CHAPTER - III

METHODOLOGY

3.1.0 Method adopted for the Study
3.2.0 Variables of the Study
3.3.0 Population and Sample of the Study
3.4.0 Development of the Instructional Material
3.5.0 Tools Used for the Study
3.6.0 Description of the Tools Used for the study
3.7.0 Experimentation
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METHODOLOGY

Research methodology is the totality of the procedure followed by the investigator to make the study scientific and valid to the maximum possible extent. It involves systematic procedure starting from the initial identification of the problem to its final conclusions. It provides the tools and techniques by which the research problem is attacked and consists of procedures and techniques for conducting the study. A suitable method helps the researcher to explore the diverse stands of the study. The success of any research depends largely upon the suitability of the research design, method used, the tools and techniques adopted for the study.

The present study proposes to find out the relative effectiveness of Cognitive Acceleration Approach over Activity Oriented Method on Thinking Skills in Chemistry, Attitude towards Science Learning and Achievement in Chemistry among the students of Standard Eight. This chapter indicates the details related to the methodology and the procedures followed in this study. It includes the research design of the study, method adopted for the study, variables included in the study, population and sample, tools used in the study, details regarding the development of the instructional material based on Cognitive Acceleration Approach, details of the construction of the tests on Thinking Skills in Chemistry and Achievement test in Chemistry, procedure adopted for data collection, and the statistical procedures adopted in the study.

3.1.0 Method adopted for the Study

The main objective of the study was to analyse the effectiveness of the Cognitive Acceleration Approach on Thinking Skills in Chemistry, Attitude towards Science Learning and Achievement in Chemistry among the students of Standard Eight. This required deliberate and systematic manipulation and control of variables. The Experimental method which is the most scientific and powerful method was found suitable for accomplishing the present study.

The Experimental method of research is a planned interference in the natural order of events by the researcher. It provides a systematic method to
establish and quantify cause-effect relationship between two variables by observation and measurement. The Experimental method allows hypotheses formulation on the basis of observation and literature survey, and then to use deductive logic to apply to particular instances. Experiments are characterised by the manipulation of one or more independent variables, use of controls such as randomly assigning participants or experimental units to one or more independent variables and careful observation or measurement of one or more dependent variables. It is the most sophisticated, exact and powerful method for discovering and developing an organised body of knowledge. Therefore the investigator adopted experimental method for the present study.

3.1.1 Research Design of the Study

Research design is the blueprint of the procedure that enables the researcher to test the hypotheses in order to arrive at valid conclusions and relationship between the independent and dependent variables. An Experimental Design is the laying out of a detailed experimental plan in advance of doing the experiment. It includes assigning experimental units to treatment levels and the statistical analysis associated with the plan. Selection of a particular design is based upon the purpose of the experiment, the type of variable to be manipulated and the conditions or limiting factors under which it is conducted (Best & Kahn, 2008).

After studying different research designs the investigator selected the Pretest-Posttest Nonequivalent Groups design for the present study. This design provides control of when and to whom the measurement is applied, but because random assignment to experimental and control treatments have not been applied, the equivalence of the groups is not assured. However, the pretest scores can be used in analysis of covariance to statistically control for any differences between the groups at the beginning of the study.

The investigator randomly selected two intact classes with 39 students each from five divisions of eighth standard in Holy Cross H.S.S. Cherpunkal, Kottayam, Kerala. The investigator randomly selected one class as the
The experimental group and the other as the control group. The experimental group was taught using the Cognitive Acceleration Approach (CAA) and the control group was taught using the existing Activity Oriented Method (AOM). The investigator statistically controlled any differences between the groups at the beginning of the study by taking the pretest scores on the dependent variables and the scores on Intelligence as covariates. The design of the study is presented in figure 3.1.

**Figure 3.1 Design of the Study**
As shown in Figure 3.1 the study was carried out in three phases.

1. The first phase involved pretesting of all the students of the two groups on Thinking Skills in Chemistry, Attitude towards Science Learning, Achievement in Chemistry and Intelligence.

2. The second phase involved the treatment, which consisted of instruction based on the Cognitive Acceleration Approach to the experimental group and that based on the existing Activity Oriented Method to the control group.

3. In the third phase, the students were posttested on Thinking Skills in Chemistry, Attitude towards Science Learning and Achievement in Chemistry.

3.2.0 Variables of the Study

Variables are the conditions or characteristics that the experimenter manipulates, controls or observes (Best & Kahn, 2008). In order to meet the objectives of the study the investigator selected the following variables namely independent, dependent and extraneous variables.

3.2.1 Independent Variable

The independent variables are the conditions or characteristics that the experimenter manipulates or controls, in order to ascertain certain relationship to observed phenomena (Best & Kahn, 2008). In this study the independent variable was the treatment variable which had two levels. The levels were i) Experimental treatment using the Cognitive Acceleration Approach to the experimental group and ii) Routine treatment using the Activity Oriented Method to the control group.

3.2.2 Dependent Variables

The dependent variables are conditions or characteristics that appear, disappear or change as the experimenter introduces, removes or changes the independent variables (Best & Kahn, 2008). In education, the dependent variable may be a test score. Thus the dependent variables are the measured changes in
pupil performance attributable to the influence of the independent variables. In this study, the dependent variables selected were:

1. **Thinking Skills in Chemistry**

   The selected components of Thinking Skills in Chemistry were the following:
   
   i. Classifying
   ii. Hypothesising
   iii. Drawing Inference
   iv. Justifying
   v. Interpreting

2. **Attitude towards Science Learning**

3. **Achievement in Chemistry**

   The selected objectives of Achievement in Chemistry were (Anderson and Krathwohl, 2001):
   
   i. Remember
   ii. Understand
   iii. Apply
   iv. Analyse
   v. Evaluate
   vi. Create

### 3.2.3 Extraneous Variable

Extraneous variables are those uncontrolled variables that may have a significant influence on the results of a study (Best & Kahn, 2008). The investigator selected Intelligence as the extraneous variable for the study, since Intelligence may affect Thinking Skills in Chemistry, Attitude towards Science Learning and Achievement in Chemistry irrespective of other learning conditions. Figure 3.2 presents the variables involved in the study.
3.3.0 Population and Sample of the Study

3.3.1 Population of the Study

The population of the study consisted of the students of Standard Eight studying in schools following the curriculum designed by Board of Secondary Education, Kerala State. The age limit of the students was thirteen to fourteen. As the population is very large, it was not possible to conduct the study on the whole group. The investigator selected different samples from the population for diverse purposes at various levels of the study. The details of these samples and sampling method are given below.

