scheme of Evaluation**

A scoring key increases the reliability of the test so that the test constructor should provide the procedure for scoring the answer script. In order to bring objectivity in a test, it is essential that a tester should be clear about the type of answer expected from a question. A scheme of evaluation includes a scoring key for the draft test, showing the number of items and correct answers. The scoring scheme of the test was one mark for each correct answer and zero score for every incorrect answer.

(The draft form of the achievement test along with its scoring key is given in Appendix V A).

**PHASE 3 - Quantitative Evaluation**

**Pilot Testing: Item Tryout**

At this stage the initial format of the test was administered on a small representative sample. The main purpose of pilot testing is to demonstrate whether they are suitable for use with intended population of students. Only a pilot testing can reveal whether the item will work as intended. Hence the Investigator administered the draft achievement test to a sample of 380 students of standard XII from different higher secondary schools in Palakkad district.

Brief instructions for completion were clearly and prominently indicated. The participant had to put a tick mark (✓) in the appropriate column A, B, C or D which represents the correct answer to each question in the answer sheet. Enough time was given to the students so as to enable them to complete the test. The average time used by these students was noted and the response sheets were collected and scored strictly in accordance with the prepared scheme of evaluation. Sample split up for the tryout is given in Table 4.11.
Table 4.11

*Sample Split up for the Tryout of the Achievement Test*

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Institution</th>
<th>No. of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>L.S.N. Convent Higher Secondary School, Ottapalam</td>
<td>110</td>
</tr>
<tr>
<td>2.</td>
<td>T.R.K.H.S.S. Vaniyamkulam</td>
<td>130</td>
</tr>
<tr>
<td>3.</td>
<td>Govt. H.S.S. East, Ottapalam</td>
<td>68</td>
</tr>
<tr>
<td>4.</td>
<td>S. S. O. H. S. S. Lakkidi</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>380</td>
</tr>
</tbody>
</table>

From the answer scripts collected, incomplete and vaguely answered 10 scripts were removed and 370 scripts were used for item analysis.

The pilot study helped the Investigator to find out the difficulty of each item; to identify distracters which do not appear plausible; to assist in determining the precision of the test and suggest the number of test items for the final test; to establish the contribution of each item to the discrimination between candidates who achieve at a high level and those who do not to check the adequacy of the administration, instruction and the time required for most students to complete the test, and to identify misconceptions held by the students through the analysis of student responses.

**Item Analysis**

Item analysis can be a powerful technique available to the researchers for the improvement of test items and the validity of test score, if they select and rewrite their items on the basis of item performance data. The result of item analysis can be used to select items of desired difficulty that best discriminate between high and low achieving students. Moreover the results of an item analysis can be useful in identifying faulty items and can specify which item can be retained and which need to be either revised or discarded (Nunnally, 1972). Only those items meeting the analysis criteria were retained for the final test.
Item analysis gives necessary information concerning the appropriateness of an item as a measure of intended outcomes of instruction. A number of statistics are reported which aid in evaluating the effectiveness of an item. The first of this is difficulty index which is the proportion of the total group who got the item wrong. Thus a high index indicates a difficult item and low index indicates an easy item. The other one is item discrimination, which is the difference between the proportion of lower group who got the item right; that is item discrimination is a measure of how well the item discriminates between examinees who are knowledgeable in the content areas and those who are not. Here the investigator analyzed the test based on the procedure suggested by Ebel (1991).

**Item Difficulty Index**

The item difficulty is a measure of the proportion of examinees who respond to an item correctly (Nunnally, 1972; Thorndike et al. 1991). The difficulty index is calculated by using formula difficulty index (\(P\)) = \(\frac{U + L}{2N}\) where \(U\) and \(L\) are number of right answers in the upper and lower groups and \(N\) is the number of students in each group.

