Chapter IV

METHODOLOGY

4.1 Method Adopted
4.2 Variables in the Study
4.3 Sample Selected for the Study
4.4 Tools Used for the Study
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METHODOLOGY

Methodology is the description of tools and techniques adopted in a research study. It occupies a very important position in any kind of research, as the validity and reliability of the findings depend upon the method adopted.

The present study was intended to investigate the effectiveness of Information Processing Models of teaching over the Activity Oriented Method of teaching with respect to achievement in mathematics and the problem solving ability of secondary school students. It was also intended to find its effectiveness upon their interest and attitude towards mathematics. The details of the methodology adopted for the study are presented in the following subheadings.

4.1 Method Adopted

Since the study was intended to find the effectiveness of Information Processing Models in comparison to the Activity Oriented Method, experimental method was found to be the best to conduct the study.

Experimental method is a systematic and logical method of hypothesis testing under carefully controlled conditions. It is the most sophisticated, exacting and powerful method for discovering and developing an organized body of knowledge.
It provides for much control and therefore establishes a systematic and logical association between manipulated factors and observed effects.

4.1.1 Design Selected

In the present study, the pretest –post test non equivalent group design was used. This design is often used in class room experiments when experimental and control groups are such naturally assembled groups as intact classes, which may be similar (Best, 1999). Hence, without disturbing the natural settings of the classrooms, intact class groups, which are normally non-equated, were selected for the study. These non-equivalent class groups were later statistically equated by applying appropriate statistical techniques.

4.2 Variables in the Study

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

4.2.1 Independent Variables:

The variable, which is manipulated by the experimenter or the variable which is suspected of being the cause in the experiment is called independent variable.
In this experiment, the teaching method is the independent variable. The Information Processing Models of teaching and the Activity-Oriented Method of teaching are the two independent variables adopted in the study.

4.2.2 Dependent Variables:

The dependent variable is the condition or characteristic that appears, disappears or changes as the experimenter introduces, removes or changes independent variable. The dependent variables used in this study are Achievement in Mathematics, Problem Solving Ability, Mathematical Interest and Mathematical Attitude.

4.3 Sample Selected for the Study

The population consisted of secondary school pupils of the government and private schools following state syllabus of Kerala. Both aided and unaided schools of private sector were included in the study. The investigator decided to adopt purposive sampling keeping in view the experimental nature of the study and its demands and limitations. Schools from Kottayam and Pathanamthitta districts were selected. Two ninth standard classes each from Government Higher Secondary School, Kudamaloor and Girideepam Bethany Higher Secondary School, Vadavathoor were selected from Kottayam district and two ninth standard classes each from M.G.M H.S Thiruvalla and Balikamadam H.S.S. Tholassery were selected from Pathanamthitta district. Out of the two divisions of standard IX, from each school one was taught through the application of Information
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Processing Models of teaching and the other through the Activity Oriented Method of teaching. The sample selected was purposive but representative of the population.

As per the statement of the problem, the secondary school pupils form the target population for the study. Standard IX, being the middle stage of high school education, is likely to represent the whole features of secondary education. Moreover the pupils of this group come under the formal operational stage according to the classification of Piaget and hence they possess the ability for formal reasoning. Hence the two methods could be experimented meaningfully within the short period available to a set of pupils belonging to that developmental stage.

The sample consisted of 331 students. By removing absentees in pre-test and post-test, the total number of students included in the study was 310, out of which 155 coming under experimental and 155 under control group.

Table 4.1
Sample Split-up for the Study

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Name of the school</th>
<th>Boys/girls</th>
<th>Locale</th>
<th>Type of management</th>
<th>No: of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Govt. H.S.S kudamaloor</td>
<td>Co-edn</td>
<td>Rural</td>
<td>Govt. Aided</td>
<td>74</td>
</tr>
<tr>
<td>2.</td>
<td>Girideepam Bethany E.H.S Vadavathoor</td>
<td>Co-edn</td>
<td>Rural</td>
<td>Private Unaided</td>
<td>88</td>
</tr>
</tbody>
</table>
4.4 Tools Used for the Study

The most important tools developed by the investigator were the lesson transcripts based on Information Processing Models of teaching and the lesson transcripts based on Activity Oriented Method of teaching. Instructional aids to be used as support system were also developed. An achievement test in mathematics and a test of problem solving ability were developed and standardized by the investigator. Mathematics interest inventory prepared by Prasannakumar and mathematics attitude scale prepared by Desai were used to measure the mathematical interest and mathematical attitude respectively.