3.3.2 Sample of the Study

A sample is a small portion of the population selected for observation and analysis. By observing the characteristics of a sample one can infer about the characteristics of the population from which it was drawn (Best & Kahn, 2008).
Sample is the basis in any form of research intending to draw a generalisation for specified population.

**Selection of sample for the construction of the tools:** The method selected for the present study was experimental. The procedure adopted in conducting the experiment had three phases- Pretest phase, Treatment phase and Posttest phase. At the pretest phase the investigator administered the test on Thinking Skills in Chemistry, Scale of Attitude towards Science Learning, Achievement Test in Chemistry and Raven’s Progressive Matrices to both the experimental and control groups. As part of the construction and validation of the test on Thinking Skills in Chemistry and Achievement test in Chemistry, the investigator carried out an initial try out. The draft tests were administered to 30 selected students of Standard Eight from S.H.G.H.S. Ramapuram, Kottayam district.

For analysing the items in the final draft of the tools, the investigator randomly selected six secondary schools from Kottayam district, which follow the curriculum designed by Board of Secondary Education, Kerala State. From those schools the investigator randomly selected 419 eighth standard students.

To establish the validity and reliability of the tests namely Thinking Skills in Chemistry and Achievement test in Chemistry, the investigator randomly two schools from Kottayam district. The investigator administered these tests on 86 eighth standard students, who were randomly selected from those two schools. The tests were administered on the same sample after a period of one month to calculate the test retest reliability.

**Selection of sample for the experimentation:** At the treatment phase the investigator randomly selected two intact classes from the five classes of Standard Eight of Holy Cross H.S.S., Cherpunkal, Kottayam District, Kerala State, keeping in view of the nature of the study and its demands and limitations. Each class comprised 39 students. Thus the total sample for experimentation consisted of 78 students. The classes were randomly assigned as experimental and control groups.
3.4.0 Development of the Instructional Material

3.4.1 Development of the Instructional Material based on the Cognitive Acceleration Approach

The investigator developed instructional material based on the Cognitive Acceleration Approach, which aims to develop students’ general ability to process information following the theoretical constructs and phases presented by Adey (1990). These phases are given below:

**Phase One - Concrete preparation:** Concrete preparation is the preliminary stage to ensure that the students understand the initial problem, in which the language of the problem is introduced. It links the new learning to previous experiences.

**Phase Two - Cognitive conflict:** This means providing students with challenging activities which are just beyond their current capabilities but which, with appropriate support from the teacher and more able peers, stretch the mind.

**Phase Three - Social construction:** In this phase, the teacher provides appropriate experiences and lead, through careful questioning. Students work in groups and discuss their ideas. Group members act as mediators for each other, suggesting solutions, trying out ideas; individuals feel less vulnerable and more able to participate; random ideas from group-members act as the clues offered by the mediator.
Phase Four - Metacognition: In this phase the learner has to put into words the line of thinking, which makes the process more available both to others listening and the learner. The students are encouraged to take time to reflect on how they solved a problem, what they found difficult about it, what sort of reasoning they used, how they sought help and what sort of help they needed.

Phase Five - Bridging: This phase includes discussion about where these ideas could be used in other contexts within science, mathematics or other parts of the curriculum and to experiences in real life.

The investigator prepared the instructional material for selected topics of Chemistry in the text book of Standard Eight. The material was so structured as to enable the students to understand various components of Thinking Skills and also to improve the Thinking Skills.

The preparation of the instructional material involved the following phases.

![Diagram of the phases of the preparation of the instructional material](image)

Figure 3.4 Phases of the preparation of the instructional material

The details of each phase of the preparation of the instructional material are as follows:
1. **Planning for the instructional material**: This phase involved defining the objectives and selection of the content.

1. **Defining the objectives**: After studying the theoretical basis of the Cognitive Acceleration Approach, the investigator framed the objectives for the instructional material. The main objectives were to enable the students to understand selected components of Thinking Skills and also to improve their Thinking Skills in Chemistry. The specific objectives stated were as follows: The student:

   1. identifies the problem presented before him/her.
   2. formulates hypotheses in connection with solving the identified problem.
   3. tests the hypotheses by conducting experiments.
   4. develops the skill of observation through careful observation of the changes taken place during the experiment.
   5. develops the skill of comparison by comparing the experimental conditions and changes.
   6. develops the skill of classification by comparing the characteristics and classifying different situations.
   7. develops the skill of making inferences and drawing conclusions from different examples provided.
   8. develops the skill of justification by explaining the given examples and by giving excuses for why something is right or not.
   9. develops the skill of interpretation by explaining the concept.

2. **Selection of the content**: The investigator carefully analysed the text book prescribed for Chemistry for Standard Eight by Government of Kerala to select the topics. The investigator had discussions with the Supervisor and the practicing Chemistry teachers at secondary level in schools following the curriculum designed by Board of Secondary Education, Kerala State. The content selected for the preparation of the instructional material and the number of lessons prepared for each content area is given in Table 3.1.
Table 3.1

Contents for the Preparation of the Instructional Material Based on CAA

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Topics</th>
<th>No of lessons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Physical and chemical change</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Elements and compounds</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>Properties of metals</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Corrosion</td>
<td>2</td>
</tr>
<tr>
<td>5.</td>
<td>Acids and bases</td>
<td>4</td>
</tr>
<tr>
<td>6.</td>
<td>Solutions</td>
<td>2</td>
</tr>
<tr>
<td>7.</td>
<td>Water</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

2. Preparation of the draft Instructional Material: This phase comprised two stages.

1. Designing and preparation of the initial draft of the lesson plans - Lessons based on Cognitive Acceleration Approach, have a definite structure comprising well defined phases. The investigator strictly adhered to the phases of CAA as given by Adey S. Philip (1990) for preparing the lesson plans.

2. Evaluation of the initial draft of the lesson plans by the supervisor - The investigator prepared the initial draft of the instructional material keeping in mind the prescribed format and submitted it to the supervisor, for suggestions. The supervisor suggested modifications regarding the introductory phase of the lesson and presentation of conflicting situations. The second draft was prepared based on the suggestions given by the supervisor.

3. Validation of the instructional material: The second draft of the lesson plans was submitted for validation to five experts including three teacher educators who were experts in Science teaching and two practicing Chemistry teachers at
secondary level. They were requested to look critically into the instructional material by keeping in mind the accuracy of the content and phases of CAA. The experts suggested making the teaching learning process more interactive by adding more activities within the framework of the lessons.

4. **Small group try out:** The instructional material was next subjected to a small group try out among thirty students of Standard Eight of S.H.G.H.S. Ramapuram, Kottayam District, Kerala State. The purpose of this try out was identification of problems, if any, regarding the time needed for administration and students’ responses. Further informal discussions were also held with experienced Chemistry teachers at secondary level regarding the objectives and content of the instructional material. The investigator incorporated the recommendations given by them.

