CHAPTER 4

METHODOLOGY

4.1 Research Methods Adopted
4.2 Variables of the Study
4.3 Sample Selected
4.4 Research Design of the Experiment
4.5 Tools Used
4.6 Procedure for Collection of Data
4.7 Statistical Techniques Employed
Introduction

Methodology of an investigation is the core of every research work and the success of all research studies depends on the methodology adopted and the tools employed. Methodology lays down the way that formal research is to be carried out and outlines the detailed description of the research variables and procedures to be used. According to Kothari (1996), Research Methodology is a way to systematically solve the research problem. A pre-planned and well-designed methodology provides the researcher with a scientific and feasible plan for solving the problems under study. According to Good, Barr and Scates (1954), “The vehicle of research cannot perform its function without methodology, since it is methodology which lays down the way in which formal research is to be carried out and outlines the detailed description of research variables and procedures”.

The present study intended to test the efficacy of a Multimedia Instructional Package on Solid Geometry at Secondary School Level. The methodology adopted for the study is detailed below under seven sub headings, viz.

4.1 Research Methods Adopted
4.2 Variables of the Study
4.3 Sample Selected
4.4 Research Design of the Experiment
4.5 Tools Used
4.6 Procedure for Collection of Data
4.7 Statistical Techniques Employed

The details follow.

4.1 Research Methods Adopted

According to Best and Kahn (2000), “Research Method refers to the behaviour and instruments used in the selection and construction of research
techniques”. Different methods and procedures were employed to aid in the acquisition of data.

Survey and Experimental methods were used for collecting relevant data for the present study. “Survey studies are conducted to collect detailed description of existing phenomena with the intent of employing data to justify current conditions and practices or to make more intelligent plans for improving them” (Koul, 1997). In the present study, the survey method was adopted to explore the difficulties experienced by Teachers in Teaching Solid Geometry at Secondary School level.

Experimental studies follow systematic and logical methods of hypothesis testing under carefully controlled conditions. They are the most sophisticated, exact and powerful methods for discovering and developing an organized body of knowledge. The study intended to prepare a Multimedia Instructional Package for enhancing learning of Solid Geometry among Students at secondary school level. The experimental method was used to test the effectiveness of this Multimedia Instructional Package on learning of Solid Geometry, viz. Conceptual Clarity, Problem Solving Ability and Achievement in Solid Geometry; as well as Retention in Solid Geometry.

4.2 Variables of the Study

Variables are the conditions or characteristics that the experimenter manipulates, controls or observes (Best and Kahn, 2000). Dependent, independent and extraneous variables play a vital role in the present study.

Independent Variables

Independent variables are the conditions or characteristics that the experimenter manipulates or controls in his or her attempt to ascertain their relationship to the observed phenomena (Best and Kahn, 2000).
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In this experimental study, the independent variables were

- the Multimedia Instructional Package on Solid Geometry
  and
- the Activity Oriented Method of Instruction on Solid Geometry.

**Dependent Variables**

Dependent Variables are the conditions or characteristics that appear, disappear or change as the experimenter introduces, removes or changes the independent variable (Best and Kahn, 2004).

The dependent variables used in the study are

- Conceptual Clarity in Solid Geometry,
- Problem Solving Ability in Solid Geometry,
- Achievement in Solid Geometry
  and
- Retention in Solid Geometry.

**Extraneous Variables**

Extraneous variables are independent variables that are not related to the purpose of study, but may affect the dependent variables. They control the relationship between the independent and dependent variables either in the research design or through statistical procedures. Extraneous Variables are the variables which operate in the experimental situation, in addition to the independent variables, such that it is difficult to determine the effects of each (Gay, 1996).

Here, the only extraneous variable considered for the experiment was

- Gender

Attempts were made to control the extraneous variable by approximating the number of students within the gender groups.
4.3 Sample Selected

Sampling is the process by which a relatively small number of individual objects or events are selected and analysed in order to find out something about the entire population from which it is selected. Sampling procedures provide generalisations on the basis of a relatively small proportion of population (Koul, 1997).

In this study, different samples were selected for the survey as well as for the experiment. The details of the sample selected follow.