In addition, class achievement in Mathematics was also collected from school records for comparison with the results arrived from other tools.

4.4.1 Lesson Transcripts

Two major units, Mensuration of Circles and Solids from the text book of standard IX were chosen. The units selected were then subjected to a thorough analysis. The concepts to be highlighted, the principles to be formulated and the processes leading to problem solving were carefully identified. The following curricular objectives were also identified from these topics.

- to frame the concept, perimeter of circles.
- to understand the number obtained by dividing perimeter by diameter is the same for all circles.
Methodology

- to understand perimeter/diameter = \pi.
- to understand the perimeter of a circle of radius \( r \) is \( 2\pi r \).
- to frame the concept, area of circles.
- to understand the area of a circle of radius \( r \) is \( \pi r^2 \).
- to frame the concept, circular ring.
- To frame the concept, arc of circles.
- To understand different types of arcs of circles.
- To frame the concept, central angle of an arc.
- To understand, if the central angle of an arc of a circle of radius \( r \) is \( x^\circ \), then the length of the arc is \( (x/180) \pi r \).
- To frame the concept, sector.
- To understand, if the central angle of the sector of a circle of radius \( r \) is \( x^\circ \), then its area is \( (x/360) \pi r^2 \).
- To understand the drawing of pie charts.
- To understand the volume of a prism is the product of its base area and height.
- To understand the lateral surface area of a prism is the product of its base perimeter and height.
- To understand the surface area of a prism is the sum of the areas of all its faces.
- To frame the concept of cylinder.
- To understand the volume of the cylinder is the product of its base area and height.
• To understand the curved surface area of the cylinder is the product of its base perimeter and height.

• To understand the surface area of a cylinder of base radius \( r \) and height \( h \) is \( 2 \pi r (r + h) \).

Lesson transcripts were prepared based on Information Processing Models of teaching (Concept Attainment Model, Advance Organizer Model and Inductive Thinking Model were used according to situations and relevance). Support systems to be used in each class were also developed by the investigator.

**4.4.1.1 Lesson Transcripts Based on Concept Attainment Model**

In developing these transcripts the theoretical constructs presented by Marsha Wail and Bruce Joyce and the detailed plan of sample transcripts presented by the same authors were taken as the guideline.

From the topics selected for teaching the investigator has located the concepts which could be taught effectively using the Reception Oriented Concept Attainment Model.

**Syntax of Concept Attainment Model**

Syntax of the Model describes the main steps of teaching through the model. There are three phases in the reception model of concept attainment. The activities in each phase are as follows.

**Phase I: Presentation of Data and Identification of Concept**

• Teacher presents labeled examples.
• Students compare attributes in positive and negative examples.
• Students generate and test hypotheses.
• Students state a definition according to the essential attributes.

**Phase II: Testing Attainment of the Concept**
• Students identify additional unlabeled examples as ‘Yes’ or ‘No’.
• Teacher confirms hypotheses, names concept and restates definitions according to essential attributes.
• Students generate additional examples.

**Phase III: Analysis of Thinking Strategies**
• Students describe thoughts.
• Students discuss role of hypotheses and attributes.
• Students discuss type and number of hypotheses.

### 4.4.1.2 Lesson Transcripts Based on Advance Organiser Model

The meaningful relationships among concepts from the selected units were decided to be taught through the use of advance organiser model.

The lesson transcripts have been written following the syntax as given below.

**Phase I: Presentation of Advance Organiser**

Clarify aims of the lesson.

• Present organiser:
  1. Identify defining attributes
2. Give examples
3. Provide multi-context
4. Repeat terminology of subsumer
   - Prompt awareness of relevant knowledge and experience from learners’ background.

**Phase II: Presentation of Learning Task.**
- Present material
- Maintain attention
- Make organisation explicit
- Make logical order of learning material explicit to students.

**Phase III: Strengthening Cognitive Organisation**
- Use principles of integrative reconciliation
- Promote active reception learning
- Elicit critical approach to subject matter
- Clarify

### 4.4.1.3 Lesson Transcripts Based on Inductive Thinking Model

From the selected topics of Standard IX, the principles which could be taught through the application of inductive thinking model were chosen after a very careful pedagogic analysis.

Lesson transcripts were prepared according to Inductive Thinking Model, the theoretical basement presented by Joyce and Weil (1997) was taken as the guideline. Accordingly the syntax of each transcript contains the following phases.
**Methodology**

**Strategy 1: Concept Formation**

Phase I : Enumeration and listing

Phase II : Grouping

Phase III : Labeling and categorising

**Strategy 2: Interpretation of Data**

Phase IV : Identifying critical relationships.

