CHAPTER –III
RESEARCH METHODOLOGY

3.1. INTRODUCTION

The previous chapter dealt with the review of related literature. This chapter presents the methodology adopted by the researcher to realize the objectives of the study. The plan and procedure used by the researcher are also dealt with in the same chapter. This chapter outlines the research design, population, sample, tools used in data collection and the method used for analysis of data.

3.2. RATIONALE OF THE STUDY

The effectiveness of the selected strategies will enhance the understanding of any abstract concept in any branch of science. The researcher has made an attempt to deal with all kinds of approaches and in particular has selected the instructional approach as a suitable means to enhance the understanding of the abstract concepts in physics among the higher secondary students. Investigator finds that selected instructional strategy will be helpful to the students to learn and retain in memory the abstract concepts easily to enable them to score high marks in examinations and also to use the same in their day to day life. The researcher attempts to find out the effectiveness of the strategy statistically, the study is necessitated.

3.3. TITLE OF THE STUDY

The title of the present study is “Effectiveness of Selected Instructional Approaches to Enhance Understanding of Abstract Concepts in Physics among Higher Secondary Students”.

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3.4. DEFINITION OF KEY TERMS

Effectiveness

‘Effectiveness’ refers to: outcome, Result, conclusion, consequence, impact, influence, efficiency.

Instructional Approach

Instructional design is defined as a systematic process that is employed to develop education and training programmed in a consistent and reliable fashion.

Enhancing

Increasing, improving, enriching.

Understanding

Make learners to learn some concepts or skills by using structured or unstructured methods.

Abstract Concepts

Abstraction is a process by which concepts are derived from the usage and by classification of literal concepts.

Physics

Physics is the branch of science concerned with the nature and properties of matter and energy. The subject matter of Physics includes Mechanics, Heat, Light and other Radiation, Sound, Electricity, Magnetism, and the Structure Of Atoms.

Higher Secondary Students

The students of 11th and 12th Standard (Higher secondary school level) approximately in the age group of 16 to 18 who pursue their studies in school.
3.5. OPERATIONAL DEFINITIONS

Effectiveness

It refers to the quality of being effective or the quality of being able to bring about an effect.

Selected Instructional Approaches

Teachers select approaches that can help students learn more and achieve a deeper understanding of the curriculum content is considered as instructional approaches. Teaching of science is of a special kind and the content has a lot of abstract concepts and mathematical derivations. Students’ are not aware of units and measurements. Due to lack of mathematical background and understanding, students develop an aversion to physics. To remove this aversion and create interest, new instructional approaches may be followed in this present study the investigator implemented the following selected instructional approaches

- Explained Formulae charts
- Simplified Symbolic instructions
- Developed Joint group instruction
- Encouraged Peer group instruction
- Transformed concept teaching into activity- based learning
- Formulated simplified table instructions
- Focused on Pictorial presentation rather than audio visual instruction
- Illustrated through Demonstration and
- Improvised diagrammatic representation of instructions
**Enhance**

‘Enhance’ means ‘increase’. The enhancement measured in this study is between the Experimental group’s scores obtained in the post-tests, after the use of Instructional approach. It means intensifying the qualities or improving something already of good quality.

**Understanding**

The ability to understand something. The quality or condition of one who understands comprehension.

**Abstract Concepts**

Abstraction is a process by which concepts are derived from usage and by classification of literal concepts.

**Physics**

Physics is the branch of science concerned with the nature and properties of matter and energy. The subject matter of Physics includes mechanics, heat, light and other radiation, sound, electricity, magnetism, and the structure of atoms.

**Higher Secondary Students**

The students of 11th and 12th Standard (Higher secondary school level) at the age group of 16 to 18 in schools.

**3.6. VARIABLES**

The variables involved are:

**1. Independent Variable**

Instructional Approach
2. Dependent Variable
Understanding of Units and Measurements, Atomic Physics and Nuclear Physics.

3.7. ASSUMPTIONS OF THE STUDY
1. The instructional approaches can be categorized in terms of their specific objectives.
2. Instructional approaches play a vital role in the teaching – learning process.
3. The effectiveness of instructional approaches can be measured.
4. The outcome implementation instructional learning approaches can be compared statistically with one another to find out the effectiveness of inductive approaches, deductive approaches and instructional approaches.

3.8. STATEMENT OF THE PROBLEM
International competition has fuelled the flame of educational reforms in different countries. One of the core issues in on-going educational reforms is the development of a highly qualified, skilled and committed teaching force for educating students from diverse backgrounds with a view to prepare them to meet the challenges in future. The National Policy on Education (1986) proposed the need of modifying curriculum and methodologies of learning through appropriate research and enhancing attention-activation techniques. Innovative technologies have provided new dimensions in teaching and learning. The problem for the present study is the “Effectiveness of Selected Instructional Approaches to Enhance Understanding of Abstract Concepts in Physics among Higher Secondary Students”.

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3.9. OBJECTIVES OF THE STUDY

The main objective of the study is to make the students proficient in basics like “units and measurements” in Physics and their level of understanding of certain concepts in the areas of “Atomic Physics” and Nuclear Physics.

1. To identify the level of difficulties experienced by the students in learning Physics particularly areas like Units and Measurements, Atomic Physics and Nuclear Physics
2. To identify the level of achievement in Physics of the higher secondary pupils of St. Joseph’s Higher Secondary School, Venkatakulam, Pudukottai District, before implementation of the instructional approach.
3. To design, validate and implement instructional approaches to facilitate better achievement level in Physics.
4. To find out enhancement effected among higher secondary students after implementation of the instructional approach.

3.10. HYPOTHESES OF THE STUDY

The following hypotheses are formulated to give a specific direction to the present study.

1. There will be significant mean difference between pre assessment and post assessment level of the achievement through instructional approaches among higher secondary students.
2. There will be significant mean difference between pre assessment and post assessment scores on units and measurement through instructional approaches among higher secondary students.
3. There will be significant mean difference between pre assessment and post assessment scores on Atomic Physics through instructional approaches among higher secondary students.

4. There will be significant mean difference between pre assessment and post assessment scores on Nuclear Physics through instructional approaches among higher secondary students.

In this study all the directional hypothesis were converted into null hypothesis for the purpose of statistical analysis.

3.11 DELIMITATION OF THE STUDY

1. In the present study, only Higher Secondary Students – who had Physics as their optional subjects are selected.

2. The experiment was spread over a period of four months. New Instructional Approaches were adopted to enhance understanding of abstract concepts in Physics by higher secondary students in the form of programmes in the classroom.

3. This study is confined only to St. Joseph’s Higher Secondary School, Venkatakulam, Pudukottai District, Tamil Nadu, South India.

3.12. DESIGN OF THE STUDY

The research design is the conceptual structure of the research procedure. It provides planning on selection of subjects, data gathering devices, and data analysis techniques in relation to the objectives of the research.
The experimental method is the best for determining the causal effect of an isolated, single variable and dependent variable. It provides a systematic and logical way for answering research questions. It is the best way to establish a cause-and-effect relationship between variables. This method is considered the best because it ensures a high degree of control over extraneous variables and enables the manipulation of variables of the study. It reduces bias and increases reliability. It helps to test hypotheses of causal relationships between variables. It also permits drawing inferences about causality.

In order to promote the sensitivity for the experimentation, single group, pre-test and post-test were chosen to assess the effectiveness of selected approaches in the enhancement of understanding of abstract concepts in Physics of higher secondary students. The experimental group received the instructions through selected instructional strategies after the pre-test.