A. Sample for the Survey

The population of the survey part of the present study consisted of Teachers of Mathematics from Secondary Schools of Kerala following the State Syllabus. Random Sampling Technique was adopted for the study and the survey was confined to a sample of 225 Teachers of Mathematics at Secondary School level from four districts of Kerala. The details of sample selected for the survey are given in Table 4.1.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>District</th>
<th>No. of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kottayam</td>
<td>69</td>
</tr>
<tr>
<td>2</td>
<td>Ernakulum</td>
<td>57</td>
</tr>
<tr>
<td>3</td>
<td>Idukki</td>
<td>36</td>
</tr>
<tr>
<td>4</td>
<td>Alappuzha</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>225</td>
</tr>
</tbody>
</table>

B. Sample for the Experiment

The population of the experimental part of the study consisted of Students studying in the Secondary Schools of Kerala following the State Syllabus. The investigator decided to adopt the Purposive Sampling
Methodology

**Technique**, keeping in view, the experimental nature of the study and its demands and limitations. The selection of the *sample* for the experiment involved Selection of Standard and Selection of Groups, the details of which follow.

**Selection of Standard:** Solid Geometry is introduced at the Secondary School level from Standard VIII onwards. Since Students of Standard VIII do not have adequate capability to logically solve different types of problems and since it was not practicable to get Students of Standard X for an experimental study, Students of Standard IX were selected for the conduct of the study.

**Selection of Groups:** The Experiment was conducted on two divisions each of two Schools of Alappuzha Educational District, giving due weightage to the Gender factor. The total sample comprised of 180 Students, with 90 each in the Experimental and Control Groups. The break-up of the sample is given in Figure 4.1.
Figure 4.1
Break-up of Sample for Experiment
4.4 Research Design of the Experiment

Research Design refers to the plan and structure of the investigation used to obtain evidence to answer research questions. The design describes the procedures for conducting the study, including when, from where, and under what conditions the data will be obtained. In other words, design indicates how the research is set up, what happens to the subjects, and what methods of data collection are used (Mac Millian & Schumacher, 1989).

The design adopted for the experimental part of the present study was the Pre-test Post-test Non Equivalent Groups Design. “This design is often used in classroom experiments when experimental and control groups are naturally assembled groups as intact classes, which may be similar” (Best, 2000). Hence, without disturbing the natural settings of the classroom, non-equated intact class groups were selected for the study.

The research design adopted for the experimental study is presented in Figure 4.2.
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Figure 4.2
Research Design of the Experiment

Students of Standard IX

Pre-tests
- Test on Conceptual Clarity in Solid Geometry
- Test on Problem Solving Ability in Solid Geometry
- Test on Achievement in Solid Geometry

Experimental Group
Multimedia Instructional Package on Solid Geometry

Control Group
Activity Oriented Method of Instruction on Solid Geometry

Post-tests
- Test on Conceptual Clarity in Solid Geometry
- Test on Problem Solving Ability in Solid Geometry
- Test on Achievement in Solid Geometry

- Test on Retention in Solid Geometry
4.5 Tools Used

A tool is one of the most important devices to acquire data. According to Best and Kahn (2000), ‘like tools in the carpenter’s box, each research tool is appropriate in a given situation to accomplish a particular purpose. The researcher needs various instruments to gather new facts for the research work. The instruments thus employed are called tools’.

The following tools and materials were prepared and validated for the present study.

1) Questionnaire for Secondary School Teachers on Difficulties in Teaching Solid Geometry
2) Test on Conceptual Clarity in Solid Geometry
3) Test on Problem Solving Ability in Solid Geometry
4) Test on Achievement in Solid Geometry
5) Multimedia Instructional Package on Solid Geometry
6) Lesson Transcripts on Solid Geometry based on Activity Oriented Method of Instruction
7) Test on Retention in Solid Geometry

The details regarding the tools employed for the study are given below.