5. **Finalisation of the instructional material:** The investigator considered the suggestions given by the experts and prepared the final draft of the instructional material. The tryout of a single lesson required one period of 70 minutes duration. The investigator prepared fifteen lesson plans of 70 minutes duration each.

6. **Preparation of Work Sheet for students:** Work sheet is considered as a data record used by the students during the teaching strategy which provides opportunities to the students to write the summary of each group activity. The investigator prepared worksheets to be used by students for each lesson.

A lesson plan based on the Cognitive Acceleration Approach is given below. The lesson plan consisted of two sections namely; a) the preliminary details and b) the teaching-learning process.

- **The preliminary details:** This section consisted of the name of the teacher, name of the school, subject, class, unit, topic, duration, Instructional objectives, content overview and learning resources.

- **The teaching-learning process:** This section is divided into two columns, (i) teacher activity (ii) student activity. The teacher activity column described the learning activities provided by the teacher in each phase of the CAA and the
student activity column was to make note of the students’ responses while taking the class at every stage of teaching.

COGNITIVE ACCELERATION APPROACH
Lesson plan No: 1

Preliminary details

<table>
<thead>
<tr>
<th>Name of the Teacher</th>
<th>:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject              : Chemistry</td>
<td></td>
</tr>
<tr>
<td>Class                : VIII</td>
<td></td>
</tr>
<tr>
<td>Name of the School   :</td>
<td></td>
</tr>
<tr>
<td>Unit                 : Changes</td>
<td></td>
</tr>
<tr>
<td>Topic                : Physical and chemical changes</td>
<td></td>
</tr>
<tr>
<td>Duration             : 70 minutes</td>
<td></td>
</tr>
</tbody>
</table>

Learning Objectives

- The student identifies the classification of changes as a ‘problem’.
- The student formulates hypotheses about classification of changes.
- The student develops the skill of observation through carefully observing the chemical reactions demonstrated.
- The student develops the skill of comparison by finding out differences between physical and chemical changes.
- The student develops the skill of classification through classifying different examples of changes, based on their characteristics.
- The student makes inferences and draws conclusions from different examples of changes.
- The student develops the skill of justification by identifying, different examples of changes as physical or chemical and explaining the reasons for the same.
- The student develops the skill of interpretation by explaining the concept of physical and chemical changes in their own words.

Content overview:

Facts

- In a physical change the occurred changes are temporary.
In physical changes, there are changes occur only in the arrangements of the molecules.

No new molecules are formed in physical changes.

In chemical changes the changes occurred are permanent changes.

New molecules (substances) are formed in chemical changes.

**Concepts:**

Physical change: Temporary changes where no new molecules are formed

Chemical change: Permanent changes in which new molecules are formed

**Learning Resources:**

1) Chemicals: Ammonium dichromate crystals, Magnesium
2) Materials: Wax, paper.
3) Equipments: Burner, tile.
4) Worksheet

<table>
<thead>
<tr>
<th>Teacher Activity</th>
<th>Student Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase 1 - Concrete preparation</strong></td>
<td></td>
</tr>
<tr>
<td>The teacher initiates a discussion on ‘changes’ by asking following questions.</td>
<td>The students answers to the questions asked by the teacher</td>
</tr>
<tr>
<td>• What do you mean by ‘change”?</td>
<td></td>
</tr>
<tr>
<td>• What changes have happened here during the past thirty or forty years?</td>
<td></td>
</tr>
<tr>
<td>• In what all ways could these changes have affected nature and the human beings?</td>
<td></td>
</tr>
<tr>
<td>• What are the different changes take place around us every day? Give examples of the changes happening in your kitchen and surroundings?</td>
<td></td>
</tr>
<tr>
<td>• Are there helpful and harmful ones among them? Are there natural changes and artificial changes? In what other ways you can categorise these changes?</td>
<td></td>
</tr>
</tbody>
</table>
### Consolidation
Changes can be classified in different ways. Natural and artificial, changes that are useful to man and harmful to man, sudden changes and changes that take time, changes that can be controlled by man and cannot be controlled by man etc.

### Phase 2 - Cognitive conflict

#### Activity 1
The teacher demonstrates concrete examples of two set of changes. Melting of wax and burning of wax; tearing of paper and burning of paper. She asks the students to observe the changes and compare the characteristics. How can we classify these changes into two? The teacher asks the students to identify the problem experienced.

#### Consolidation
The problems identified are: How do we classify these two set of changes? What will be the criterion of classification?

The teacher asks the students to identify the products in each of the reaction and to list the differences between the two sets of changes? The teacher encourages the students to suggest probable solutions to the identified problem.

#### Consolidation
The two sets of changes may be classified on the basis of the nature of the products formed in these changes.

### Phase 3 - Social Construction

#### Activity 2
The teacher gives the following examples for changes.
- milk changing to curd
- evaporation
- digestion
- photosynthesis

The students classify the given changes into two groups according to the nature of...
• cooking of food
• sugar dissolving in water
• burning of wood

The teacher divides the students into groups and asks them to classify the given changes into two groups according to the nature of the products formed in the change.

The teacher asks the students to write the common characteristics of each group of changes in their worksheet.

The teacher assists the students in their works and asks the group leaders to write their answers in the worksheet.

**Consolidation**

Changes are of two types; physical and chemical. Physical changes are temporary changes. There are changes only in the arrangements of the molecules and no new molecules are formed in physical changes. Chemical changes are permanent changes. New molecules (substances) are formed in chemical changes or chemical reactions.

**Activity 3**

The teacher conducts the following experiments and gives more examples for changes. The teacher asks the students to write their inferences based on the observation, in the worksheet.

- Burn of Ammonium dichromate crystals
- Magnesium ribbon burns in oxygen
- Water into steam

**Observation tips**

- Whether a new substance is formed in the reaction
- What are the changes occurred

The teacher asks the students to write the inferences based on their observation, in the worksheet.
Consolidation
In both the experiments new substances are formed. Changes are permanent. So it is inferred that these changes are chemical changes.

Activity 4
The teacher asks the students to interpret the terms Physical change and Chemical change in their own words. The students write the definitions of the concepts ‘Physical change’ and ‘Chemical change’ in their own words.

Consolidation
Physical change: Changes which are temporary in which no new substances are formed.
Chemical change: Permanent changes in which new substances are formed.

Activity 5
The teacher gives more examples and asks the students to identify the type of change, and write their justifications in the worksheet.
- Melting of ice
- Respiration

Consolidation
Melting of ice is a physical change because no new substances are formed in this change. Respiration is a chemical change because new substances are formed in this change.