3.13. EXPERIMENTAL METHOD

Experimentation is defined as 'Observation under Controlled Conditions'. Experiments are studies involving intervention by the researcher beyond that required for measurement. The usual intervention is to manipulate some variables in a setting and observe how it affects the subjects being studied by the researcher, manipulate the independent or explanatory variables and then observe whether the hypothesized dependent variable is affected by the intervention.

In experimental studies, observable changes take place, which help the researcher to establish a cause and effect relationship. It is the description and analysis of the impact of the application of the strategy under carefully controlled
conditions. Experimentation consists in the deliberate and controlled modification of the conditions determining an event and in the observation and interpretation of the changes that occur in the event itself.

Experimenters deliberately and systematically manipulate certain stimuli, treatment or environmental conditions and observe how the condition or behavior of the subject is affected or changed. They are also aware of other factors that could influence the outcome and remove or control them in such a way that they can establish a logical association between manipulated factors and observed effects.

In a well-executed experiment, the researcher must complete a series of activities to carry out the craft successfully. Although the experiment is the premier scientific method for establishment of causation, the resourcefulness and creativity of the researcher are needed to make the experiment live up to its potential. Experimentation is extensively used in units and measurement, atomic Physics and nuclear Physics.

3.14. EXPERIMENTAL DESIGN

The researcher used Pre-Assessment - Treatment –Post-Assessment experimental group design for this study which involves one group alone. In this design the only available group is experimental followed by pre-assessment treatment and post assessment.

Pre-assessment and post- assessment is done on the same group. In this experimental design all sources of internal validity are controlled due to random assignment. Written tests were developed for the collection of data. Pre-test was developed from the first chapters (units and measurement) of higher secondary 1st
level in Physics. Out of 50 questions, 12 for knowledge, 8 for comprehension, 9 for application, 14 for analysis, and 7 questions for synthesis were constructed. Pre assessment was developed from the chapter (Atomic Physics and nuclear Physics) of Higher secondary II\textsuperscript{nd} level in Physics.

Post assessment tool was constructed from the two chapters of the same textbook whereas the distribution of the questions from the area remained same for each domain as in the pre-test. Test items were finalized after item analysis. Item difficulty and item discrimination index were calculated and test items of mixed difficulty were selected finally. Content validity of the tools was established by discussing them with two different subject experts and an educationist in the field of science education.

3.14.1. Single Group Pre-Assessment- Treatment Post-Assessment Design

Experimental designs are unique to the experimental method. They serve as positional and statistical plans to designate relationships between experimental treatments and the experimenter's observations or measurements in the temporal scheme of the study. Judicious selection of the design improves the probability that the observed change in the dependent variable was caused by the manipulation of the independent variable and not by other factors. It simultaneously strengthens the generalizability of results beyond the experimental setting. (Schuman, Jahoda, Deutsht). The single group method is the elementary and least rigorous design.
Table 3.2. Pre-Assessment – Treatment – Post-Assessment

Pre-Assessment

Achievement test in Units and measurements, Atomic Physics and Nuclear Physics

Treatment

Implementation of Instructional Approach

Post-Assessment

Achievement test in Units and measurements, Atomic Physics and Nuclear Physics
EFFECTIVENESS OF SELECTED INSTRUCTIONAL APPROACHES TO ENHANCE UNDERSTANDING OF ABSTRACT CONCEPTS IN PHYSICS AMONG HIGHER SECONDARY STUDENTS

RESEARCH DESIGN
EXPERIMENTAL STUDY

Variables

Independent variables

Dependent variables
Comprehensive reading competency

Instructional Approach

Understanding of units and measurements
atomic physics nuclear Physics

Tools

Achievement test in units and measurements
(pre test-Posttest) Assessment

Implementation of instructional approaches

Achievement test in Atomic Physics measurements
(pre test-Posttest) Assessment

Achievement test in Nuclear Physics
(pre test-Posttest)

Sample

50 higher secondary school students

Statistical Measure

Descriptive Analysis
Mean SD

Correlation analysis
‘r’ value

Differential analysis
‘t’ value

Non parametric analysis
1. Kruskal Wallis
2. Omega Square
3. Effect Size
4. Gain ratio

Fig3.1 Experimental Design
3.15. PROCEDURE FOR THE EXECUTION OF THE RESEARCH

- Identifying Components of Instructional Approach
- Validation of Instructional Approach
- Developing Instructional Approach on enhancing understanding of abstract concepts in Physics
- Administrating Pre-Test on Units And Measurement, Atomic Physics And Nuclear Physics In Higher Secondary Level Physics
- Theoretical Orientation Implementation of Instructional Approach
- Treatment (Implementation of Instructional Approach in Physics)
- Demonstration of the materials of instructional approach on enhancing understanding abstract concepts in Physics at Higher secondary level
- Administrating Post-Test on Units And Measurement, Atomic Physics and Nuclear Physics In Higher Secondary Level Physics
- Statistical treatment of the data analysis
- Findings
3.16. SAMPLE OF THE STUDY

3.16.1 Location

The present investigation was conducted in St. Joseph’s Higher Secondary School, Venkatakulam, Pudukottai District, Tamil Nadu, South India.

3.16.2 Selection of the sample

All the 50 students of Higher Secondary Level (Physics optional) formed the sample of the study. A Single group pre-test treatment post-test design and purposive sampling technique was followed.

The researcher is a practicing teacher much concerned with low scores in Physics in final examination that prevents many aspirants from joining professional courses. So all the students in the Physics group were chosen. The primary objective was to meet the needs of the students from the examination point of view and as a prelude to promote concept understanding through the treatment.

3.17. RESEARCH TOOLS

The investigator was teaching Physics to Higher Secondary students for over three decades. The investigator observed that the level of understanding of abstract concepts on Units and Measurement, Atomic Physics and Nuclear Physics was considerably lower than in other units. In the half yearly examination performance of all the 50 students was very low. This was an alarming situation for the investigator. It drove him to think of designing and implementing innovative instructional approaches to re-teach the three units. When the students’ academic session after the second terminal exam started a pre assessment was given to them on the same three units to diagnose the difficulties.
The topic of the research was “Effectiveness of Selected Instructional Approaches to Enhance Understanding of Abstract Concepts in Physics among Higher Secondary Students: An Experimental study” keeping this topic in mind.

The tools used were as follows

1. Achievement test in Units and Measurement
2. Achievement test in Atomic Physics
3. Achievement test in Nuclear Physics

The Instructional approach in Physics was developed by the researcher. Instructional approach was used for teaching three chapters from the text book of Physics for the Higher Secondary Level.

The researcher constructed an achievement test for both the pre and post assessments. Selected topics of Physics (Units and Measurement, Atomic Physics and Nuclear Physics) of higher secondary followed the Tamil Nadu state board curriculum. The constructed test was shown to the subject expert in the field of Physics. Their suggestions were duly incorporated in the achievement test. The achievement test was for 50 marks each and of one hour duration.

After analyzing the theoretical content in ‘Units and Measurement, Atomic Physics and Nuclear Physics, an achievement test was prepared with the help of a Blue Print. The three units were chosen on the basis of pedagogic experience and on the basis of performance analysis of student scores in various unit tests. The concepts that require special attention were identified through interaction with students in other schools. Based on the blue print researcher designed a blue print with three units in physics. The structure of the blue print is given in the Table below:
3.17.1. Structure of Content

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Content</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Units and Measurement</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>Atomic Physics</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>Nuclear Physics</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td><strong>Total Score</strong></td>
<td><strong>150</strong></td>
</tr>
</tbody>
</table>

3.17.2. Objectives

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Objectives</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knowledge</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>Comprehension</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Application</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>Analysis</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>Synthesis</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td><strong>Total Score</strong></td>
<td><strong>50</strong></td>
</tr>
</tbody>
</table>

3.18. VALIDATION OF TOOLS

At the planning stage, the investigator developed a Criterion Test to be administered at the beginning and completion of the program for measuring the effectiveness of his instructional approach in relation to the realization of specific instructional objectives. Multiple choice questions, framed properly are claimed to be most reliable tools of evaluation. The investigator reviewed literature on the procedures of evaluating the understanding of abstract concepts in Physics at the higher secondary level. The investigator also consulted
experts in the field. After getting the relevant information and suggestions, the researcher applied his personal experience and the felt need of his class, for developing the tool.