The \(P\) value of an item difficulty provided an accurate indication of how difficult the item was for the test takers in the pilot study. The difficulty index, the proportion of students answering an item correctly, can range from 0.00 to +1.00. For a multiple choice test consisting of four or more alternatives, items in the range between 0.35 and 0.85 should be selected (Nunnally, 1972). All items found to be too easy (answered correctly by more than 85% of respondents) or proved to be too difficult (answered correctly by less than 35% of respondents) were excluded. The item difficulty indices were used to rank the items from the easier items at the beginning provide respondents an optimistic start and placing more difficult items near the end prevent respondents from spending too much time on difficult items early in the test period (Nunnally, 1972).

**Item Discrimination**

To aid interpreting the index of discrimination, the maximum discrimination value and discrimination efficiency are given for each item. The maximum
discrimination is the highest possible index of discrimination for an item at a given level of difficulty.

The discrimination power was calculated using the formula:

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

\( U = \) Correct response in the upper group
\( L = \) Correct response in the lower group
\( N = \) the number of students in each group

For this calculation, the Investigator arranged 370 answer sheets in the descending order of the total scores. The top 27% answer sheets and bottom 27% answer sheets were used for comparisons. The numbers of examinees getting the same item correct in the top group (U) and in the bottom group (L) were identified.

The discrimination index is determined by subtracting the number of students who answered the item correctly in the lower group, from the number of students who answered it correctly in the upper group and dividing the difference by the respondent number in one group (Thorndike et al., 1991). The larger the difference, the better the item as it could discriminate the top from the bottom respondents. If the difference is small, the item failed to discriminate between good and bad performers. The items which have a discrimination index of below 0.20 are poor discriminators and they were eliminated (Thorndike et al., 1991).

Item having difficulty index between 0.3 and 0.8 and discriminating power above 0.3 were taken for the final test. The difficulty index and discriminating power of each item are given in Appendix V B.

**Assembling the Final Test**

Those items that met the item analysis criteria formed the final test. Test items were recorded to take note of their difficulty. That is the easiest questions were presented first. This was to encourage candidates to proceed through the test and to ensure that the weaker candidates do not become discouraged before providing adequate evidence of their achievement and skills. The final test contained 42 multiple choice items with a maximum score of 42 and the time for the test was 45
minutes. The final form of the achievement test along with the scoring key is given in Appendix V C and a copy of the response sheet is given in Appendix V D.

**Phase 4. Validation - Reliability and Validity of Achievement Test**

a) Reliability of the Test

Reliability of the test is usually expressed by a co-efficient of correlation which is called reliability co-efficient. Split-half method is used by the Investigator to determine the reliability of the test.

Split-half method is the method of splitting the test in two halves and finding the correlation between the two halves. All odd numbered items may constitute one test and even numbered items the second test. The answer sheets of 100 students were used for the purpose. The scores of two halves were correlated and reliability of the test was found to be 0.713.

b) Validity of the Test

i. Face Validity and Content Validity

The face validity and content validity of the test was assured while preparing the blue print, by giving adequate weightage to content and objectives. The opinion of experts in this field was taken into consideration while preparing the test and necessary modifications were made according to their suggestions.

ii. Concurrent Validity

Concurrent validity of the test was calculated by correlating the test scores of 100 students with their marks of recently conducted test obtained from the school. The co-efficient of correlation obtained was 0.844.

**4.2.6 Construction and Standardization of Science Process Skill Assessment Test**

In order to evaluate the changes in the process domain suggested by Yager and Mc Cormack (1989) in their taxonomy of science teaching, a process skill assessment test for science students of standard XII was constructed and standardized by the Investigator.

Construction and standardization of process skill assessment test involves the following stages.
1. Selection of content
2. Selection of appropriate process skills
3. Preparation of the design
4. Construction of the draft test
5. Tryout of the draft test
6. Scoring and consolidation of data
7. Item analysis and construction of final test
8. Establishing reliability and validity

1. Selection of Content

Since the process skill assessment is made to find out the effectiveness of the Computer Based Instructional Package prepared on the topic ‘Ray Optics and Optical Instruments’, the content is limited to the unit ‘Ray Optics and optical Instruments of the physics textbook of XII grade science students.