Phase 4- Metacognition
The teacher asks the students to reflect on how they solved the problem, what difficulties they experienced during problem solving, what sort of reasoning they used, how they sought help and what sort of help they needed. The teacher asks the students to go through their own thinking and learning processes. She asks them to find out the different steps they adopted for solving the problem.

The students write the definitions of ‘Physical change’ and ‘Chemical change’ in their own words.

The students identify the type of changes as physical/chemical. They write the reasons for each answer.

The students reflect on how they solved the problem and the difficulties experienced.
Consolidation

The students identify the different skills used in their thinking process such as identifying the problem, hypothesizing, experimenting, observing, comparing, classifying, drawing inferences and interpreting.

Phase 5 - Bridging

The teacher shares the importance of changes in our daily life. The teacher asks the students to share about the physical and chemical changes experienced in daily life.

The students share about the physical and chemical changes experienced in their daily life.

WORKSHEET

Problem identified:

Hypothesis formulated:

Activity 1: Comparing

<table>
<thead>
<tr>
<th>Melting of wax, tearing of paper Characteristics</th>
<th>Burning of wax, burning of paper Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Activity 2: Classification

Examples of different changes: milk changing to curd, evaporation, digestion, photosynthesis, cooking of food, sugar dissolving in water, burning of wood.
Criterion of classification:

<table>
<thead>
<tr>
<th>Group I</th>
<th>Group II</th>
</tr>
</thead>
</table>

Activity 3: Drawing inferences

<table>
<thead>
<tr>
<th>Experiment, example etc</th>
<th>Observation (changes occurred, characteristics of the products formed etc.)</th>
<th>Inferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Water into steam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Steam into water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Set fire to the heap of ammonium dichromate crystals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Magnesium ribbon burns in oxygen</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Activity 4: Interpretations:

1. Physical change:

2. Chemical change:

Activity 5: Justification

<table>
<thead>
<tr>
<th>Example</th>
<th>Type of change</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting of ice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiration</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Metacognition: (write about your thinking process)

The remaining fourteen lesson plans and the corresponding worksheets are given in Appendix A.
3.4.2 Preparation of the Lesson Plans based on the Activity Oriented Method (AOM)

The investigator prepared fifteen lesson transcripts of 70 minutes duration based on the Activity Oriented Method, currently practised in the schools following the curriculum designed by Board of Secondary Education, Kerala State. The lesson transcripts were in the model of the lesson plans used in the state schools. A sample of the lesson plan based on AOM is given in Appendix B.

3.5.0 Tools Used for the Study

The tools of research are the instruments that are used for the collection of the data. The investigator used the following tools during the different phases of the study.

1. Test on Thinking skills in Chemistry constructed by the investigator and validated by experts to measure the Thinking skills in Chemistry of the students

2. Scale of Attitude towards Science Learning (SATSL) developed and standardised by Joseph and Suresh (1998) to measure the Attitude towards Science Learning of the students

3. Achievement test in Chemistry constructed by the investigator and validated by experts to measure the Achievement in Chemistry of the students

4. Raven’s Standard Progressive Matrices (RPM,1996) to measure Intelligence of the students

3.6.0 Description of the Tools Used for the study

The investigator gives the details of the tools used to measure different variables involved in the study in the following sections.

3.6.1 Construction of the Test on Thinking Skills in Chemistry
3.6.2 Scale of Attitude towards Science Learning
3.6.3 Construction of Achievement Test in Chemistry
3.6.4 Raven’s Progressive Matrices (RPM)
3.6.1 Construction of the Test on Thinking Skills in Chemistry

The investigator constructed the Test on Thinking Skills in Chemistry to measure the Thinking Skills in dealing the content in Chemistry of the students of Standard Eight, since there was no appropriate tool available. The construction of the tool involved the following phases:

1. Planning
2. Writing of test items
3. Try out of the test
4. Items analysis
5. Final form of the test
6. Validity of the test on Thinking Skills in Chemistry
7. Reliability of the test on Thinking Skills in Chemistry

The details of each phase of the test preparation are as follows:

1. Planning: During the planning stage of the test, the investigator took decisions regarding the selection of the components of thinking skills to be included in the tool and selection of the content areas in order to prepare test items.

Selection of the components of Thinking Skills: Thinking Skills are the mental capacities that we use to investigate the world, solve problems and make judgements. The list of all such skills will be endless. Over the years there have been a number of attempts made to develop a classification system for Thinking Skills. The investigator selected the components of Thinking Skills for the construction of the tool, after surveying books and handbooks on Thinking and after seeking the opinion of the supervisor and other experts in the field. In the present study, the investigator followed the product and process approach developed by Passi, Subhashini and Mishra (2004) for the classification of Thinking Skills. From different micro Thinking Skills identified by Passi et al. (2004) the investigator selected the following five components of Thinking Skills, namely Classifying, Hypothesising, Drawing Inference, Justifying and Interpreting for the present study which were relevant to the age level of students studying in Standard Eight. Thus the tool titled “Test on Thinking Skills in Chemistry” was
intended to measure the components of Thinking Skills namely Classifying, Hypothesising, Drawing Inference, Justifying and Interpreting. The definitions of these components of Thinking skills are as follows.

*Classifying:* It refers to the process of distributing elements into different classes, arranging in sets according to some method founded on common properties or character.

*Hypothesising:* It is the process of formulating or suggesting the most suitable solution(s) to a problem or to explain an unknown phenomenon or an unfamiliar situation.

*Drawing Inference:* It is the process of arriving at an unknown truth from the truths already known or moving from specific observations to broader generalisations.

*Justifying:* It is the process of defending the arguments based on relevant criteria. It involves the defence of what we regard as true and the refutation of what we regard as false.

*Interpreting:* It is the process of presenting the meaning of a vague/ difficult/ mysterious concept in understandable terms in the light of individual beliefs, judgements or circumstances.