The investigator administered the scale to measure the effectiveness of academic achievement in Physics (dependent variable) and instructional approach (independent variable). The achievement test was developed and validated by the investigator through peer consultation.

In order to establish, whether the listed items really tallied under the specific category, the items were arranged in a random order and subjected to expert scrutiny. The experts were drawn from the field of teacher education. Based on the experts’ opinion, items in the achievement tests were modified. Thus, the validity of the test was established. All the items contemplated were found to be valid and selected for administration, some with pruning.

3.19. RELIABILITY OF THE TOOLS

Reliability refers to the consistency of a measure. A test is considered reliable if we get the same result repeatedly. If a test is designed to measure a trait, then each time the test is administered to a subject, the results should be approximately the same. Unfortunately, it is impossible to calculate reliability exactly, but it can be estimated in a number of different ways.

The reliability of the tools were established by KR 20 method. The reliability of the tool is 0.83.
3.20. DEVELOPMENT OF INSTRUCTIONAL APPROACHES TO TEACH ABSTRACT CONCEPTS IN PHYSICS TO HIGHER SECONDARY STUDENTS

The instructional design involves knowledge of multiple methods or activity sequences that lead to successful student learning of a specific concept or process skill. The teacher should be able to employ a variety of concrete and abstract representations and experimental procedures to appeal to the variety of ways students learn. The teacher should always encourage students to arrive at an answer by reasoning rather than by memorization and recall.

Instructional design is defined as a systematic process programmed in a consistent and reliable manner that is employed to develop education and training. In addition, instructional design models or theories may be thought of as frameworks for developing modules or lessons that enhance the possibility of learning and encourage the engagement of learners so that they learn faster and gain deeper levels of understanding.

Instructional design is also called the instructional systems design (ISD) and it is the practice of maximizing the effectiveness, efficiency and appeal of instruction and other learning experiences. The process consists broadly of determining the current state and needs of the learner, defining the end goal of instruction, and creating some “intervention” to assist in the transition. There are many instructional design models based on the ADDIE model with five phases - Analysis, Design, Development, Implementation and Evaluation. The instructional design is traditionally rooted in cognitive psychology.
The teacher uses and encourages students to construct multiple representations of the same idea during a lesson; asks students to explain (using queries like “How?,” “Why?,” or “Explain”) phenomena or answers; and allows students to discuss questions in groups before presenting an answer. When students have difficulty in understanding a concept, the teacher suggests or encourages students to employ alternative approaches.

The present instructional approaches adopted in this study is for the higher secondary students who learn Physics as one of their subjects.
Fig. 3.2 Thomas’s Model on Selected Instructional Approaches

THOMAS’S MODEL FOR SELECTED INSTRUCTIONAL APPROACHES

ANALYZE

STUDENTS

Learning Difficulties

Lack of Interest

Absence of previous Knowledge about physics

Irregular Attendance

Aversion in Solving Mathematical Problems

Unawareness of the Concept of Units and Measurements

Neglect the Particular Chapter

Inattentive Nature in the Class

Lack of Awareness on Units and measurement In Proper Usage

DESIGN

Formulating tables units and measurement developed 6X6 unit matrix

Simplifying table of $\alpha, \beta$ and $\gamma$ in nuclear physics

Concretising working models on Atomic physics

Presenting pictorial diagrams

Illustrating diagrammatic representation

Formulating innovative tables other than in text books

Training on fill up the vacant boxes of the table

DEVELOPMENT AND IMPLEMENTATION

Explained formula chart & formulated simplified tables

Facilitated passive listener to active listener & Simplified Symbolic Instruction

Transformed concept teaching in activity based concept & Experimental illustrated through Demonstration

Focused Pictorial presentation rather than audiovisual & encouraged peer group Instruction

Improved diagrammatic representation

Converted abstract formulae in simplified versions & Developed Join group Instruction

Simplified abstract concept in to clearly defined concept

EVALUATION

Assessing Learners
Entry on Ultimate Desired Learning Outcomes

Pre Assessment

The entire lessons were divided in to three units.
Each unit was subdivided into many conceptual areas.
For each sub unit content and computation was divided into five taxonomy like knowledge, comprehension, application, analysis, synthesis and evaluation.
Multiple choice question were developed based on weightage of the content.
In total 50 multiple choice were used for assessment.
The same procedure was adopted for post assessment.
The difference between pre and post assessment shows the significant of innovative instructional approaches.
3.21. STAGES OF THE STUDY

The duration of the experiment was four months

Stage - I
- Examining various instructional approaches suitable for learning Physics at higher secondary level

Stage - II
- Selecting an appropriate learning approaches for teaching Physics at the Higher Secondary Level

Stage - III
- Selecting the Experimental Group

Stage - IV
- Administering pre-test to the Experimental group

Stage - V
- Treatment

Stage - VI
- After the four month period - Conduct of post assessment

Stage - VII
- Analyzing the data to find out the effectiveness of the selected instructional/learning approach
3.22. EXPERIMENTAL PHASES

3.22.1. PHASE I: Examining various instructional approaches suitable for learning Physics at higher secondary level

By experience was observed that teachers rarely adopt instructional approaches that are always be useful and effective in enhancing understanding of abstract concepts in Physics. The investigator selected 50 higher secondary level students from St. Joseph’s Higher Secondary School, Venkatakulam, Pudukottai District, Tamil Nadu, South India.

The various instructional approaches suitable for learning Physics were developed and implemented among the higher secondary students in the following experimental phases.

3.22.2. PHASE II: Selecting appropriate learning approaches for teaching Physics at the Higher Secondary Level

To make the students understand concepts is no easy task. In the present scenario, students face a lot of learning difficulties and do not respond to the traditional methods of teaching. They want easy ways in everything and demand simplified methods of communication and teaching. In the teaching-learning process short cut methods play a vital role.

Modern man depends on too many gadgets and this can reduced the dynamic power of their brain/body. Students become lethargic and prefer to understand abstract concepts in the proper way. This leads to learning difficulties and creates a shortfall in understanding.
Every year the investigator used to follow the routine conventional teaching approaches in teaching of physics, higher secondary students. Over this years the achievement of the students in higher secondary physics in Government examination was very low. Hence the investigator from his personal experiences decided to think, design and implement innovative instructional approaches to teach physics. In this circumstance innovative instructional approaches were utilized. In this present study the investigator implemented the following selected instructional approaches

- Explained Formulae charts
- Simplified Symbolic instructions
- Developed Joint group instruction
- Encouraged Peer group instruction
- Transformed concept teaching into activity-based learning
- Formulated simplified table instructions
- Focused on Pictorial presentation rather than audio visual instruction
- Illustrated through Demonstration and
- Improvised diagrammatic representation of instructions

3.22.2.1. Implementation of the Instructional Approach

In this study, achievement tests in Units and Measurement, Atomic Physics and Nuclear Physics are the dependent variables and Implementation of instructional approach is the independent variable. Pre assessment of achievement in Units and Measurement, Atomic Physics and Nuclear Physics was the first step. During the treatment, the instructional approach designed by the investigator was carried out. After the treatment was over, post assessment was also completed by the investigator.
3.22.2.2. Instructional Approaches

Instructional design is defined as a systematic process that is employed to develop education and training programmes in a consistent and reliable fashion. In addition, instructional design models or theories may be thought of as frameworks for developing modules or lessons that enhance the possibility of learning and encourage the engagement of learners so that they learn faster and gain deeper levels of understanding.