2. Selection of Process Skills

As one of the major objectives of the present study was to construct a test for assessing the level of acquisition of science process skills among higher secondary school students, the first major task was the selection of process skills in science.

The main consideration in the selection of process skills in science were as the following

a) The process skills must be appropriate for the age level of higher secondary school students.

b) The process skills selected must be emphasized in the objective of science curriculum followed by the higher secondary school students in Kerala.

Keeping in view the above two criteria, the Investigator selected the six basic process skill in science such as observing, inferring, measuring communicating, classifying and predicting for the construction of the process skill assessment test. Even though experimenting is a very important skill, because of the practical difficulties in arranging the experiments as part of process skill assessment, it was not included in the test.
3. **Preparation of the Design**

The design of the test specifying the weightage assigned to different process skills was prepared. It is given in Table 4.12

**Table 4.12**

*Process-wise Distribution of Questions in the Draft Test.*

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Process Skills</th>
<th>Marks</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Observing</td>
<td>5</td>
<td>16.67</td>
</tr>
<tr>
<td>2</td>
<td>Inferring</td>
<td>5</td>
<td>16.67</td>
</tr>
<tr>
<td>3</td>
<td>Measuring</td>
<td>5</td>
<td>16.67</td>
</tr>
<tr>
<td>4</td>
<td>Communicating</td>
<td>5</td>
<td>16.67</td>
</tr>
<tr>
<td>5</td>
<td>Classifying</td>
<td>5</td>
<td>16.67</td>
</tr>
<tr>
<td>6</td>
<td>Predicating</td>
<td>5</td>
<td>16.67</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>30</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

4. **Construction of the Draft Test**

For the preparation of process skill assessment test, the Investigator collected all possible information through related literature, discussion with higher secondary school physics teachers, other experts in the field and research workers. Then the Investigator framed several objective type questions to find out the level of acquisition of the above mentioned process skills among higher secondary school science students based on the topic ‘Ray optics and Optical instruments’.

The objective type questions written under each process skill were thoroughly analyzed and evaluated by consultation with colleagues, higher secondary school physics teachers, supervising teacher and other experts. Also the Investigator analyzed the questions in consultation with the students who have completed the higher secondary science course recently. Based on these opinions the questions were edited properly and 30 questions were selected so that there were 5 suitable questions under each process skill selected.
The draft of the process skill assessment test was administered on a small group of higher secondary school science students. It was done with a view in getting feedback so that necessary correction and re-structuring of the items could be made. On the basis of the feedback from pilot testing, changes in the language and structure of the items were made. The draft test along with scoring key is given in Appendix VI A.

5. Tryout of the Draft Test

Although the entire test items included in the draft was thought to have considerable potential to measure the science process skills, it was found that a good number of them may prove to be unsatisfactory for one reason or other. For example, if an item is answered correctly by all students, it means that is too easy and vice versa. Hence a tryout of the draft test was conducted. The draft test was administered in a group of students who formed a representative sample of the original target group. The testing conditions were carefully controlled in consistent with the administration of the final test.

For the present study, the tryout sample consisted of 380 students of XII standard from different higher secondary schools in Palakkad district.

There was no time limit set out for tryout. But they were given instruction to attempt every question. A separate response sheet was provided with four spaces marked A, B, C, and D corresponding to four choices. The students were asked to put a tick (✓) mark on the letter indicating the answer selected by them for each item.

6. Scoring and Consolidation of Data

The data collected were consolidated codified and used for suitable analysis. Out of the 380 scripts collected 10 had to be rejected, as they were incomplete or vaguely marked. Thus the final sample for the tryout was 370. Each correct response was given a score of ‘1’ and a score of ‘0’ was given to wrong answer. The total score of the test was calculated in terms of the total number of correct responses made.
7. **Item Analysis and Construction of Final Test**

The purpose of the preliminary test was to select items that are acceptable. This process of selecting the acceptable item is known as item analysis. For analyzing the items, the Investigator followed the same method described above in the case of standardization of rating scale. The ‘t’ value for all the 30 items were calculated and are given in Appendix VI B. The items which have ‘t’ values greater than 1.96 were selected for the final test. After item analysis 26 items were found to be appropriate for the final test.