The blue print gives the frame work for the tool and indicates the broad limit within which the investigator has to work. Based on the selected components of Thinking Skills and the subcomponents of each skill the investigator prepared the blue print for the tool and is given in Table 3.2.
Table 3.2

*Blue Print for the Test on Thinking Skills in Chemistry*

<table>
<thead>
<tr>
<th>Components of Thinking Skills</th>
<th>Subcomponents of Thinking Skills</th>
<th>No. of items</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(TEST I)</td>
<td>Identify criterion or commonality</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Skill of Classifying</td>
<td>Classification based on commonality</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Identification of the cases which do not conform with commonality</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Identify the reason</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>(TEST II)</td>
<td>Identify the causal variable</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Skill of Hypothesising</td>
<td>Identify the variable which may not affect the phenomenon</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>(TEST III)</td>
<td>Identify the base of inference</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Skill of Drawing Inference</td>
<td>Apply deductive inference</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Apply inductive inference</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>(TEST IV)</td>
<td>Show that something is right, reasonable or just</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Skill of Justifying</td>
<td>Explain why something is right</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Give good reason or excuse for something</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>(TEST V)</td>
<td>Explain what something means</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Skill of interpreting</td>
<td>Decide the meaning or purpose of something</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>To translate something</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>
Selection of the Content: The test intended to assess the Thinking Skills in dealing with the content areas of Chemistry among the students of Standard Eight studying in schools following the curriculum designed by Board of secondary education, Kerala State. In order to select the content for the test, the investigator discussed with the supervisor and practicing Chemistry teachers at secondary level in schools following the curriculum designed by Board of Secondary Education, Kerala State. The investigator selected the content for the test from the following Chemistry portions of the Science text books prescribed for classes Six to Eight namely, physical and chemical changes, elements and compounds, types of solutions, acids and bases, water and properties of metals.

2. Writing of Test Items: The investigator decided the type of questions to be included in the test on Thinking Skills in Chemistry as multiple choice types of objective test items, which carry four options (A/B/C/D). The multiple choice type is relatively high in ability to discriminate between better and poor students. The test items were constructed in English language, based on the Chemistry portions of the Science text books from standards Six to Eight. While writing the items the following points were taken into consideration:

1. The items should measure the selected components of Thinking Skills.
2. The language used in the items should be simple enough to be understood by the students of Standard Eight.
3. There should not be any ambiguity in the wordings or task included in the test items.

After discussions with the supervisor the investigator commenced the preparation of the first draft of the test. A total of 100 items were prepared for the initial draft. The first draft of the Test on Thinking Skills in Chemistry was submitted to a panel of experts comprising three practicing teachers teaching Chemistry at the secondary level in schools following the curriculum designed by Board of Secondary Education, Kerala State, and three teacher educators, for further suggestions and corrections. Based on the feedback from the experts, discussions were held with the supervisor and the investigator prepared a second
draft including 75 items, with 15 items to assess each component of Thinking Skills.

3. **Try out:** The second draft of the Test on Thinking Skills in Chemistry was administered on a sample of 30 students of Standard Eight selected from S.H.G.H.S. Ramapuram, Kottayam district. On the basis of the try out, five items that lacked clarity were excluded. The third draft (final draft) comprised 70 items. This draft was used for item analysis. The draft form of the test is given in Appendix C.

4. **Item Analysis:** The investigator carried out a try out, in order to select test items capable of discriminating high and low Thinking Skills achievers based on statistical analysis. It was carried out among randomly selected 419 students of Standard Eight belonging to randomly selected six secondary schools of Kottayam district of Kerala State. The try out was done during the academic year 2012-2013. The administration of the final draft of the test required two periods of 40 minutes duration each. Each item of the tool carried one score. The investigator prepared a response sheet that provided space for students to fill their name, class, school, date and their responses. The general instructions for answering the test were also prepared. The scoring was done according to the scoring key prepared for this purpose. One score was assigned to each correct response. The sum of the scores of the 70 items was taken as the total score for the draft test.

Item analysis involved selection of items with high discriminating power and optimum difficulty level for the final test. For this the investigator analysed the scores obtained by the students in the final draft of the test for computation of difficulty index and discriminating power of each item. The investigator had the response of 419 students from which 29 incomplete response sheets were rejected. From the 390 response sheets 20 answer sheets were rejected randomly in order to bring down the number into 370 for the sake of convenience. The investigator arranged all the scored response sheets in ascending order. The highest score obtained was 69 and the lowest was eight.
From the arranged response sheets, the highest 27% and the lowest 27% with respect to the entire test were separated. 100 students who secured the highest marks were treated as the upper group and similarly 100 students who secured the lowest marks were treated as the lower group. The upper group and the lower group were the two criterion groups. The discriminating power and difficulty index of each item were calculated by using the method given by Ebel and Frisbie (1991) and Gronlund (1993).

**Determination of the Difficulty Index of the items** - The difficulty index of the items was determined by the percentage of students who responded to it correctly. The more the percentage of correct responses, the easier are the items. The difficulty index was calculated by the formula;

\[
Di = \frac{U + L}{2N}
\]

Where,
- \(Di\) = Difficulty index
- \(U\) = The number of correct responses for any item in the upper group
- \(L\) = The number of correct responses for any item in the lower group
- \(2N\) = Total number of answer sheets in the upper and lower group

**Determination of Discriminating Power** – The discriminating power of an item is evidenced by its power to discriminate between the upper and lower groups. The difference between the correct responses in the two groups was the indication of how far it can discriminate the two groups. The investigator calculated the discriminating power of the test items using the formula;

\[
Dp = \frac{U - L}{N}
\]

Where,
- \(Dp\) = Difficulty index
- \(U\) = The number of correct responses for any item in the upper group
- \(L\) = The number of correct responses for any item in the lower group
- \(N\) = Number of answer sheets either in the upper or lower group
The difficulty index and discriminating power of the test items of the tool ‘Test on Thinking Skills in Chemistry’ is given in Appendix D.

5. **Final form of the test**: Test items having difficulty indices ranging from 0.4 - 0.7 and discriminating power above 0.4 were taken as valid items and the investigator selected such items for the final test. The final test consisted of 50 items. The investigator prepared instructions regarding marks, way of writing answers and time duration for administering the test. The investigator fixed the duration for the test, as one hour. This included the time needed for explaining the instructions, clearing doubts if any and answering the test. The investigator prepared the response sheet for writing the answer and the scoring key for the scoring purpose. The final form of the test, the response sheet and the scoring key are given in Appendix E, F and G respectively.

6. **Validity of the test on Thinking Skills in Chemistry**: Validity is that quality of data gathering instrument that enables it to measure what it is supposed to measure (Best & Kahn, 2008). The investigator ensured the content, construct and concurrent validity of the test on Thinking Skills in Chemistry.

Evidence for the content and construct validity of the test refers to the degree to which the test items actually measure, or are specifically related to, the traits for which the test was designed and is to be used (Best & Kahn, 2008). It was ensured during the development stage of the test by submitting the first draft of the test to a panel of experts, in order to get suggestions and corrections based on their scrutiny of each item with respect to the construct and the content. The panel comprised three practicing teachers who taught Chemistry at the secondary level in schools following the curriculum designed by Board of Secondary Education, Kerala State, and three teacher educators. They examined the content and construct of each items of the test, relevance of test items, instructions and scoring procedure and offered valuable suggestions. These suggestions were considered and integrated in the test at its developmental stage.