3.22.2.3. Analysis of the Content

The Content was selected from the Physics Text Book of the Higher Secondary Course. Physics at higher secondary level is divided into two parts. The researcher selected Units and Measurement from higher secondary- I level and Atomic Physics and Nuclear Physics from higher secondary- II level. These Chapters were selected after consulting, discussing and analyzing the content of chapters with teachers of various schools.

3.22.2.4. Design of the Content

After thoroughly going through the chapters the content was analysed as shown below.

I. Units and measurement

II. Atomic Physics

III. Nuclear Physics
3.22.2.5. Content Scrutiny and Material Development

The chief concern of the learning process and instructional approach was the content and its scrutiny, which plays a vital role in deciding the instructional approach. This instructional approach was prepared for the students of the higher secondary level who are going to appear for the public exam conducted by Tamilnadu Government. The content of the chapter is made up of theories and problems from higher Physics. The theories and problems included demand continuity of study. Keeping this point in mind and as per programmed learning, the content was divided into smaller fragments. In between or at the end, multiple choice questions were placed as per the need. Initially the material was prepared with the help of textual content. The important words are highlighted and necessary meanings were given. The material was prepared both in English and Tamil by the investigator.

3.22.2.6. Implementation of the Instructional Approach

The following are the chief features of the new approach.

1. Learning becomes self-paced and self-directed.
2. Learners can skip over a topic if information is already known, making the learning process more efficient.
3. The new instructional approach gives learners more control over the learning process.
4. Students feel successful and motivated to learn and gain self-confidence and self-esteem.
5. Students learn more and more rapidly in the instructional approach.
6. This learning process improves the roles of teachers and administrators in the education process.

3.22.2.7. Units and Measurements

The students of Physics have an aversion for the numerical problems and for that reason they find the subject difficult. The basic reason for this is the lack of knowledge about the concept of units and measurements which the students conveniently neglect and as a result they find the subject difficult. The design formed here would certainly enhance the understanding capacity of the students.

Energy is the term often used in Physics in all the chapters. The international system of units and measurements recommends six different terms for the expression of energy units. They are

“Joule” is the unit of energy, heat and work done in a process.

“KJmol⁻¹” is the unit of energy in all chemical reactions

“eV” electron volt is the unit of energy in nuclear reactions

“au” atomic unit is the unit of energy in spectroscopy.

“cm⁻¹” is the unit of energy in spectroscopy particularly in infrared spectroscopy

“Hz” is the unit of energy in measuring the energies of electromagnetic radiations.

The present design is intended for the higher secondary students to enable them to know the interrelation of different forms of energy. This table also serves as the conversion table for energy units.
Table.3.3 Units and Measurements table

<table>
<thead>
<tr>
<th>Joule</th>
<th>KJmol(^{-1})</th>
<th>eV</th>
<th>*au</th>
<th>cm(^{-1})</th>
<th>(\theta) Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.023x10(^{-20})</td>
<td>6.242x10(^{-18})</td>
<td>2.295x10(^{17})</td>
<td>5.03x10(^{-22})</td>
<td>1.509x10(^{13})</td>
</tr>
<tr>
<td>1.66x10(^{-21})</td>
<td>1</td>
<td>1.036x10(^{-2})</td>
<td>3.81x10(^{-8})</td>
<td>83.51</td>
<td>2.505x10(^{12})</td>
</tr>
<tr>
<td>1.602x10(^{-19})</td>
<td>96.52</td>
<td>1</td>
<td>3.677x10(^{-2})</td>
<td>8060</td>
<td>2.418x10(^{13})</td>
</tr>
<tr>
<td>4.357x10(^{-18})</td>
<td>2625</td>
<td>27.2</td>
<td>1</td>
<td>2.192x10(^{5})</td>
<td>6.58x10(^{15})</td>
</tr>
<tr>
<td>1.987x10(^{-23})</td>
<td>1.197x10(^{-2})</td>
<td>1.24x10(^{-4})</td>
<td>4.56x10(^{-9})</td>
<td>1</td>
<td>3x10(^{19})</td>
</tr>
<tr>
<td>6.626x10(^{-34})</td>
<td>3.99x10(^{-15})</td>
<td>4.133x10(^{-15})</td>
<td>1.52x10(^{-16})</td>
<td>3.33x10(^{11})</td>
<td>1</td>
</tr>
</tbody>
</table>

*1au = 1 atomic unit = twice the ionization energy of H – atom

= 2 x 13.6eV = 27.2eV

1Hz = 1 Hertz = 1 second\(^{-1}\) = S\(^{-1}\)

In the above table the 6x6 unit matrix design has been formed

The next task is to fill up the vacant boxes of the table

Avogadro’s constant is 6.023x10\(^{23}\) mol\(^{-1}\)

**Step 1**

1J = 6.023x10\(^{-23}\) Jmol\(^{-1}\)

Since 1Kilo refers to 10\(^3\), we have

1J = 6.023x10\(^{20}\) KJmol\(^{-1}\)

**Step 2**

1.602 x 10\(^{-19}\) C x 1 V=1eV

Since 1vc = 1J, we have

1 eV = 1.602x10\(^{-19}\) J

1.602 x 10\(^{-19}\) J = 1 eV

1J = ?

1J x 1 ev / 1.602 x10\(^{-19}\)J

1J = 6.242 x10\(^{18}\)eV
**Step 3**

1 au = 1 atomic unit = 27.2 eV  
1eV = 1.602 x 10^{-19} J  
27.2eV = 27.2 eV x 1.602 x 10^{-19} J / 1 eV  
= 4.357 x 10^{-18} J  
(OR) 4.357 x 10^{-18} J = 1 au  
1J = ?  
1J x 1 au / 4.357 x 10^{-18} J = 2.295 x 10^{17} au

**Step 4**

\[ E = hf = \frac{hc}{\lambda} = \frac{1J}{6.626 \times 10^{-34} JS \times 3 \times 10^8 ms^{-1}} \]

\[ \hat{F} = \frac{E}{hc} = 1J/6.626\times10^{-34}JS \times 3\times10^8ms^{-1} \]

\[ \hat{F} = 5.03 \times 10^{24} m^{-1} \]

\[ \hat{F} = 5.03 \times 10^{22} cm^{-1} \]

\[ 10^2 cm = 1m \]

\[ 1 cm = 10^{-2} m \]

\[ 1 m^{-1} = 10^2 cm^{-1} \]

**Step 5**

\[ E = hf \]

\[ f = \frac{E}{h} = 1J/6.626 \times 10^{-34} Js \]

\[ f = 0.1509 \times 10^{33} S^{-1} \]

\[ f = 1.509 \times 10^{33} HZ \]