Phase V : Exploring relationships

Phase VI : Making inferences

**Strategy 3: Application of Principles**

Phase VII : Predicting consequences, explaining unfamiliar phenomena

Phase VIII: Explaining or supporting the predictions

Phase IX : Verifying the prediction

**4.4.1.4 Lesson Transcripts Based on Activity Oriented Method**

Lesson transcripts were prepared based on the Activity Oriented Method existing in the schools of Kerala state. Instructional aids were used and activities were also given in the class to make the classes effective.

**4.4.2 Achievement Test in Mathematics**

The investigator developed and standardized an achievement test in mathematics for standard IX. In the present study, the achievement test was constructed to
• evaluate the instructional strategies adopted

• assess entry behavior and criterion behavior by treating achievement test as pre-test and post-test respectively.

In the preparation and standardization of the achievement test, the following sequence was adopted.

1. **Choosing the Course Content**

Two major topics, Mensuration of Circles and Prisms from the Mathematics curriculum of standard IX were selected. They were divided into five teaching units as given below.

Unit 1: Perimeter and Area of Circles

Unit 2: Arcs and their Lengths.

Unit 3: Sectors and their Areas.

Unit 4: Prisms - Volume and Surface Area

Unit 5: Cylinders

2. **Deciding the Teaching Objectives**

This test was constructed keeping in view the objectives, knowledge, comprehension application, analysis, synthesis and evaluation in the cognitive domain. (Bloom, 1968). While preparing questions, the following mental processes were also given due consideration.

MP\(_1\) retrieves/recollects information.

MP\(_2\) readily makes connections to new information based on past experiences and formulates initial ideas or concepts.
MP_3 detects similarities and differences.

MP_4 classifies/categories/organizes information appropriately.

MP_5 translates/transfers knowledge or understanding and applies them in new situations.

MP_6 establishes cause-effect relationships.

MP_7 makes connections/relates prior knowledge to new information/applies reasoning and draw inferences.

MP_8 designs/predicts based on received information.

MP_9 judges/appraises/evaluates the merits or demerits of an idea/develops own solutions to a problem.

Preparation of Test Items for Draft Test

Objective type test items are more economical, time saving and tend to possess higher score of reliability and content validity. Keeping this in view, the investigator selected objective type test items only. Since the test preparation demanded vast experiences in the field, the help of experts and experienced teachers was sought. With their support and help the investigator was able to prepare multiple-choice items in the subject area. The items were arranged according to their increasing order of difficulty. A question paper consisting of 45 multiple-choice items was prepared with necessary directions on the first page. A copy of the draft test is provided as Appendix 2. The answer sheet and the scoring key of the draft test are provided as Appendix 3 and Appendix 4 respectively.
Try Out of the Draft Test

The try out of the draft test for item analysis was conducted on a sample of 406 pupils of standard IX selected by stratified random sampling technique. Previous arrangements were made with the authorities for a proper conduct of the test, under satisfactory examination conditions. Test was conducted in all the institutions under identical conditions, especially regarding the instructions given to the examinees. Enough time was given so as to enable all the students to complete the test. The scoring was done according to the scoring key prepared for this purpose. Sample split up for the try out is given in table 4.2
Table 4.2

Sample Split-up for the Try Out

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Name of the school</th>
<th>Boys/girls</th>
<th>Locale</th>
<th>Type of Management</th>
<th>No: of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CMS H.S. Olassa</td>
<td>Co-edn</td>
<td>Rural</td>
<td>Private Aided</td>
<td>48</td>
</tr>
<tr>
<td>2.</td>
<td>Infant Jesus H.S Manarcad</td>
<td>Girls</td>
<td>Rural</td>
<td>Private Unaided</td>
<td>42</td>
</tr>
<tr>
<td>5.</td>
<td>M.C.V.H.S.S Arpookara</td>
<td>Co-edn</td>
<td>Rural</td>
<td>Govt. Aided</td>
<td>42</td>
</tr>
<tr>
<td>7.</td>
<td>Don Bosco H.S.S Puthuppally</td>
<td>Co-edn</td>
<td>Rural</td>
<td>Private Unaided</td>
<td>42</td>
</tr>
</tbody>
</table>

Item Analysis

It is the process of establishing the suitability of an item for inclusion in the final test. The quality of each item was ascertained by analyzing two important characteristics of the item, namely 1) Difficulty Index and 2) Discriminating Power.
From the obtained answer sheets, 370 scripts, complete in all respects were finally selected for analysis. Based on the scores obtained, response sheets of the students were arranged in descending order from highest to the lowest. The responses of the top scoring 27 percent and the bottom scoring 27 percent were used for item analysis. For the present study the procedure and formula suggested by Ebel and Frisbie (1991) were used to calculate the difficulty index and discriminating power.