1) Questionnaire for Secondary School Teachers on Difficulties in Teaching Solid Geometry

The Questionnaire for Secondary School Teachers on Difficulties in Teaching Solid Geometry was prepared by the Investigator with the help of her Supervising Teacher. The Questionnaire comprised 22 questions that were intended to gather data regarding four areas of difficulty relating to Curriculum, Teaching Strategy, Time Factor and Student Factor. An effort was also made to gather information regarding the needs, the limitations as well as the suggestions of the Secondary School Teachers in relation to Teaching of Solid Geometry using three questions. The distribution of items in the Questionnaire is given in Table 4.2.
The Investigator also gathered some general information about the Teachers, viz. their Gender, Teaching Experience as well as the Name and Locality of the School. The Questionnaire for Secondary School Teachers on Difficulties in Teaching Solid Geometry is provided as Appendix A.

Validation of the Questionnaire

The Questionnaire was validated by discussing with experienced Mathematics Teachers of Secondary and Higher Secondary Schools and Colleges of Education. The List of Experts used for validating the tools developed is provided as Appendix B.

2) Test on Conceptual Clarity in Solid Geometry

Conceptual Clarity refers to the clearness in the understanding of the characteristics and the logical linkage within a concept. It is an essential factor to learn meaningfully any concept or idea. This factor wipes out all doubts related to a concept. Teachers should utilise more time for the introduction of an idea or concept so as to enable students to attain clarity. Conceptual Clarity among students greatly influences the quality of their educational outcome. This is essential for internalising the basic Mathematical concepts.

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**Table 4.2**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Area of Difficulty</th>
<th>Question Numbers</th>
<th>Total no. of Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Curriculum</td>
<td>1, 2, 3, 4, 5</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Teaching Strategy</td>
<td>6, 7, 8, 9, 10, 11, 12</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>Time</td>
<td>13, 14, 15, 16, 17, 18</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>Students</td>
<td>19, 20, 21, 22</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Open ended questions</td>
<td>23, 24, 25</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>25</strong></td>
</tr>
</tbody>
</table>
The Investigator, with the help of her Supervising Teacher, prepared and standardised the Test on Conceptual Clarity in Solid Geometry, keeping in view the different components of Conceptual Clarity, that were identified. The four components of Conceptual Clarity that were identified were:

1. Observation of Solid figures to identify their features,
2. Awareness about figures and Shapes,
3. Ability to identify different positions of figures, and
4. Expression in picture form.

The Test was prepared on the Topic ‘Prisms’ - Chapter 13 of Standard IX Mathematics Text Book of Kerala State Syllabus. The details of different stages of preparation of the Test are detailed below.

**The Draft Test on Conceptual Clarity in Solid Geometry**

The number of items decided for the Test was fixed as 60. The items were distributed among the different components of Conceptual Clarity.

Objective type items were prepared to maintain objectivity throughout the Test. One word answer type was used for testing Conceptual Clarity so that the problem of guessing was avoided. The wordings, language and figures used were given due care while preparation. Also, objectivity was ensured by fixing one answer as the expected response.

The items were organised in the order of their level of difficulty in each area. Clear instructions were provided in the question paper.

The Scoring Key of the Draft Test was prepared, in which correct response against each item number was noted, so that scoring can be done in an objective way. The scoring scheme of the Test was to give ‘one score’ for each correct response and ‘zero score’ for incorrect response.
The Test on Conceptual Clarity in Solid Geometry (Draft Form) – English and Malayalam Versions, its Response Sheet and Scoring Key are provided as Appendix C.

Try out of the Draft Test

The items were tried on eight Secondary School students and the wordings used in the question paper were modified to make the test clearer and avoid ambiguity from the students’ point of view. Then the Draft Test was administered on 385 students selected by random sampling procedure. Separate Response Sheets were provided to the students. The average time taken by the students to answer all questions was noted to estimate the time required for the Final Test. More than 96% of the students completed the test and the answer scripts were collected and valued. Incomplete Response Sheets were rejected and thus 370 Response Sheets were taken for analysis.