**Step 6**

\[ 6.023 \times 10^{20} KJmol^{-1} = 1J \]

\[ 1 KJmol^{-1} = ? \]

\[ 1 KJmol^{-1} x 1J / 6.023 \times 10^{20} KJmol^{-1} = 1.66 \times 10^{-21} J \]

\[ 1 KJmol^{-1} = 1.66 \times 10^{-21} J \]
**Step 7**

\[
6.023 \times 10^{20} \text{KJmol}^{-1} = 6.242 \times 10^{18} \text{eV}
\]

\[
1 \text{KJmol}^{-1} = ?
\]

\[
1 \text{KJmol}^{-1} \times 6.242 \times 10^{18} \text{eV} / 6.023 \times 10^{20} \text{KJmol}^{-1}
\]

\[
= 1.036 \times 10^{-2} \text{eV}
\]

**Step 8**

\[
6.023 \times 10^{20} \text{KJmol}^{-1} = 2.295 \times 10^{17} \text{au}
\]

\[
1 \text{KJmol}^{-1} = ?
\]

\[
1 \text{KJmol}^{-1} \times 2.295 \times 10^{17} \text{au} / 6.023 \times 10^{20} \text{KJmol}^{-1}
\]

\[
= 3.81 \times 10^{-4} \text{au}
\]

**Step 9**

\[
6.023 \times 10^{20} \text{KJmol}^{-1} = 5.03 \times 10^{22} \text{cm}^{-1}
\]

\[
1 \text{KJmol}^{-1} = ?
\]

\[
1 \text{KJmol}^{-1} \times 5.03 \times 10^{22} \text{cm}^{-1} / 6.023 \times 10^{20} \text{KJmol}^{-1}
\]

\[
1 \text{KJmol}^{-1} = 83.51 \text{cm}^{-1}
\]

**Step 10**

\[
6.023 \times 10^{20} \text{KJmol}^{-1} = 1.509 \times 10^{33} \text{Hz}
\]

\[
1 \text{KJmol}^{-1} = ?
\]

\[
1 \text{KJmol}^{-1} = 1 \text{KJmol}^{-1} \times 1.509 \times 10^{33} \text{Hz} / 6.023 \times 10^{20} \text{KJmol}^{-1}
\]

\[
1 \text{KJmol}^{-1} = 2.505 \times 10^{12} \text{Hz}
\]

**Step 11**

\[
1.036 \times 10^{-2} \text{eV} = 1.66 \times 10^{-19} \text{J}
\]

\[
1 \text{eV} = ?
\]

\[
1 \text{eV} = 1 \text{eV} \times 1.66 \times 10^{-21} \text{J} / 1.036 \times 10^{-2} \text{eV}
\]

\[
= 1.602 \times 10^{-19} \text{J}
\]

\[
1 \text{eV} = 1.602 \times 10^{-19} \text{J}
\]
Step 12

\[ 1.036 \times 10^{-2} \text{eV} = 1 \text{KJmol}^{-1} \]

1eV = 96.52 KJmol^{-1}

1eV = \frac{1 \text{eV} \times 1 \text{KJmol}^{-1}}{1.036 \times 10^{-2} \text{eV}}

Step 13

\[ 1.036 \times 10^{-2} \text{eV} = 3.81 \times 10^{-4} \text{au} \]

1eV = \frac{1 \text{eV} \times 3.81 \times 10^{-4} \text{au}}{1.036 \times 10^{-2} \text{eV}}

1eV = 3.677 \times 10^{-2} \text{au}

Step 14

\[ 1.036 \times 10^{-2} \text{eV} = 83.51 \text{ cm}^{-1} \]

1eV = \frac{1 \text{eV} \times 83.51 \text{ cm}^{-1}}{1.036 \times 10^{-2} \text{eV}}

1eV = 8060 \text{ cm}^{-1}

Step 15

\[ 1.036 \times 10^{-2} \text{eV} = 2.505 \times 10^{12} \text{Hz} \]

1eV = \frac{1 \text{eV} \times 2.505 \times 10^{12} \text{Hz}}{1.036 \times 10^{-2} \text{eV}}

1eV = 2.418 \times 10^{14} \text{Hz}

Step 16

\[ 3.677 \times 10^{-2} \text{au} = 1.602 \times 10^{-19} \text{J} \]

1au = \frac{1 \text{au} \times 1.602 \times 10^{-19} \text{J}}{3.677 \times 10^{-2} \text{au}}

4.357 \times 10^{18} \text{J}

1au = 4.357 \times 10^{18} \text{J}
Step 17

\[ 3.677 \times 10^{-2} \text{au} = 96.52 \text{KJmol}^{-1} \]

1 au = ?

1 au = 1 au \times 96.52 \text{KJmol}^{-1} / 3.677 \times 10^{-2} \text{au}

1 au = 2625 \text{KJmol}^{-1}

Step 18

\[ 3.677 \times 10^{-2} \text{au} = 1 \text{ eV} \]

1 au = ?

1 au = 1 au \times 1 \text{ eV} / 3.677 \times 10^{-2} \text{au}

1 au = 27.2 \text{ eV}

Step 19

\[ 3.677 \times 10^{-2} \text{au} = 8060 \text{ cm}^{-1} \]

1 au = ?

1 au = 1 au \times 8060 \text{ cm}^{-1} / 3.677 \times 10^{-2} \text{au}

1 au = 2.192 \times 10^5 \text{ cm}^{-1}

Step 20

\[ 3.677 \times 10^{-2} \text{au} = 2.418 \times 10^{14} \text{ Hz} \]

1 au = ?

1 au = 1 au \times 2.418 \times 10^{14} \text{ Hz} / 3.677 \times 10^{-2} \text{au}

1 au = 6.58 \times 10^{15} \text{ Hz}

Step 21

\[ 2.192 \times 10^5 \text{ cm}^{-1} = 4.357 \times 10^{-18} \text{ J} \]

1 cm\(^{-1}\) = ?

1 cm\(^{-1}\) = 1 cm\(^{-1}\) \times 4.357 \times 10^{-18} \text{ J} / 2.192 \times 10^5 \text{ cm}^{-1}

1 cm\(^{-1}\) = 1.987 \times 10^{-23} \text{ J}
Step 22

\[2.192 \times 10^5 \text{ cm}^{-1} = 2625 \text{ KJ mol}^{-1}\]

\[1 \text{ cm}^{-1} = ?\]

\[1 \text{ cm}^{-1} = 1 \text{ cm}^{-1} \times \frac{2625 \text{ KJ mol}^{-1}}{2.192 \times 10^5 \text{ cm}^{-1}}\]

\[1 \text{ cm}^{-1} = 1.197 \times 10^{-2} \text{ KJ mol}^{-1}\]

Step 23

\[2.192 \times 10^5 \text{ cm}^{-1} = 27.2 \text{ eV}\]

\[1 \text{ cm}^{-1} = ?\]

\[1 \text{ cm}^{-1} = 1 \text{ cm}^{-1} \times \frac{27.2 \text{ eV}}{2.192 \times 10^5 \text{ cm}^{-1}}\]

\[= 1.24 \times 10^{-4} \text{ eV}\]

\[1 \text{ cm}^{-1} = 1.24 \times 10^{-4} \text{ eV}\]

Step 24

\[2.192 \times 10^5 \text{ cm}^{-1} = 1 \text{ au}\]

\[1 \text{ cm}^{-1} = ?\]

\[1 \text{ cm}^{-1} = 1 \text{ cm}^{-1} \times \frac{1 \text{ au}}{2.192 \times 10^5 \text{ cm}^{-1}}\]

\[1 \text{ cm}^{-1} = 4.56 \times 10^{-6} \text{ au}\]

Step 25

\[2.192 \times 10^5 \text{ cm}^{-1} = 6.58 \times 10^{15} \text{ Hz}\]

\[1 \text{ cm}^{-1} = ?\]

\[1 \text{ cm}^{-1} = 1 \text{ cm}^{-1} \times \frac{6.58 \times 10^{15} \text{ Hz}}{2.192 \times 10^5 \text{ cm}^{-1}}\]

\[1 \text{ cm}^{-1} = 3 \times 10^{10} \text{ Hz}\]