The final form of the process skill assessment test along with its scoring key is given in Appendix VI C and a copy of the response sheet is given in Appendix VI D. The process wise distribution of items in the final test is given in Table 4.13

**Table 4.13**

**Process-wise Distribution of Items in the Final Test**

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Process Skills</th>
<th>Marks</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Observing</td>
<td>4</td>
<td>15.38</td>
</tr>
<tr>
<td>2</td>
<td>Inferring</td>
<td>5</td>
<td>19.23</td>
</tr>
<tr>
<td>3</td>
<td>Measuring</td>
<td>4</td>
<td>15.38</td>
</tr>
<tr>
<td>4</td>
<td>Communicating</td>
<td>5</td>
<td>19.23</td>
</tr>
<tr>
<td>5</td>
<td>Classifying</td>
<td>4</td>
<td>15.38</td>
</tr>
<tr>
<td>6</td>
<td>Predicating</td>
<td>4</td>
<td>15.38</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>26</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

8. **Establishing the Reliability and Validity of the Test**

Reliability refers to the consistency of scores obtained by same person when they are re-examined with the same test on different occasions or with different set of equivalent items. The concept of reliability underlies the computation of the error measurement of a single score, where by one can predict the range of fluctuations
likely to occur in a single individual’s score as a result of irrelevant or unknown chance factors.

In the present study reliability of the process skill assessment test was established using Cronbach alpha method and it was found to be 0.668.

The unit ‘Ray Optics and Optical Instrument’ was divided into subunits and items were chosen by giving adequate weightage to these sub topics and the process skills selected. Hence it has got content validity.

A very glance at the test could indicate that the items measure some skills in science and the items were verified by expert science teachers ensuring face validity of the test.

4.2.7 Construction and Standardization of Scientific Attitude Scale

A Scale of Scientific Attitude was constructed and standardized by the Investigator in order to evaluate the changes in the Attitude domain, suggested by Yager and McCormack (1989) in their taxonomy of Science teaching. This is a 3 point Likert type scale consisting of more or less equal number of statements indicating favourableness and unfavourableness.

Construction and standardization of the Attitude Scale involves the following steps.

1. Planning

During the planning stage, the Investigator studied some of the available reference materials in the area of attitude scale construction. The informal criteria of editing the statements by various researches in the field of psychological measurements like Edward and Kilpatrick (1940), Thurstone and cheve (1956), Likert (1932) was reviewed thoroughly.

The attitude scales prepared by Hemalatha (2002), Vinodkumar (2003), Dhanya (2008), etc. were reviewed by the Investigator in order to get an insight in to the constructs for preparing attitude scales. The constructs of attitude reviewed were found to be without much deviation from the major frame work of attitude.

Attitude is very broadly used in discussing issues in science education and is often used in various contexts. Two general categories that are distinguishable are attitude towards science and scientific attitude. American Association for the
Advancement of Science (1990) has emphasized seven constructs which comes under the Attitude domain. The Investigator decided to select these seven constructs for constructing the Scientific Attitude Scale. They are:

1. Exploration of human emotions.
2. Expression of personal feelings in constructive ways.
3. Decision making about personal values.
4. Decision making about social and environmental issues.
5. Development of more positive student attitudes towards science in general.
6. Development of positive attitude towards oneself (“I can do it” attitude) and
7. Development of sensitivity to and respect for the feelings of other people.

The draft scale was intended to have fifty (50) statements with equal number of positive and negative statements and adequate representation of items for each construct selected. To each statement the respondent has to mark the responses which may reveal the degree of agreement or disagreement towards each statement in a 3-point continuum, viz. Agree, undecided and Disagree.