Index of item difficulty  \[ Di = \frac{U + L}{2N} \]

Index of discriminating power \[ Dp = \frac{U - L}{N} \]

where,

\[ U = \text{Number of correct responses in the upper group} \]
\[ L = \text{Number of correct responses in the lower group} \]
\[ N = \text{Number of pupils in each group} \]

Generally items having difficulty index between 0.4 and 0.6 and discriminating power above 0.4 are considered to be ideal. In the present study, items having difficulty index between 0.35 and 0.65 and discriminating power above 0.3 are also considered in order to have sufficient number of test items in the final form of the test. The details regarding the difficulty index and discriminating power are given as appendix 5.
**Preparation of the Final Test**

The final test was prepared based on a blue print by giving due weightage to content, objectives and difficulty level.

**Weightage to Content**

**Table 4.3**

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Unit</th>
<th>Marks</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Perimeter and area of circles</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Arcs and their lengths</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Sectors and their areas</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>Prisms-volume and surface area</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>5</td>
<td>Cylinders</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td><strong>25</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
**Weightage to Instructional Objectives**

*Table: 4.4*

**Weightage to Instructional Objectives**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Objectives</th>
<th>Marks</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knowledge</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Comprehension</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Application</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>Analysis</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>Synthesis</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>Evaluation</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>25</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Weightage to Difficulty Level**

*Table 4.5*

**Weightage to Difficulty Level**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Difficulty Level</th>
<th>Marks</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Easy</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>2.</td>
<td>Average</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>3.</td>
<td>Difficult</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>25</strong></td>
<td><strong>100</strong></td>
</tr>
<tr>
<td>Content</td>
<td>Knowledge</td>
<td>Comprehension</td>
<td>Application</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-----------</td>
<td>---------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Perimeter and area of circles</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(2)</td>
<td>(2)</td>
<td>(1)</td>
</tr>
<tr>
<td>Arcs and their lengths</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>Sectors and their areas</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>Prisms-Volume and Surface area</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Cylinders</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(1)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>5</strong></td>
<td><strong>5</strong></td>
<td><strong>4</strong></td>
</tr>
</tbody>
</table>
**Weightage to Type of Questions**

The investigator selected objective type test items only, as they provide scope for greater sampling of content and more objective scoring. 25 multiple choice test items were included.

The final test consisted of 25 objective type test items carrying one mark each. The time duration of the test was decided to be 30 minutes. The copy of achievement test in the final form is given in appendix 6. The answer sheet and the scoring key of the final form of the test are given in appendix 7 and appendix 8 respectively.

**Reliability and Validity of the Achievement Test**

The reliability and validity of the achievement test was assessed before it was used in the final data collection.

The reliability of the test was established by using split-half method. A sample of 100 pupils studying in standard IX was used for this purpose. Here, the odd numbered items were treated as one half of the test and scored separately and all the even numbered items were treated as another half and scored for each examinee. The scores of the halves were correlated and the reliability of the test was found to be 0.8124.

Making questions based upon pre-determined specific behaviors, ensuring that the expected answers are definite and objective, providing clearly spelt-out scheme for scoring and conducting test under identical and ideal examinations conditions helped in enhancing reliability of the test.
Content Validity

Before the construction of the test, a thorough analysis of the curriculum objectives was done with the help of standard textbooks. The test was constructed keeping in view the weightage given for content area with instructional objectives on one hand and experts’ comments and opinions on the other. So it can be treated as a valid test.

Empirical or Statistical Validity

The empirical validity of the test was calculated by correlating the scores of the test with marks of a recently conducted test obtained from the school. The co-efficient of correlation obtained was 0.7823. This value ensures the empirical validity of the test.

In the prepared achievement test, objectivity was ensured by including only objective type items and by using scoring key for valuation. The test was easy to administer as it was in the booklet form. It was economical, as it was reusable, since the answer sheets were provided separately. Time needed for scoring was minimum as the window stencil method was adopted. Hence, the test had good practicality.