Step 26

\[3 \times 10^{10} \text{ Hz} = 1.987 \times 10^{-23} \text{ J}\]

\[1 \text{ Hz} = ?\]

\[1 \text{ Hz} = 1 \text{ Hz} \times \frac{1.987 \times 10^{-23} \text{ J}}{3 \times 10^{10} \text{ J}}\]

\[1 \text{ Hz} = 6.626 \times 10^{-34} \text{ J}\]
Step 27

\[ 3 \times 10^{10} \text{ Hz} = 1.197 \times 10^{-2} \text{ KJmol}^{-1} \]

1 Hz = ?

1 Hz = 1 Hz \times 1.197 \times 10^{-2} \text{ KJmol}^{-1} / 3 \times 10^{10} \text{ Hz}

1 Hz = 3.99 \times 10^{-13} \text{ KJmol}^{-1}

Step 28

\[ 3 \times 10^{10} \text{ Hz} = 1.24 \times 10^{-3} \text{ eV} \]

1 Hz = ?

1 Hz = 1 Hz \times 1.24 \times 10^{-3} \text{ eV} / 3 \times 10^{10} \text{ Hz}

1 Hz = 4.133 \times 10^{-15} \text{ eV}

Step 29

\[ 3 \times 10^{10} \text{ Hz} = 4.56 \times 10^{-6} \text{ au} \]

1 Hz = ?

1 Hz = 1 Hz \times 4.56 \times 10^{-6} \text{ au} / 3 \times 10^{10} \text{ Hz}

1 Hz = 1.52 \times 10^{-16} \text{ au}

Step 30

\[ 3 \times 10^{10} \text{ Hz} = 1 \text{ cm}^{-1} \]

1 Hz = ?

1 Hz = 1 Hz \times 1 \text{ cm}^{-1} / 3 \times 10^{10} \text{ Hz}

= 3.33 \times 10^{-11} \text{ cm}^{-1}

1 Hz = 3.33 \times 10^{-11} \text{ cm}^{-1}

The investigator identified the difficulties and problems of students in learning abstract concepts in Physics. Through his new instructional approaches explain formulate charts, simplified Symbolic instructions and formulated simplified table instructions the investigator dealt with the content on ‘Units and Measurement’
Associated with adequate training in mathematical concepts, the research has revealed that students have mastered the unit on ‘Units and Measurement’.

3.22.2.8. Atomic Physics

The study of Atomic Physics is concerned with the understanding of the atom model, the nature of subatomic particles present in it, properties of the subatomic particles and their applications. The development of the atom model was a historic event in science. J.J. Thomson was the first to propose the structure of the atom. He considered atom to be the smallest particle of a chemical element possessing the chemical properties of the element. J.J. Thomson conceived his atomic model as a sphere of size $10^{-10}$ m and of positively charged matter in which electrons were embedded.

The understanding of this concept can be made easier with the example of a Dharbhooshani fruit Cutting programme which shows the inner surface, the red coloured stuffy matter is the positively charged matter and the black coloured seeds are the embedded electrons. However Dharbhooshani model was not intended to explain the properties of electrons and the formation of chemical compounds through chemical reactions.

Later in 1911, Rutherford performed a number of experiments on the scattering of α-particles by a very thin gold foil. Most of the α-particles went undeflected while a few were turned back. Only one α-particle out of 20,000 turned back. This shows that, since α-particles are positively charged and since one out of 20000 returned, it was elucidated that most of the space in an atom remains vacant as hollow space and α-particles were deflected due to the fact that there is one
positively charged nucleus at the centre which offers the resistance to penetration, as a result it turned back.

(a) Information obtained from Rutherford’s α – particle scattering experiment

The atom has a small positively charged nucleus. All positive charges in an atom and most of the mass of the atom are concentrated in the nucleus. Electrons have no place inside the nucleus. Electrons revolve around the nucleus at some distance from the nucleus. The discovery of the nucleus of the atom was due to Rutherford. Just like the wound up spring, the electrons in the electronic orbits will spiral like a spring and enter into the nuclear.

(b) Demerits of the Model

If the electrons have gone inside the nucleus then how are chemical compounds formed? This is a discrepancy that cannot be explained by this model. If the electrons have gone inside the nucleus then how does the concepts of the stability of atoms hold good? In order to overcome these demerits, the Bohr’s Atom Model was proposed in the year 1920.

According to Bohr an electron cannot revolve round the nucleus in all possible orbits. The electron can revolve around the nuclear only in those allowed or permissible orbits for which the angular momentum of the electron is an integral multiple of \( \frac{h}{2\pi} \)

\[
2\pi r = n\lambda \\
2\pi r = n \frac{h}{muv}
\]
Circumference of the electronic orbit

\[ mvr = n \frac{h}{2\pi} \]

\( mvr = \) angular momentum

\( \text{The angular momentum is the integral multiple of } \frac{h}{mv} \text{ or } h \)

If an electron jumps from a higher energy level to a lower energy level, it emits energy in the form of radiation.

\[ E_2 - E_1 = \Delta E = h\theta \]

Using these two concepts Bohr derived expressions for the radius of the atom and the energy of the electron in an atom. Bohr’s atom model was applicable only to the Hydrogen atom and not to other atoms. Bohr’s first assumption is \( 2\pi r = n\lambda \) where \( 2\pi r \) is the circumference of the electron orbit was obtained from classical mechanics and other part is \( n\lambda \) (ie) \( n \frac{h}{2\pi} \) which is obtained from quantum mechanics. / Bohr Atom model is goes partially through classical mechanics and partially through quantum mechanics. That is why the Bohr model is not in a position to explain the models of other atoms.

The atom models should be taught to the students in such a way as to show how the development has taken place gradually. Suitable day – today life examples must be given. Bohr’s atom model was in a position to explain only H-atom and not other atoms. It must be clarified to the students that Bohr mixed up classical mechanics and quantum mechanics. Classical mechanics is meant for large mass bodies and not for subatomic particles. Quantum mechanics is meant for subatomic particles. After Bohr, people applied fully the principles of quantum mechanics to understand the structure of other atoms.
Fig3.3 Instructional Model for atomic Physics
With respect to the Syllabus - unit on ‘Atomic Physics’, in the beginning students could not understand the atom model. They only memorized the details to get marks in the exam. By using the innovative instructional approaches such as Focused on pictorial presentation rather than audio visual instruction, Illustrated through Demonstration and improvised diagrammatic representation of instructions blended with life experiences, the teacher was able to make the students understand the concept and achieve clarity in understanding.