2. Preparation of the Scale.

For the preparation of statements the Investigator collected all possible information through related literature, conducted formal and informal interviews with science teachers, other experts in the field and research workers. Some ideas of constructing the statements are collected from authoritative books.

The Investigator took a lot of efforts to select the statements that are believed to cover the entire attributes. While writing and editing, the criteria suggested by Edward (1969) were followed. The Investigator started with a broad pool of statements. The statements written off were evaluated by asking familiar teachers respond to the statement as they would, if they had favourable attitude towards the object. The same teachers were asked to respond to the statements as they would if they had unfavourable attitude, thereby eliminating many ambiguous factual statements.
While editing the items, the Investigator took care to avoid factual statements, statements which could be interpreted in more than one way, statements likely to be endorsed similarly by everyone and statements in compound sentences.

The constructs identified and one example each from the draft scale representing the constructs selected are given below.

Construct - 1 Exploration of human emotion
   E.g. – I am not able to control myself in turbulent situations.

Construct - 2 Expression of personal feelings in constructive ways.
   E.g. - The development of science often influences my mind.

Construct - 3 Decision making about personal values
   E.g. - Whenever I find it difficult to take decisions regarding my personal issues, I give importance to logic.

Construct - 4 Decision making about social and environmental issues
   E.g. - Development in the field of science is the reason for all the facilities that we enjoy in today’s human life.

Construct - 5 Development of more positive student attitudes towards science in general.
   E.g. – The scientific theories are followed forever.

Construct - 6 Development of positive attitude towards oneself (an “I can do it”)
   E.g. - I have faith in my talents

Construct - 7 Development of sensitivity to and respect for the feelings of other people
   E.g. - It is possible for me to understand the feelings and emotions of others

More or less equal weightage was given to all the seven constructs. Necessary instructions regarding the purpose of the scale were provided at first. It was decided to provide separate response sheets for marking the responses of the subjects. In the response sheets, provisions for indicating the degree of agreement or disagreement of the respondents on a 3 point scale with response categories Agree, Undecided and Disagree were given.
3. Pilot Testing

In order to finalize any instrument, the items of the tool should be tried out with a small group in pilot run (Wiersma, 1986). The draft scale was administered on a small group of higher secondary students. It was done with a view to get feedback so that necessary corrections and restructuring of the items could be made. On the basis of the feedback from pilot testing, changes in the language and structure of the statements were made and an estimate of the time required to complete the marking of responses were obtained.

Construct wise distribution of the statements and weightage given to each construct in the draft tool is given in Table 4.14

Table 4.14

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Constructs</th>
<th>Statement No.</th>
<th>No. of Statements</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Exploration of human emotions</td>
<td>14, 28, 35, 40, 41</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Expression of personal feelings in constructive ways</td>
<td>1, 11, 13, 18, 25, 30, 43, 50</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>Decision making about personal values</td>
<td>4, 10, 19, 29, 36, 44</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>Decision making about social and environmental issues</td>
<td>3, 6, 7, 15, 22, 37, 39, 45</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>Development of more positive student attitudes towards science in general</td>
<td>2, 5, 9, 23, 31, 34, 42</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>6</td>
<td>Development of positive attitude towards oneself (an I can do it, attitude)</td>
<td>8, 16, 17, 24, 26, 27, 46, 47, 49</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>7</td>
<td>Development of sensitivity to and respect for the feelings of other people</td>
<td>12, 20, 21, 32, 33, 38, 48</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>50</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
The scale contains both positive and negative statements. Example for each statement is given below.

Positive statement

E.g. - I consider the achievements of my friends as my own and feel happy for them.

Negative statement

E.g. - There is nothing wrong in doing some malpractices when the results of experiments go wrong in several times.