4.4.3 Test of Problem Solving Ability

Problem solving is the main goal of teaching mathematics. All successful engineers, scientists, social scientists, lawyers, accountants, business managers, ministers, and so on, have to be good problem solvers too. Although the problem that people encounter
maybe very diverse, there are common elements and an underlying structure that can help to facilitate problem solving. The National Council of Teachers of Mathematics’ 1989 Curriculum and Evaluation Standards for School Mathematics called for increased attention to the teaching of problem solving in mathematics. Areas of emphasis include word problems, applications, patterns and relationships, open-ended problems and problem situations, represented verbally, numerically, graphically, geometrically or symbolically.

To solve an exercise, one applies a routine procedure to arrive at an answer. But to solve a problem, one has to pause, reflect and perhaps take some original step never taken before to arrive at a solution. This requires some sort of creative step on the solver’s part. Correct answers are not a safe indicator of good thinking. Teachers must examine more than answers and must demand from students more than answers (Sowder, Threadgill-Sowder, Moyer & Moyer, 1983).

A large body of mathematical problem solving has been based on the work of a famous mathematician, George Polya.

George Polya, the father of modern problem solving devoted much of his teaching to helping students to become better problem solvers. His major contribution is what has become known as “Polya’s four step process” for problem solving.
**Step 1: Understand the Problem**

- Do you understand all the words?
- Can you restate the problem in your own words?
- Do you know what is given?
- Do you know what the goal is?
- Is there enough information?
- Is this problem similar to another problem you have solved?

**Step 2: Devise a Plan**

Can one of the following strategies/heuristics be used in solving the problem?

- Guess and Test
- Use a Variable
- Draw a Picture
- Look for a Pattern
- Make a List
- Solve a Simpler Problem
- Draw a Diagram
- Use Direct Reasoning
- Use Properties of Numbers
- Work Backward
- Solve an Equation
- Look for a Formula
Step 3: Carry Out the Plan

This is to implement the strategy or strategies that you have chosen until the problem is solved.

Step 4: Look Back

This is to check whether the solution is correct, whether the answer satisfy the statement of the problem.

Usually a problem is stated in words, either orally or written. Then to solve the problem, one translates the words into an equivalent problem using mathematical symbols, solves this equivalent problem and then interprets the answer. This process is summarized in figure 4.1

![Figure 4.1 Process of Problem Solving](image)

Problem solving is as much an art as it is a science. Selecting an appropriate strategy is critical in problem solving. Learning to utilize Polya’s four steps and the diagram in figure 4.1 are first steps in becoming a good problem solver. In particular, Devise a Plan step is
very important. The different strategies found more appropriate for pupils at the secondary level are explained below.

**Strategy 1: Guess and Test**

To use the Guess and Test strategy you guess at a solution and test whether you are correct. If you are incorrect, you refine your guess and test again. This process is repeated until you obtain a solution. It can be a random guess or a systematic or inferential guess, which explore the consequences. In a systematic guess, you develop a scheme to ensure that you have tested all possibilities. Inferential guess simplifies the solution process by looking for unique aspects of the problem. This strategy is approximate when there are a limited number of possible answers to test and also when there is no obvious strategy to try.

**Strategy 2: Use a Variable**

This strategy, one of the most useful problem solving strategies is used extensively in algebra and in mathematics that involves algebra. Letters used here in place of numbers are called variables or unknowns.

**Strategy 3: Draw a Picture**

Often problems involve physical situations. In these situations, drawing a picture can help you better understand the problem so that you can formulate a plan to solve the problem. Training children in the process of using pictures to solve problems
results in more improved problem-solving performance than training students in any other strategy (Yancey, Thomson & Yancey, 1989).

The Draw a Picture strategy may be appropriate when a physical situation is involved and the visual representation of the problem is possible.

**Strategy 4: Look for a Pattern**

When using the ‘Look for a Pattern’ strategy one usually lists several specific instances of a problem and then looks to see whether a pattern emerges that suggests a solution to the entire problem. Inductive reasoning is used to draw conclusion or make predictions about a large collection of objects or numbers based on a small representative sub collection. It is appropriate when you have to make prediction or generalization and when information can be expressed and viewed in an organized manner.

**Strategy 5: Make a List**

The Make a List strategy is often combined with the Look for a Pattern strategy to suggest a solution to a problem. It is appropriate when the information can easily be organized and presented.

**Strategy 6: Solve a Simpler Problem**

This strategy is useful when problem involves complicated computations and direct solution of it is too complex. This strategy combined with the strategies, Make a List and Look for a Pattern is very useful.
Strategy 7: Draw a Diagram

Often there are problems where, although it is not necessary to draw an actual picture to represent the problem situation, a diagram that represents the essence of the problem is useful.