In order to obtain the concurrent validity the investigator administered the test on Thinking Skills in Chemistry to 42 students of Standard Eight of St.
Thomas H.S.S., Pala and 44 students of St. Mary’s G.H.S.S. Pala. The concurrent validity of the test was calculated by correlating the scores on the test on Thinking Skills in Chemistry with the marks obtained by the same students in the first terminal examination in Chemistry conducted during the academic year 2011-12. The coefficient of correlation was found to be 0.74.

7. Reliability of the test on Thinking Skills in Chemistry: Reliability is the measure of degree of consistency of items. In the present study the investigator calculated the test-retest reliability and split half reliability of the test on Thinking Skills in Chemistry.

1. Test-Retest Reliability method: This method is used to assess the consistency of a measure from one time to another. The investigator administered the test on Thinking Skills in Chemistry to 42 students of Standard Eight of St. Thomas H.S.S., Pala and 44 students of St. Mary’s G.H.S.S. Pala, to estimate the test-retest reliability coefficient. The test was again administered to the same sample after a period of one month to find the test-retest reliability coefficient of the test scores. The investigator calculated the reliability coefficient using Pearsons’ Product Moment Correlation Coefficient (r), by finding out the correlation between the scores obtained by the same person on the two administrations of the test.

   The Test-Retest Reliability coefficient of the test on Thinking Skills in Chemistry and the subtests namely, TEST I (Skill of Classifying), TEST II (Skill of Hypothesising), TEST III (Skill of inferring), TEST IV (Skill of justifying) and TEST V (Skill of interpreting) were 0.82, 0.84, 0.86, 0.78, 0.77 and 0.83 respectively. This shows that there exists a high relationship between the test and retest scores on the test on Thinking Skills in Chemistry. This proved that the test is reliable.

2. Split Half Reliability method: The items of a test should be highly correlated to each other. This is essential because the test needs to measure a single construct. The test on Thinking Skills in Chemistry consisted of five subtests namely TEST I (Skill of Classifying), TEST II (Skill of Hypothesising), TEST III (Skill of inferring), TEST IV (Skill of justifying) and TEST V (Skill of interpreting). The
investigator used the Split-Half reliability method to estimate the internal consistency of the test on Thinking Skills in Chemistry and also of the subtests. For this the tool and the subtests were split into two equivalent halves, odd numbered items were pooled into one half and even numbered items were pooled into other half. The correlation coefficient between the scores of two halves of the test was calculated and the reliability of the whole test and the subtests were calculated by applying Spearman-Brown formula.

The split-half reliability coefficient of the test on Thinking Skills in Chemistry and the subtests namely, TEST I (Skill of Classifying), TEST II (Skill of Hypothesising), TEST III (Skill of inferring), TEST IV (Skill of justifying) and TEST V (Skill of interpreting) were 0.82, 0.82, 0.84, 0.79, 0.78 and 0.81 respectively.

3.6.2 Scale of Attitude towards Science Learning (SATSL)

Attitude towards Science Learning is the favourable or unfavourable disposition of the individual towards the learning of science, which cannot be directly observed, but can be inferred from overt behavior. In order to measure the attitude of students towards Science Learning, the Scale of Attitude towards Science Learning (SATSL) developed and standardised by Joseph and Suresh (1998) was used by the investigator. The components of Attitude towards Science Learning included in the scale were 1) Attitude towards classroom learning; 2) Attitude towards science related activities; 3) Attitude towards scientists and 4) Attitude towards scientific contributions. SATSL contained 25 statements. Out of the 25 statements, 13 were of negative and 12 were of positive polarity. Items with negative and positive polarity were distributed evenly in the decreasing order of discriminating index. Specific directions for the respondents were included in the scale. The scoring procedure for the items of positive polarity was as follows: for every SA response 5, A response 4, U response 3, D response 2, and SD response 1. For the items of negative polarity the scoring procedure was as follows: for every SA response 1, A response 2, U response 3, D response 4, and SD response
5. The maximum and minimum scores, which the students may score on SATSL, were 125 and 25 respectively.

The concurrent validity of SATSL was computed by using average marks obtained in Physics, Chemistry and Biology for the first and second terminal examinations of standard 1X students. The average marks in science of 100 ninth standard students were used for that purpose. The score obtained in the SATSL was correlated with achievement in science. The coefficient of correlation was found to be 0.79. The reliability of SATSL was calculated by using split-half method and corrected by using Spearman-Brown formula and it was found to be 0.87. The reliability of scale, calculated by test-retest method was found to be 0.86. The high validity and reliability coefficients thus obtained showed that the scale is a reasonably valid and reliable one.

3.6.3 Construction of the Achievement Test in Chemistry (ATC)

The investigator constructed an achievement test to measure the Achievement in Chemistry of the students of Standard Eight. In the present study the achievement test intended to

- Evaluate the students’ mastery of the specified objectives
- Evaluate the effectiveness of the instructional material
- Measure the entry behavior and criterion behavior of the students by treating achievement test as pretest and posttest respectively

The construction and validation of Achievement Test in Chemistry involved the following phases:

1. Planning
2. Writing of Test Items
3. Try out of the final draft of ATC
4. Items analysis
5. Preparation of the final form of the test
6. Establishing Validity and Reliability

The details of each phase of the test preparation are as follows:
1. Planning: In the planning phase of the test, the investigator considered selection of the objectives of Achievement Test in Chemistry, selection of the content area, decisions regarding the number and type of items to be included in the test, weightage to be given for the content areas and objectives and the duration of answering the test. The details regarding planning of Achievement Test in Chemistry is given below.

i) Selection of the objectives of Achievement Test in Chemistry: The investigator selected the instructional objectives to be tested by the Achievement Test in Chemistry based on the Bloom’s revised taxonomy of objectives (Anderson & Krathwohl, 2001). The selected objectives were:

   i. Remember
   ii. Understand
   iii. Apply
   iv. Analyse
   v. Evaluate
   vi. Create

Weightage allotted to different objectives of the Achievement test in Chemistry are given in Table 3.3.