Details of positive and negative statements in the draft tool are given in Table 4.15

**Table 4.15**

*Details of Positive and Negative Statements in the Draft Tool*

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

4. Scoring

The responses were recorded along a three point scale, and the scoring adopted for the scale is as follows. For positive statements, scores 3, 2, and 1 were given for making responses Agree, Undecided and Disagree respectively. Reverse scoring procedure was adopted in the case of negative statements. The scientific attitude of a student is the total scores obtained for all the statements of the scale.
5. Try out and Finalization of the Tool.

The draft tool was tried out on a sample of 380 higher secondary school science students, from various higher secondary schools in Palakkad District. All response sheets collected were scored as per the scoring procedure explained. The scores given to each item was summated to yield the total score. Finally 370 response sheets were randomly selected for item analysis.

6. Standardization of the Tool.

The Investigator used the following procedure in order to standardize the tool.

**Item Analysis**

Statements were selected for the final scale on the basis of discriminating power of each item. The discriminating power of each item was calculated on the basis of “t” value of item. Edward’s (1957) method of item analysis was following here. The method is as follows.

The response sheets were scored using the scoring scheme as described earlier. The scores obtained on each item and the total score for each individual were marked. On the basis of the scores obtained, the response sheets were arranged in the descending order. Then the top 100 and bottom 100 response sheets were taken as High and Low groups respectively. The number of subjects marking A, U and D for each item was calculated and presented in the form of a frequency table. For each item the mean and standard deviation of the scores were then found out. The “t” value of each item was calculated as done in the case of standardization of the rating scale explained earlier. The draft form of the scientific attitude scale and the obtained ‘t’ value of each statement in the draft attitude scale are given in Appendix VII A, and VII B respectively.

A statement with ‘t’ value greater than or equal to 1.96 is considered to be good item for measuring the attitude. Thus 44 statements out of 50 were selected for the final tool. The final form of the scientific attitude scale is given in Appendix VII C. Details of construct-wise distribution of the statements and weightage given to each construct in the final tool are given in Table 4.16.
Table 4.16

*Construct-wise Distribution of the Statements in the Final Tool*

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Constructs</th>
<th>Statement number</th>
<th>No. of Statements</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Exploration of human emotions</td>
<td>13, 27, 34, 37, 38</td>
<td>5</td>
<td>11.36</td>
</tr>
<tr>
<td>2</td>
<td>Expression of personal feelings in constructive ways</td>
<td>1, 10, 12, 17, 24, 29, 39, 44</td>
<td>8</td>
<td>18.18</td>
</tr>
<tr>
<td>3</td>
<td>Decision makings about personal values</td>
<td>4, 9, 18, 28, 35, 40</td>
<td>6</td>
<td>13.64</td>
</tr>
<tr>
<td>4</td>
<td>Decision making about social and environmental issues</td>
<td>3, 6, 14, 21, 36</td>
<td>5</td>
<td>11.36</td>
</tr>
<tr>
<td>5</td>
<td>Development of more positive student attitudes towards science in general</td>
<td>2, 5, 8, 22, 30, 33</td>
<td>6</td>
<td>13.64</td>
</tr>
<tr>
<td>6</td>
<td>Development of positive attitude towards oneself (an “I can do it” attitude)</td>
<td>7, 15, 16, 23, 25, 26, 41, 42, 43</td>
<td>9</td>
<td>20.45</td>
</tr>
<tr>
<td>7</td>
<td>Development of sensitivity to and respect for the feeling of other people</td>
<td>11, 19, 20, 31, 32</td>
<td>5</td>
<td>11.36</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>44</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

The details of the Positive and Negative Statements in the Final Scale are given in Table 4.17
Table 4.17

*Details of Positive and Negative Statements in the Final Tool*

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Statement Type</th>
<th>Statement Number</th>
<th>No. of statements</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Positive</td>
<td>1, 2, 3, 4, 7, 8, 10, 11, 12, 14, 15, 17, 18, 19, 23, 25, 31, 36, 41, 43</td>
<td>20</td>
<td>45.45</td>
</tr>
<tr>
<td>2</td>
<td>Negative</td>
<td>5, 6, 9, 13, 16, 20, 21, 22, 24, 26, 27, 28, 29, 30, 32, 33, 34, 35, 37, 38, 39, 40, 42, 44</td>
<td>24</td>
<td>54.55</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>44</td>
<td>100</td>
</tr>
</tbody>
</table>

7. **Validity of the Scale.**

According to joint committee on Standards for Educational and Psychological Testing (1999), different types of tests are used for different purposes and therefore need different types of validity evidence. Attitude scales are based on psychological theory or construct. Therefore evidence for content and prediction are necessary.