Strategy 8: Use Direct Reasoning

The Use Direct Reasoning strategy is used virtually all the time in conjunction, with other strategies when solving problems. Direct reasoning is used to reach a valid conclusion from a series of statements. Often statements involving direct reasoning are of the form “if A then B”. Once this statement is shown to be true, statement B will hold whenever statement A does.

Strategy 9: Use Properties of Numbers

The Use Properties of Numbers strategy is appropriate when special type of numbers such as odds, evens, primes, and so on are involved or when the problems can be solved by using certain properties.

Strategy 10: Work Backward

The Work Backward strategy is appropriate when a problem proceeds from being complex initially to being simple at the end or when a problem involves a sequence of reversible actions.

Strategy 11: Solve an Equation

The Solve an Equation strategy may be appropriate when the stated conditions can easily be represented with an equation.
Vygotsky (1978) referred “Zone of Proximal Development as the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers”. This theory influenced the assessment procedure that targeted student’s cognitive characteristics.

Haywood (1992) describes a program designed to stimulate the acquisition of cognitive processes so that students’ perception, learning, thinking and problem solving are enhanced across a wide range of cognitive activities. It is based on a series of fifteen instruments of increasing complexity each designed to develop thinking process using pencil and pen exercises.

**Preparation of the Test of Problem Solving**

The test of problem solving ability demands good reasoning power on the part of students for the effective solution of it. As far as the present study is concerned, development of reasoning power is actually the nurturant effect of models of teaching. The nurturant effects come from experiencing the environment created by the model. The main outcome of using a model of teaching is that students learn how to reason in a certain fashion.

When the students experience the environment created by the IPM, they acquire certain nurturant effects like precise thinking, logical reasoning, inductive reasoning, sensitivity to language, interest
in inquiry etc which could be reflected through their ability in problem solving. So the investigator prepared and standardized a test of problem solving ability which demanded logical thinking and reasoning from the part of the students. Hence the test of problem solving ability becomes one of testing the nurturant effect of the models of teaching.

For the construction of the test a number of criteria for the possession of scientific problem solving ability in a person has been identified first. For the purpose the sources utilized were the following.

1. Standard Literature in the subject.
2. Psychological tests which measure variables similar to those under investigation and
3. Experts in the field of education, mathematics and psychology.

Items collected were then edited. The draft form of the test contains fifty objective type test items which come under different categories as described below.

1. **Logical Diagrams**

   It deals with questions which aim at analyzing the student’s ability to relate certain given group of items and illustrate it diagrammatically. Each circle in this category represents an item and the size of the circle has nothing to do with the item. The candidate has to pick up the figure that represents the relation among three
items. Item numbers 10, 11 and 44 of the draft form of the test are from this category and can be solved using the strategy, Direct Reasoning.

2. **Spotting out the Dissimilar**

Five items are given, out of which four are almost the same in nature but the remaining one is different from the other four. The candidate has to find out which one is different from the rest. Question number 12 and 13 of the draft form come under this category. The strategy, Look for a Pattern can be used here.

3. **Mirror Images**

A mirror image means the image of an object as seen in a mirror. In the mirror image of an object, the right side appears on the left side and vice-versa. A mirror image is said to be laterally inverted. Item numbers 14 and 15 of the draft form of the test are of this type. The investigator noticed the pupils using the strategy, Draw a Picture, to solve this problem.

4. **Analogy Test**

Analogy means correspondence. A particular relationship is given and another similar relationship has to be identified from the alternatives provided. Question number 16, 17, 18 and 19 come under analogy type which could be solved using the strategy, Look for a Pattern.
5. **Numerical Aptitude Test**

In this part of reasoning, the ability to reason with numbers, diagrams with numbers and to deal with quantitative materials and ideas using common sense as well as quick calculation techniques are tested. The candidate has to analyze the problems within the given data or framework and arrive at conclusion by logical reasoning. Strategies like Work Backward, Use Property of Numbers, Use a Variable, Solve an Equation, Guess and Test and Solve a Simpler Problem are also used. Question numbers 20, 21, 22, 23, 49 and 50 of the draft form of the test are of this type.

6. **Time Sequence Test**

It is meant to test candidate’s ability to use the correct sequence of days of the week, calendar, month, time, etc. item numbers 32, 33, 34 and 35 of the draft form of the test are of this type.

7. **Direction Sense Test**

In this type of tests, the candidates should have knowledge of the direction of the analogy of map reading. He has to keep in mind the directions given in the question, the right-hand or left-hand turnings and the distance covered. They use their sense about the direction and answer the given questions correctly. Item numbers 36, 37, 38, 39 and 40 and 47 of the draft form of the test are of this type. The strategy, Draw a Diagram can be used to solve these problems.
8. **Analytical Reasoning Test**

Some confusing information is given and the candidate is required to analyze it and answer the questions. Analysis of complex figures is also included in analytical reasoning test. Question numbers 24, 25, 27, 28 and 31 of the draft form of the test are of this type.