Table 3.3
Weightage Alotted to Objectives of Achievement Test in Chemistry

<table>
<thead>
<tr>
<th>No.</th>
<th>Instructional Objectives</th>
<th>Number of items</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Remember</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Understand</td>
<td>14</td>
<td>35</td>
</tr>
<tr>
<td>3</td>
<td>Apply</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>Analyse</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Evaluate</td>
<td>3</td>
<td>7.5</td>
</tr>
<tr>
<td>6</td>
<td>Create</td>
<td>3</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>40</td>
<td>100</td>
</tr>
</tbody>
</table>
ii) Selection of the content: The test was proposed to evaluate the Achievement in Chemistry of the students of Standard Eight studying in schools following the curriculum designed by Board of Secondary Education, Kerala State. For this, the investigator had discussions with the supervisor and practicing Chemistry teachers at secondary level in schools following the curriculum designed by Board of Secondary Education, Kerala State and surveyed through the related literature, text books of Science for Standard Eight and Source books for teachers of Science. Finally, the investigator selected the content for the test from the following areas of Chemistry namely; Physical and Chemical Changes, Acids and Bases, Elements and compounds, Types of Solutions, Water, Properties of Metals and Corrosion. The weightage given to the content area is shown in Table 3.4.

Table 3.4

<table>
<thead>
<tr>
<th>No.</th>
<th>Topics</th>
<th>Number of items</th>
<th>Marks</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Physical and chemical changes</td>
<td>5</td>
<td>5</td>
<td>12.5</td>
</tr>
<tr>
<td>2</td>
<td>Elements and compounds</td>
<td>5</td>
<td>5</td>
<td>12.5</td>
</tr>
<tr>
<td>3</td>
<td>Properties of metals</td>
<td>6</td>
<td>6</td>
<td>15.0</td>
</tr>
<tr>
<td>4</td>
<td>Solutions</td>
<td>8</td>
<td>8</td>
<td>20.0</td>
</tr>
<tr>
<td>5</td>
<td>Acids and bases</td>
<td>10</td>
<td>10</td>
<td>25.0</td>
</tr>
<tr>
<td>6</td>
<td>Water</td>
<td>2</td>
<td>2</td>
<td>5.0</td>
</tr>
<tr>
<td>7</td>
<td>Corrosion</td>
<td>4</td>
<td>4</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>40</td>
<td>40</td>
<td>100</td>
</tr>
</tbody>
</table>

iii) Preparation of blueprint: The blue print gives the frame work for the tool and indicates the broad limit within which the investigator has to work. Based on the
objectives and the content selected, the investigator prepared the blue print of the tool. Table 3.5 details the blue print.

Table 3.5

*Blue Print for Achievement Test in Chemistry*

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyse</th>
<th>Evaluate</th>
<th>Create</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical and chemical changes</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>12.5</td>
</tr>
<tr>
<td>Elements and compounds</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>12.5</td>
</tr>
<tr>
<td>Properties of metals</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>15.0</td>
</tr>
<tr>
<td>Corrosion</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>10.0</td>
</tr>
<tr>
<td>Solutions</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>20.0</td>
</tr>
<tr>
<td>Acids and bases</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>10</td>
<td>25.0</td>
</tr>
<tr>
<td>Water</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>5.0</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>14</td>
<td>12</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>40</td>
<td>100</td>
</tr>
</tbody>
</table>

2. **Writing of Test Items:** The investigator prepared multiple choice objective test items, based on the selected content of the text book. Each item had four options (A/B/C/D). The test items were intended to measure the components of the test and were constructed in English language. A total of 70 items were prepared for the initial draft. A response sheet was prepared that provided space for students to fill in details such as their name, class, school, date and their response to each item.
The first draft was submitted to a panel of experts comprising, three practicing Chemistry teachers at the secondary level in schools following the curriculum designed by Board of secondary education, Kerala State and three teacher educators, for further suggestions and corrections. Based on the recommendations given by the experts, discussions were held with the supervisor and a second draft of 60 items was prepared.

3. Try out of the final draft of ATC: The second draft was administered on a sample of 30 students of S.H.G.H.S. Ramapuram, Kottayam district in order to ensure the clarity of the wordings and the level of questions. On the basis of this try out, five items that students found difficult to understand were deleted. The final draft of the Achievement Test in Chemistry comprised 55 items. This draft was used for item analysis. The draft form of the test is given in Appendix H.

4. Item Analysis: The investigator carried out a tryout of the final draft of the Achievement Test in Chemistry in order to select test items to be included in the final test based on statistical analysis. It was carried out among 419 students of Standard Eight selected randomly from six schools. These schools also were selected randomly from the secondary schools of Kottayam district, Kerala State. The investigator scored the answer sheets according to the scoring key prepared for the purpose. One score each was assigned to the correct response of each test item. The sum of the scores of the 55 items was taken as the total score for the final draft of the test. After rejecting the incomplete entries 397 answer sheets were available for the item analysis. Further 27 response sheets were rejected randomly in order to bring down the number to 370, to follow the psychometric procedures of analysis.

The investigator arranged the 370 response sheets in the descending order of the total score. The highest 27% and the lowest 27% with respect to the total scores in the test were separated. Thus in the upper group and lower group there were 100 answer sheets. The investigator examined each response sheet in the upper and lower levels. The number of students who answered each item correctly in the upper and lower groups was found out. The discriminating power
and difficulty index of each item were calculated by using the method given by Ebel and Frisbie (1991) and Gronlund (1993).

The difficulty index was calculated by the formula;

\[
D_i = \frac{U + L}{2N}
\]

Where, \( D_i \) = Difficulty index

\( U \) = The number of correct responses for any item in the upper group

\( L \) = The number of correct responses for any item in the lower group

\( 2N \) = Total number of answer sheets in the upper and lower group

The discriminating power of each item indicates the degree to which it discriminates higher and lower achievers, in a given group. It is calculated by using the formula;

\[
D_p = \frac{U - L}{N}
\]

Where, \( D_p \) = Difficulty index

\( U \) = The number of correct responses for any item in the upper group

\( L \) = The number of correct responses for any item in the lower group

\( N \) = Number of answer sheets either in the upper or lower group

Difficulty index and discriminating power of the test items of the tool ‘Achievement test in chemistry’ is given in Appendix I.

5. Preparation of the Final form of the test: Test items having difficulty indices ranging from 0.4 - 0.7 and discriminating power above 0.4 were taken as valid items and the investigator selected such items for the final test. The final test consisted of 40 items. The investigator prepared instructions regarding marks, way of writing answers and duration of the test. The duration of the test was fixed as 45 minutes. This included the time needed for explaining the instructions, clearing doubts if any and answering the test. The scoring key was prepared for the scoring
purpose. The final form of the test, the response sheet and the scoring key are given in Appendix J, K and L respectively.