The scale of scientific attitude was prepared on the basis of theory of construction of attitude scale by Likert. The Investigator adopted the constructs emphasized by American Association for the Advancement of Science (1990) for constructing the scale of scientific attitude. The statements representing the universe of interest were prepared from an extensive review and also by asking the subjects to write short description of their feelings about the constructs. Due care was taken to avoid statements which may be given particular interpretation by the individual themselves. Hence it is assumed that the scale has construct validity.

Maximum effort was taken to avoid statements which are factual and statements with complexity in comprehending the language. Each statement was so written as to reveal the subject’s scientific attitude. Through these efforts the Investigator was able to establish face validity.
8. Reliability of the Scale.

A test is reliable to the extent that it measures whatever it is measuring consistently. In tools that have high coefficient of reliability, error of measurement has been reduced to minimum. Reliability tests are stable in whatever they measure and yield comparable scores on repeated administration. The reliability of attitude scale was established through test-retest method. The scores of attitude scale were correlated with scores of retest administered after one week. The reliability coefficient obtained was 0.914 (N = 100). This index suggests that the scale is highly reliable.

4.2.8 Scientific Creativity Test

To evaluate the developments in the creativity Domain, suggested by Yager and Mc Cormark in their taxonomy of science teaching, the Investigator adopted the Scientific Creativity test constructed and standardized by Weiping Hu and Philip Adey (2002). They have constructed a Scientific Creativity Structure Model (SCSM) on the basis of an analysis of meanings and aspects of scientific creativity found in the literature. 50 science teachers in China took part in an initial evaluation of this model. On the basis of their analysis and comments, and drawing on the experiences of the Torrance Test of Creative Thinking, a 7 item scale for measuring scientific creativity was developed and validated through analysis of item response data of 160 secondary school students in England. Item analysis was conducted to check on item discrimination, internal consistency, agreement between scores, construct-related validity and face validity. Analysis showed adequate reliabilities and validities. The description of the nature and development, illustration of items, scoring procedure and standardization of the Scientific Creativity Test developed and standardized by Hu and Adey (2002) is given in Appendix VIII A.

The test was used with slight modifications so that it becomes culture fair, without altering the basic structure of the test. The modified version of the test is given in Appendix VIII B. The modified version of the Scientific Creativity Test was given to both the experimental and control groups in both pre and post test stages. Enough time was given to the students so that they can express their creative ideas. The scoring of the scripts was made strictly on the basis of the scoring procedure
described in the tool itself. In order to make the scoring as objective as possible a panel of teachers including the Investigator together evaluated the scripts. The scores thus obtained were used for statistical analysis.

**4.2.9 Standard Progressive Matrices Test**

Non verbal intelligence of the subjects was measured by administering the standard form of the Ravens Progressive Matrices Test. This is a nonverbal test developed by Raven (1958) was used to estimate the subjects ability to discern and utilize a logical relationship presented by nonverbal materials. The test was revised in 1988 and that was used in the study. The test consists of five subsets of 12 items each. In each item a part of the geometrical design is mixing. Six or eight alternatives are given for each design. All of those fit the missing part, but only one logically belongs to it. The test is a popular measure of ‘g’ factor of intelligence.

Researcher have used the Raven’s progressive matrices test to classify the sample of the study both experimental and control group in to two groups as having average intelligence and above and average intelligence and below. The variable intelligence has been treated as the control variable of the study. Response sheet of Ravens Progressive Matrices test is given in Appendix IX.