9. **Series Completion Test**

Here the candidates are required to observe that specific order in which the number or alphabet would suit for the blank space if they continue to change in the same order. In the given test, item numbers 1, 2, 3, 4, 5, 6, 7, 8 and 9 are under this category. The problem solving strategies like Look for a Pattern, Make a List, Guess and Test or these strategies in combination can be used to complete the series.

10. **Family Relations**

This is to recognize relationships and the multiple roles of each person (example: grandmother, mother, sister). Question number 29, 30, and 46 of the draft form of the test are of this type. The strategy, Solve a Simpler Problem can be used here.

11. **Comparison Type**

This involves comparison of the objects or dimensions such as size, form, number, spatial components, temporal components as well as abstract components not immediately perceived. Item numbers 26.
43 and 48 come under comparison type. The strategy, Draw a Diagram can be used for the effective solution of this type of items.

12. Ranking

Generally the ranks of a person both from top and from the bottom are mentioned and the total number of persons is asked. Sometimes the question is put in the form of a puzzle of interchanging sets by two persons. Item numbers 41, and 42 of the draft form of the test come under comparison type. Strategies like Draw a Diagram and Solve a Simpler Problem can be used for the effective solution of this type of item.

Try out of the Draft test

The try out of the draft test for item analysis was conducted on a sample of 406 pupils of standard IX selected by stratified random sampling technique. Previous arrangements were made with the authorities for a proper conduct of the test, under satisfactory examination conditions. Test was conducted in all the institutions under identical conditions, especially regarding the instructions given to the examinees. Enough time was given so as to enable all the students to complete the test. The test of problem solving ability in its draft form is given in Appendix 9. Sample answer sheet and key of the draft form of the test are given in Appendix 10 and Appendix 11 respectively. The scoring was done according to the scoring key prepared for this purpose. Sample split up for the try out is given in table 4.2.
Item Analysis

It is the process of establishing the suitability of an item for inclusion in the final test. The quality of each item was ascertained by analyzing two important characteristics of the item, namely 1) Difficulty Index and 2) Discriminating Power.

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

Index of item difficulty \[ D_i = \frac{U + L}{2N} \]

Index of discriminating power \[ D_p = \frac{U - L}{N} \]

where,

\[ U = \text{Number of correct responses in the upper group} \]
\[ L = \text{Number of correct responses in the lower group} \]
\[ N = \text{Number of pupils in each group} \]

Generally items having difficulty index between 0.4 and 0.6 and discriminating power above 0.4 are considered to be ideal. In the present study, items having difficulty index between 0.35 and 0.65 and discriminating power above 0.3 are also considered in order to have sufficient number of test items in the final form of the test. The
details regarding the difficulty index and discriminating power are
given as appendix 12

**Preparation of the Final Test**

The investigator finally selected 25 items from the draft test and arranged them in the form of a booklet. Necessary information and other details were added to get a final form of the test. Separate score sheets were also printed. Sample of the final form of the test is given as Appendix 13. The answer sheet and key are given in Appendix 14 and Appendix 15 respectively

**Reliability of the Test**

In this study, the split half method was used for determining the reliability of the test. The test was conducted once and the test scores were divided into two halves, one for even numbers and the other for odd number of items, the obtained correlation was 0.8978.

**Validity of the Test**

A test is valid if it measures what it is supposed to be measured. Content validity refers to the adequacy with which the test items represent the conceptual domains of interest. It examines whether the test includes all of the important aspects of the target that we wish to measure and whether the various aspects are properly weighed. Experts evaluated the relevance of each test item. Items were collected from each area of problem solving. Hence test is having content validity.
Methodology

The empirical validity of the test was calculated by correlating the scores of the test with the marks obtained by the same student in the terminal examination conducted during the same period. The coefficient of correlation between the two tests was calculated as 0.7819. This shows that the test is valid.

According to the cognitive development stages explained by Piaget, the child’s reasoning process becomes logical during concrete operational period. The items contained in the test come under sections like analogies, time and speed, seriation etc, and these are the processes which were explained by Piaget. Thus the test is having a good theoretical base.

Based on the obtained values of reliability coefficient and coefficient of correlation related to criterion validity, the test is valid and reliable and hence it is having test accuracy.