6. Establishing Validity and Reliability: The investigator evaluated the evidence for the content validity of the test content. This was done at the development stage of the test by submitting copies of the first draft of the test to a panel of experts, to get suggestions and corrections. The panel comprised three practicing teachers who taught Chemistry at the secondary level in schools following the the curriculum designed by Board of Secondary Education, Kerala State, and three teacher educators. They examined the content of the test, relevance of the test items, instructions and scoring procedure and gave valuable suggestions. These suggestions were considered and integrated in the test at its developmental stage.

The investigator calculated the concurrent validity of the Achievement Test in Chemistry by administering the test to 42 students of Standard Eight of St. Thomas H.S.S., Pala and 44 students of St. Mary’s G.H.S.S. Pala and correlating the scores on the test with the marks obtained by the same students in the first terminal examination in Chemistry conducted during the academic year 2011-12. The coefficient of correlation was found to be 0.79

The reliability of the test was calculated by using Test-Retest Reliability method and Split Half Reliability method.

1. Test-Retest Reliability method: The investigator administered the test on Thinking Skills in Chemistry to 42 students of Standard Eight of St. Thomas H.S.S., Pala and 44 students of St. Mary’s G.H.S.S. Pala, to estimate the reliability. The test was administered on the same sample after a period of one month. The investigator calculated the reliability coefficient using Pearsons’ Product Moment Correlation Coefficient (r), by finding out the correlation between the scores obtained by the same person on the two administrations of the test and the Test-Retest Reliability Coefficient calculated was (r) = 0.84. This shows that there exists a high relationship between the test and retest scores on the Achievement Test in Chemistry. The test was thus considered reliable.
2. Split-Half Reliability method: The investigator used the Split-Half reliability method to estimate the internal consistency of Achievement test in Chemistry. For this the tool was split into two equivalent halves. The odd numbered items formed one half and even numbered item formed other half. The correlation coefficient between the scores of the two halves of the test was calculated and the reliability of the whole test was found out by applying Spearman- Brown formula. The correlation coefficient for the score of the two halves was 0.76 and the split-half reliability coefficient of the test was 0.86.

3.6. 4 Raven’s Standard Progressive Matrices (RPM, 1996)

Raven's Progressive Matrices (RPM) is a nonverbal group test of Intelligence used in educational settings. It is one of the most common and popular test administered to groups ranging from 5-year-olds to the elderly. It is made of 60 multiple choice questions, listed in the order of difficulty. This format is designed to measure the test takers’ reasoning ability or, (meaning-making) component of Spearman's ‘g’, which is often referred to as general intelligence. The tests were originally developed by John C. Raven in 1936. In each test item, the subject is asked to identify the missing element that completes a pattern. Many patterns are presented in the form of a 4x4, 3x3, or 2x2 matrices, giving the test its name. The Matrices are available in three different forms for participants of different ability: Standard Progressive Matrices, Coloured Progressive Matrices, and Advanced Progressive Matrices.

**Standard Progressive Matrices:** These were the original form of the matrices, first published in 1938. The booklet comprises five sets (A to E) of 12 items each (e.g., A1 through A12), with items within a set becoming increasingly difficult, requiring ever greater cognitive capacity to encode and analyse information. All items are presented in black ink on a white background. The scale has a retest reliability varying with age from 0.83 to 0.93.

In the present study the investigator administered RPM to the students in the experimental and control groups in the pretest stage after giving the necessary instructions. The students were asked to relax and take their own time to complete
the test. They were assured that the test results would in no way affect their class position. The students were provided separate answer sheets to indicate their choice options. They were asked to fill in the necessary details about them in the space provided in the answer sheet before starting to answer the test. The answer sheets were hand scored with the help of the scoring key given in the manual.

### 3.7.0 Experimentation

The investigator conducted the experimental study to find the effectiveness of the Cognitive Acceleration Approach in improving Thinking Skills in Chemistry, Attitude towards Science Learning and Achievement in Chemistry among the students of Standard Eight. The procedure adopted in conducting the experiment had three phases—Pretest phase, Treatment phase and Posttest phase.

The investigator selected Holy Cross H.S.S. in Kottayam District of Kerala State for the experimentation included in the present Study. There were five divisions of Standard Eight, each comprising 39 students, in the school. The investigator randomly selected two intact divisions namely VIII D and VIII E as the sample of the study. The students in the selected divisions were treated as the two groups included in the study. The test on Thinking Skills in Chemistry, Scale of Attitude towards Science Learning (SATSL) and Achievement test in Chemistry were administered to both groups before starting the treatment. The scores on intelligence of the two groups were collected by administering the Raven’s Progressive Matrices Test (RPM). Then the groups were randomly allotted as the experimental and control groups.

The investigator taught the experimental group using instructional material, comprising fifteen lesson plans, based on Cognitive acceleration Approach. Each lesson required a period of 70 minutes duration. The Control Group was taught the same content using the Activity Oriented Method, by the investigator herself. Equal time and efforts were devoted for the teaching of the control group.

After completion of the treatment the test on Thinking Skills in Chemistry, Scale of Attitude towards Science Learning (SATSL) and Achievement test in
Chemistry were administered to the experimental and control groups. The answer sheets were scored and the scores were subjected to statistical analysis.

### 3.8.0 Statistical Techniques Used

The scores obtained from the students in the experimental and control groups, in the pretests and posttests, were tabulated and analysed using appropriate statistical techniques. The following descriptive and inferential statistical techniques were used by the investigator:

1. Mean, median, mode, standard deviation, skewness and frequency distribution to analyse the distribution of the pretest and posttest scores on the dependent variables
2. Pearson’s Product Moment Coefficient of Correlation $r$, to find out the relationship among the scores on Intelligence and the dependent variables
3. Test of significance of correlation, to find out the significance of the relationship among the scores on the dependent variables and the scores on the covariate
4. Test of significance of difference between the means of two independent groups, to find out the significant difference if any, in the pretest and posttest scores on dependent variables, between the students in the experimental and control groups
5. Test of significance of difference between the means of two correlated groups, to find out the significant difference if any, between the pretest and posttest scores on the dependent variables, of the students in the experimental and control groups
6. ANCOVA (Analysis of Covariance) and one way MANCOVA (Multivariate Analysis of Covariance) to test the genuineness of the effect of the Cognitive Acceleration Approach on the dependent variables when compared with the existing Activity Oriented Method

The investigator used Statistical Package Social Sciences (SPSS) version 20.0 for analysing the data. The results of the analysis are presented in the next chapter.
Conclusion

This chapter has outlined the research method adopted for the study, research design, sampling procedure, development of the tools and instructional material based on Cognitive Acceleration Approach, the experimentation procedure and the statistical techniques used to analyse the data collected in the study. It revealed the various activities used by the investigator for the systematic study of the research problem. The analysis and interpretation of the data along with the description of the testing of the hypotheses are given in the following chapter.