3.22.2.9. Nuclear Physics

(a) Introduction

The atomic nucleus was discovered in 1911 by Rutherford. Rutherford’s $\alpha$ – particle scattering experiments showed that the atom consists of a very small nucleus of $10^{-14}$ m in diameter surrounded by orbiting electrons. All atomic nuclei are made up of elementary particles called protons and neutrons. A proton has a positive charge of the same magnitude as that of an electron. A neutron is electrically neutral. The protons + neutrons = Nucleons

(b) Radioactivity

The radioactive nuclei, will be unstable due to the presence of excess of neutrons. In order to attain stability, the heavier nuclei spontaneously emit $\alpha$ -, $\beta$ – and $\gamma$ – rays. The properties of $\alpha$ -, $\beta$ – and $\gamma$ – can be tabulated as shown below. Such types of tables are not given in text books for higher secondary classes. If the students master this Table, they will be in a position to understand the subject matter easily and clearly.
Table No: 3.4

Comparison of the properties of radioactive rays

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Property</th>
<th>(\alpha) – rays</th>
<th>(\beta) - rays</th>
<th>(\gamma) - rays</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mass</td>
<td>4 amu (or) 4x1.66x10(^{-27}) Kg</td>
<td>9.1 x 10(^{-31}) Kg</td>
<td>Negligible</td>
</tr>
<tr>
<td>2.</td>
<td>Charge</td>
<td>+2 Units</td>
<td>-1 Unit</td>
<td>0</td>
</tr>
<tr>
<td>3.</td>
<td>Identity</td>
<td>(\frac{4}{2}) He Helium Nuclei</td>
<td>electrons</td>
<td>high energy radiations</td>
</tr>
<tr>
<td>4.</td>
<td>Energy</td>
<td>6 to 16 x 10(^{-13}) J per (\alpha) – particle</td>
<td>0.03 to 5 x 10(^{-13}) J per (\beta) -particle</td>
<td>0.03 to 5 x 10(^{-13}) J per single ray</td>
</tr>
<tr>
<td>5.</td>
<td>Velocity</td>
<td>Nearly (\frac{1}{10}) th the velocity of light</td>
<td>nearly same as that of velocity of light</td>
<td>same as that of the velocity of light 3x10(^8) ms(^{-1})</td>
</tr>
<tr>
<td>6.</td>
<td>Penetrating power</td>
<td>small say 1 time</td>
<td>Large say 100 times That of (\alpha) -rays</td>
<td>Very Large say 10000 times that of (\alpha) - rays</td>
</tr>
<tr>
<td>7.</td>
<td>Magnetic property</td>
<td>deflected towards the – ve pole</td>
<td>deflected towards the +ve pole</td>
<td>Not deflected towards any pole ( go straight)</td>
</tr>
<tr>
<td>8.</td>
<td>Power to ionise the gases</td>
<td>Very Large</td>
<td>Small</td>
<td>Very small</td>
</tr>
<tr>
<td>9.</td>
<td>effect on photographic plate and ZnS screen</td>
<td>affected strongly</td>
<td>effect less than (\alpha) – rays</td>
<td>least effect</td>
</tr>
</tbody>
</table>
(c) Radioactive nuclear decay

In order to attain stability the nucleus can undergo various types of decay modes. Students may get perplexed in studying the different modes of decay. In such circumstances, the following chart may enable students to know the processes in an easier way.
The number of $\alpha$-Particles and the number of $\beta$-particles emitted from the radioactive element can easily be calculated by using the following simple improvised technique.

(d) **Series are of four types.**

- **4n Series (or) Thorium series** $^{232}_{90} Th \rightarrow ^{208}_{82} Pb$

- **(4n+1) Series (or) Neptunium Series** $^{237}_{93} Np \rightarrow ^{209}_{83} Bi$

- **(4n+2) Series (or) Uranium Series** $^{238}_{92} u \rightarrow ^{206}_{82} Pb$

- **(4n+3) Series (or) Actinium Series** $^{235}_{92} u \rightarrow ^{207}_{82} Pb$

\[ \alpha \rightarrow \beta \]

\[ \alpha = \frac{a-b}{4} \text{ and } \beta = d + 2 \alpha - c \]

- **4n Series** $^{232}_{90} Th \rightarrow ^{208}_{82} Pb$

\[ \alpha = \left[ \frac{232 - 208}{4} \right] = \left[ \frac{24}{4} \right] = 6 \]

\[ \beta = 82 + 12 - 90 = 4 \]

- **(4n+1) Series** $^{237}_{93} Np \rightarrow ^{209}_{83} Bi$
\[ \alpha = \left[ \frac{237 - 209}{4} \right] = \left[ \frac{28}{4} \right] = 7 \]

\[ \beta = 83 + 14 - 93 = 4 \]

(4n+2) Series \( {}_{92}^{238} \text{U} \rightarrow {}_{82}^{206} \text{Pb} \)

\[ \alpha = \left[ \frac{238 - 206}{4} \right] = \left[ \frac{32}{4} \right] = 8 \]

\[ \beta = 82 + 16 - 92 = 6 \]

(4n+3) Series \( {}_{92}^{235} \text{U} \rightarrow {}_{82}^{207} \text{Pb} \)

\[ \alpha = \left[ \frac{235 - 207}{4} \right] = \left[ \frac{28}{4} \right] = 7 \]

\[ \beta = 82 + 14 - 92 = 4 \]

Usual calculation Method is to set the algebraic sum of the chemical equation and setting \( \alpha = x \) and \( \beta = y \)

Example:

\( {}_{92}^{235} \text{U} \rightarrow {}_{82}^{207} \text{Pb} + {}_{2}^{4} \text{He} + y_{-1}^{0} e \)

\[
\begin{align*}
235 + 207 + 4X + 0 & \quad 92 = 82 + 2X - y \\
235 - 207 = 4X & \quad 92 = 82 + 14 - y \\
28 = 4x & \quad y = 82 + 14 - 92
\end{align*}
\]
The method given first for the calculation of $\alpha$ and $\beta$ particles will be easier to the pupils to understand rather than the conventional method.

With respect to ‘Nuclear Physics’ students found it difficult to calculate the number of Alpha particles, Beta particles and Gama particles. The investigator tried out with the selected instructional strategies in explaining the abstract concept specially framed in the area of Nuclear Physics such as Developed joint group instruction, encouraged peer group instruction, transformed concept teaching into activity based learning and formulated simplified table instructions. By the innovative instructional approaches the concept of ‘radio activity’ was well understood this showed clearly that the strategies selected have been found to be more appropriate and very effective. The students were able to understand the concept on radio activity fully and scored very good marks in the examination.

3.22.3. Phase III: Selecting the Experimental Group

One school, St. Joseph’s Higher Secondary School, Venkatakulam, Pudukottai District, Tamil Nadu, South India was selected and pilot testing was made on boys and girls. For Pilot testing of academic achievement, students were selected on the basis of their marks in the Physics subject. The pilot testing is as follows.
50 students of Higher Secondary Level (Physics optional) formed the sample of the study. A Single group pre-test – treatment - post-test design and purposive sampling technique was followed.

3.22.4. Phase IV: Conducting a Pre – Assessment

After conducting orientation programme about instructional approaches in Physics, to assess the present level of instructional approaches in Physics, various tools were used for St. Joseph’s Higher Secondary School, Venkatakulam, Pudukottai District, Tamil Nadu, South India. These pre assessment tools was constructed and validated by the investigator with the help of experts. The investigator assessed the academic achievement in Physics of higher secondary students and the scores were averaged to get the level of performance. The same tools were used in the post-assessment.

3.22.5. Phase – V: Treatment

After conducting of pre-assessment, the investigator conducted a theoretical orientation programme on instructional approaches to higher secondary students. Before starting of orientation programme, the students were not aware of these instructional approaches. During this treatment period the investigator explained in detail about the role of the approach in enhancing understanding abstract concepts in Uits and Measurement, Atomic Physics and Nuclear Physics.

3.22.6. Phase-VI: Conducting Post-Assessment

Post-assessment was conducted by the investigator after the implementation of the treatment. The post-assessment was done with the same academic achievement parameters as those in the pre-test.
3.22.7. Experimental Threats

The main objective of planning an experiment is to maximize the treatment variance and minimize the error variance. This, in other words, is termed as ‘validity’ of the experimental design. Campbell and Stanley (1963) have identified some sources of error. These sources of error are related to internal validity and dealt with in detail.