The objectivity of the test was ensured by including only objective type items. All steps were taken to ensure the practicability of the test. The prepared test was easy to administer as it was in a booklet form. It was economical as it was reusable. The answer sheets were provided separately. Time needed for scoring was minimum as the window stencil method was adopted.

4.4.4 Measuring Attitude towards Mathematics

Attitudes are the pre-disposition to react specially toward an object, situation or value, usually accompanied by feeling and emotion. Attitudes cannot be directly observed but must be inferred
Methodology

from overt behavior. An individual’s attitude towards mathematics is an organization of motives around his responses to the subject Mathematics, its theories, applications and uses. Attitudes show an evaluation of personal reaction.

The investigator used the attitude scale for Mathematics prepared by H.G. Desai of Department of Education, Saurashtra University, Rajkot for measuring the Attitudes towards Mathematics of students in the sample.

1. Description of Attitude Scale.

The attitude scale contains 20 items. Each item is in the form of statements of which 9 items are positive statements and 11 are negative statements. The statements are arranged on 3-point scale with the responses “agree”, “disagree” and “no-opinion”. The student has to put a tick (√) against each item in the respective column. Weight 3,2,1, are assigned to Agree, Disagree and No opinion respectively for positive items and weights are reversed for negative items.

2. Reliability and Validity

To establish the reliability of the test split half method and test-retest method were used. The reliability co-efficient for split-half method and test-retest method was found to be 0.86 and 0.74 respectively. To establish the validity of the test the test scores are validated against teacher’s ratings. The co-efficient of co-relation of
the two was found the 0.66. A sample of the Attitude scale for Mathematics is given in appendix. 16.

4.5.5. Measurement of Interest in Mathematics

Interest in mathematics of an individual can be measured by measuring the interest of the individual in doing problems, studying mathematical theorems and identifying figures and shapes and in activities in which principles of mathematics are involved. The investigator used the interest inventory prepared by Mr. Prasannakumar, Department of Education, University of Kerala to measure the interest in mathematics of students in the sample.

Description of the Interest Inventory

The present mathematics inventory consists of 40 items. Each item contains three different statements. Each item is an appeal to the student to choose one alternative from the three alternatives given, supposing that equal facilities are provided to three alternatives in each item. Naturally one of the three choices is related to mathematics and that particular choice scores a point one in each of these 40 items. The rest of the two alternatives are given no points. The maximum score is 40 points.

Reliability and Validity

The reliability of the mathematics interest inventory was found by split half method. The reliability coefficient of the test was found to be 0.816. The teachers were requested to rate the pupils according to their mathematics interest on a five-point scale. Then using the rating
and scores obtained by using interest inventory were correlated and it was found to be 0.49. A sample of the inventory is given in Appendix 17.

4.5 Procedure Adopted in Experimentation

The experiment was conducted to study the effectiveness of Information Processing Models in teaching Mathematics at secondary level.

After finalizing the sample and tools to be used, the investigator approached the authorities of the schools and sought their permission for conducting the study. The investigator met the heads of the schools and class teachers and had discussions with them and their co-operation ensured.

Before starting the experiment, the investigator administered the achievement test, test of problem solving ability, mathematics interest inventory and mathematics attitude scale as pretests in both the experimental and control groups. A short explanation of the aim and scope of the study was given to the students and their co-operation ensured. The rules and procedure prescribed for each type of test were strictly followed. The answer sheets were collected back after the allotted time and were scored.

Then the investigator herself conducted classes based on Information Processing Models in the experimental group and classes based on Activity Oriented Method in the control group. 22 lesson transcripts were prepared and used. Each lesson transcript was
taught in period of 40 minutes duration. The same topics were taught in both the groups.

After the completion of classes, all the four tests were administered again as posttests to both the groups. The scores were then analyzed statistically.

**Statistical Techniques Used for Analysis**

The pretest and posttest scores of the experimental group and control group were consolidated for statistical analysis. The mean and standard deviation of the scores for each pretest were found out and ensured the equivalence of the two groups by adopting critical ratio test. A preliminary analysis was done using the method of critical ratio and test of significance to compare the performance of experimental and control groups.

The experiments were done using intact, previously non equated class room groups. Analysis of covariance is a method that enables the researcher to equate the pre-experimental status of the groups in terms of relevant known variables. Difference in the initial status of the group can be removed statistically so that they can be compared as though their initial status had been equated.(Best,1996). Thus in the present study the technique of ANCOVA was adopted for sharper experimental comparison of performance between experimental and control groups. The details of analysis of data using relevant statistical methods have been compiled in the next chapter.