**4.3 PROCEDURE OF THE STUDY**

As it was very difficult to get two equivalent groups, the Investigator decided to conduct the experiment with two non equivalent class room groups. 120 higher secondary school science students from T.R.K. higher secondary school, Vaniyamkulam, Palakkad were selected for the study. These students were divided into two groups; each consists of 60 students, based on their previous achievement. Then one group was randomly selected as experimental group and the other as control group. An intelligence test (Standard Progressive Matrices Test, Raven, 1988) was administered to all the students.

After administering the pre tests to both the groups, the experimental group was given instruction through Computer Based Instructional Package. For that the students in the experimental group were divided into small groups and sufficient number of computers was arranged in the laboratory. Each group is assigned with a computer and CD’s of the developed package. Computers were arranged in the
laboratory for providing necessary learning materials for the learner to perform their activities. Students were given instruction about how to use the package and allow them to learn by performing the activities using necessary materials provided and following the instructions given in the package.

After arriving at their own conclusions or generalizations by performing the activities, the students can verify their conclusions by referring the explanations and illustrations provided in the package through various colourful pictures, graphics, and animations. CD’s are made available to the learners to repeat or continue their studies as they wish to learn. Each learner gets the chance to repeat the activities at any number of times according to their need interest and time. While learning through the package, if they felt some difficulty, they can consult with the teacher. The Investigator gave assistance wherever necessary.

The control group was taught the same unit through the existing Activity Oriented Method of Instruction by the Investigator. After completing the unit, both the groups were given the post tests. The pre test and post test scores of both the groups were subjected to statistical analysis.

4.4 Statistical Techniques Used for Analysis

The hypotheses of the present study were tested by employing appropriate statistical techniques. The entire statistical processing was done using the statistical software SPSS.

Statistical techniques employed are given below

A. Test of Significance of Difference Between Means for Large and Small Independent Samples

To test the hypotheses the test of significance of difference between means of large and small independent samples were used. Control group and experimental group were compared with respect to their pre and post test scores of achievement. The difference in means was tested using two tailed test of significance and the results were interpreted using appropriate degrees of freedom.
B. One-Way Analysis of Variance (ANOVA) with 2X2 Factorial Design

To study the main effect and interaction effect of Computer Based Instructional Package, Activity Oriented Method of Instruction and intelligence one way analysis of variance with 2X2 factorial design was employed. By this method one can study the single effect of Independent variable on the dependent variable and interaction effect of Independent variable on the dependent variable. Interpretation of the analysis was done on the basis of ‘F’ values. That is whether ‘F’ ratio is significant at 0.01 or 0.05 level for appropriate degrees of freedom.

Further on analyzing the F ratio, it was found to be significant and to know which of the following groups actually differ in their mean scores Sheffee post hoc analysis was carried out and the significant difference in mean scores between the groups were established.

C. Analysis of Covariance (ANCOVA)

In the present study, two factor ANCOVA employing one Covariate (single and in combination) was used to confirm the effectiveness of Computer Based Instructional Package. Through Analysis of Covariance one can control or adjust the effects of one or more uncontrolled variables and thereby permit a valued evaluation of the outcome of the experiment. It is applied when there are correlated variables. In the present study Pre-Achievement was taken as the Covariate for statistically equating the pre experimental status of the groups.

The present experiment was conducted with intact classroom groups for practical reasons. To ensure the equivalence of the groups, before treatment variables were introduced to co-variate analysis. The variable selected for determining the equivalence of the groups was pre achievement. Analysis of co variance was used to equate the pre experimental status of the treatment groups in terms of pre-achievement.

E. Repeated Measures ANOVA

In order to ensure retention in achievement for the Computer Based Instructional Package delayed post test was analyzed. One factor repeated measures ANOVA was performed in situations where we are interested in examining the same
sample across three or more treatment conditions. This test is conducted because the same dependent variable is subjected to several measurements. In the present study the repeated measures performed on each student and the dependent variable is represented by three variables, namely pre test, post test and delayed post test.