3.22.8. Internal Validity

3.22.8.1. History

The special events that affect the dependent variable and bring in error are called history effect.

During the ongoing experiment investigator instructed students on the instructional approach. At the same time as Physics is one of the compulsory papers they used to go to the Physics class, so they were acquainted with the atmosphere. The experiment was conducted at the same time in a school at Venkatakulam, Pudukottai District, Tamil Nadu, South India., so it could be said that no effect of history arose during the experiment.

3.22.8.2. Maturation

The time period that elapses during the experimentation may produce certain changes in the subjects. The subject may perform differently on the dependent variable due to processes like fatigue, age, interest or motivation. Therefore the effect of such changes on the dependent variable along with treatment may bring in the error called ‘Maturation’ effect.
Here, the duration of the experiment is short and group arrangements are random. Hence, the results obtained are due to the treatment given in the experiment.

3.22.8.3. Pre-testing

The student in the experiment has been tested before and after the treatment. Due to this exposure the subject serves as the learning experience. This factor does not controlled during the experiment procedure as the design is so selected.

3.22.8.4. Measuring Instrument

Different measuring instruments cause the threats to internal validity. Here the same pre assessment and post assessment prepared by the researcher himself was implemented. This will control the factor.

3.22.8.5. Statistical Regression

The group is chosen on the basis of extreme scores. This refers to the tendency for extreme scores to regress towards the common mean on subsequent measure.

In the experiment the groupings were done by random sampling technique, so in the groups there is an equal probability that all students get equal opportunity to be selected. Thus this factor has been controlled.

3.22.8.6. Experimental Mortality

The dropping out of the subjects during experimentation is called Mortality. During the experiment no students dropped out before or after the pre-testing. So, there is no differential loss to affect the findings of the study. Secondly the duration of the experiment was short which nullified all probability of any decrease in the number of subjects.
3.22.8.7. Differential Effect of Subjects

The groups may differ significantly on some important variables related to the dependent variable even before the application of the experimental treatment. If the researcher had taken two different groups they may not be similar with respect to many other intervening variables. This is called selection effect. But here only one group was taken.

3.22.8.8. Interactive Combination of Factors

The discussed factors do not exist in isolation, all of them occur simultaneously during experimentation. Such interaction of selection and factors may boost the scores on dependent variables even in the absence of treatment. There was no scope for this in the present study.

3.22.9. External Validity

The extent to which the objective of the research is attained is a measure of the external validity of the experimental design. This validity is concerned with the generalizability. Braacht and Glass (1968) have classified external validity into two types: (1) Population validity (ii) Ecological validity.

3.22.9.1. Population Validity

Population validity is concerned with the identification of the population to which the result of an experiment can be generalized. In the experiment the researcher has studied the effectiveness of a particular instructional approach in enhancing understanding of the abstract concepts on Physics by students studying higher secondary science in Tamil medium at Venkatakulam, Pudukottai District, Tamil Nadu, South India. This was considered as the accessible population of the
study. The target population was all the students studying higher secondary of science stream of Tamil medium schools of Venkatakulam, Pudukottai District, Tamil Nadu, South India.

3.22.9.2. Ecological Validity

This is concerned with generalizing experimental effects to the environmental condition. The experimentation effects would be valid for other units also.

3.22.10. Procedure for Data Collection

The required data were collected with the help of pre-test, treatment, post-test and opinionnaire which were constructed by the researcher. After the pretest, the researcher implemented the instructional approaches for one month on the experimental group. After implementation the researcher administrated a post-test after one month and opinionnaire was administered to know the reaction of the students regarding learning through the newly designed instructional approaches.

This served as interim feedback. It was positive and so the investigator continued with his new forged strategy that was a eclectic. In the third phase the researcher administrated the post-test to the students to study the effectiveness of the new techniques in enhancing understanding of the abstract concepts in Physics.

3.22.11. Phase-VII: Data Analysis

Data collected in Pre-test, Treatment and Post-test was analyzed using appropriate statistical techniques.
3.23. SCHEME OF DATA ANALYSIS

In the present study, the relevant data obtained from the pre and post assessment scores of 50 higher secondary students have been analyzed as follows:

3.23.1. Mean

\[ \text{Mean} = A + \frac{\sum fd}{N} \times C.I \]

Where \( A \) = Assumed Mean

\( f \) = Frequency

\( d \) = Deviation from the assumed mean

\( C.I \) = Class Interval

3.23.2. Standard Deviation

\[ \text{Standard Deviation} = \sqrt{\frac{\sum fd^2}{N} - \left(\frac{\sum fd}{N}\right)^2} \times C.I \]

Where \( f \) = Frequency

\( d \) = Deviation from the assumed mean

\( C.I \) = Class Interval

\( N \) = Total Frequency

3.23.3. ‘t’ -Test

\[ t = \frac{M_1 - M_2}{\sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}} \]
Where $M_1$ & $M_2$ = Means of groups

$\sigma_1$ & $\sigma_2$ = Standard deviations of each group

$N_1$ & $N_2$ = Total number of sample in each group

$r$ = correlation between the score

3.23.4. F-Test

$$F = \frac{V_k}{V_w} = \frac{\text{Between Groups Variance}}{\text{Within Groups Variance}}$$

3.23.5. Correlation Coefficient

$$r = \frac{N \sum xy - \sum x \sum y}{\sqrt{(N \sum x^2 - (\sum x)^2) (N \sum y^2 - (\sum y)^2)}}$$

3.23.6. Non Parametric Test

3.23.6.1. Effect Size

Although the difference between means is a useful concept to understand power, we need statistics to compare different experiments. Specifically we need one that will allow us to compare directly the results of different experiments using the same scale. Cohen decides on such statistics and called it Effect Size (ES). This is represented by the index ‘d’ which is defined as the degree of departure from Ho of the alternate hypothesis or the effect size we wish to detect (1988, p.20) for the directional (one tailed) case.
\[ d = \frac{|M_1 - M_2|}{\sigma} \]

where \( d \) = Effect Size index for the ‘t’ ratio of the difference between means.

\( M_1 - M_2 \) = Population Means estimated by the sample.

\( \sigma \) = Common standard deviation of the population assumed to be normal

\[ \sigma = \frac{S_1 + S_2}{2} \]

Effect size (d) for the difference between means of sample

3.23.6.2. Gain Ratio

Mc-Gain and Peters (1965) suggested that best criterion of programme effectiveness is the gain ratio between amount learned and the amount that could be learnt.

Gain ratio = \( \frac{\text{Mean of (Post assessment scores – Pre assessment scores)}}{\text{Mean (full scores – Pre assessment scores)}} \)
3.23.6.3. Omega Square $\Omega^2$

$\omega^2$ value tells us to what extent the independent variable affects dependent variable

$$\omega^2 = \frac{t^2 - 1}{t^2 + N_1 + N_2 - 1}$$

t = ‘t’ value

$N_1 \& N_2 =$ Total number of cases in each group or each assessment

3.23.6.4. Kruskal – Wallis Test

This test is a direct generalization of the Mann-Whitney test in which case there are three or more independent groups. This tests the null hypothesis that all samples came from identical populations. The Kruskal-Wallis test is used to find out whether there was a difference between the effectiveness of pre and post assessment scores in Atomic Physics, Nuclear Physics and Units and Measurement

3.24. CONCLUSION

In this chapter details regarding the origin of the study, the design of the research, the population of the research, the sample of the study, tools for data collection, procedure for data collection and details regarding the development of the instructional package and the statistical techniques employed for the data analysis have been mentioned. In the next chapter the analysis and interpretation of data is presented in detail.