Item Analysis

Item Analysis is the process of examining the students’ response to each item to determine the quality and merit of the Test. The procedure suggested by Ebel and Frisbie (1991) was used for this purpose. In accordance, the Response Sheets were arranged in the order of their total scores from high to low. The Upper Group (the 27% from the higher level) and the Lower Group (27% from the lower level) were separated. These two Groups were used for item analysis. The two important characteristics, the Difficulty Index (DI) and Discriminating Power (DP) were found out and the suitability of the item for the final test was established. DI and DP were given by the formulae

\[
DI = \frac{U + L}{2N} \quad \text{and} \quad DP = \frac{U - L}{N}, \quad \text{where}
\]

\[
U \quad \text{is the number of correct responses in the Upper Group,}
\]

\[
L \quad \text{is the number of correct responses in the Lower Group, and}
\]

\[
N \quad \text{is the number of students in each Group.}
\]
The Final Test

The items with DI values between 0.4 and 0.6 and DP values 0.4 and above were selected for the Final Test. Thus, 33 items were selected for the Final Test and 27 were rejected. The Difficulty Index and Discriminating Power of Items in the Test on Conceptual Clarity in Solid Geometry (Draft Form) are provided as Appendix D.

The time limit for the Final Test was fixed as 40 minutes. The distribution of the test items under the Components of Conceptual Clarity are shown in Table 4.3.

Table 4.3
Distribution of Test Items under the Components of Conceptual Clarity

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Components of Conceptual Clarity</th>
<th>Item Numbers</th>
<th>Total Number of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Observation of Solid figures to identify their features</td>
<td>1 to 9</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>Awareness about figures and shapes</td>
<td>10 to 24</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>Ability to identify different positions of figures</td>
<td>25 to 29</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Expression in picture form</td>
<td>30 to 33</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>33</strong></td>
</tr>
</tbody>
</table>

The items were organised in the order of their level of difficulty in each area. Clear directions were provided in the question paper. The Scoring Key of the Final Test was prepared.

The Test on Conceptual Clarity in Solid Geometry (Final Form) – English and Malayalam Versions, its Response Sheet and Scoring Key are provided as Appendix E.
Administration and Scoring of the Final Test

The Test on Conceptual Clarity in Solid Geometry was administered on 192 students under ideal conditions. The time limit of 40 minutes was strictly followed. The answer scripts were valued strictly according to the Scoring Key prepared and total scores were arrived at.

Validity of the Test

Validity accurately reflects the concepts it is intended to measure. Validity of the Test was taken care of while giving weightage to different Components of Conceptual Clarity. Also, during preparation of items, opinions of experts (Appendix B) were given due importance. Thus content validity of the Test was ensured.

The Test was correlated with the scores of recently conducted Mathematics Test, which were collected from the class teachers and the Coefficient of Correlation estimated using Pearson’s Product–Moment Method was 0.86. Thus, it can be seen that the empirical or statistical validity of the Test is high.

Reliability of the Test

Reliability refers to the degree of consistency in the performance of the examinees. The reliability of the Test was established using the Test-Retest Method. Three weeks after conduct of the Final Test, the same Test was readministered on the same set of students. Correlation coefficient between these sets of scores was found to be 0.85, which shows that the Test is highly reliable.

Objectivity and Practicability

Objectivity demands definiteness in the answer expected. The Test was made cent percent objective by including only objective type items and by preparing one-word-answer items carefully. Besides this, the Test was
conducted under ideal conditions and the Response Sheets were valued strictly according to the Scoring Key. So objectivity was ensured to its fullest extent.

Practicability is the feasibility of the Test. The time fixed for the Test was 40 minutes, which was sufficient. The Test Booklets were reusable, since the Response Sheets were provided separately. Thus practicability of the Test was ensured.

**Determination of Norms**

Norms provide average standards of specific groups, with a view to make comparisons and thereby take instructional as well as other decisions. The values of Arithmetic Mean and Standard Deviation of the Test were 18.96 and 5.45 respectively on the basis of which three groups were formed, viz. upper, average and lower groups. The norms of the Test on Conceptual Clarity in Solid Geometry were calculated as follows:

- **Upper Group**: Students with scores 24 and above
- **Average Group**: Students with scores from 14 to 23
- **Lower Group**: Students with scores below 14

**3) Test on Problem Solving Ability in Solid Geometry**

According to **Joyce and Weil (1997)**, Problem Solving involves selecting the correct rules and applying them in combination. “The productive work involved in the evaluation of a situation and the strategy worked at to reach one’s set goals is collectively termed Problem Solving” (**Mangal, 1999**).

The Investigator with the help of her Supervising Teacher prepared and validated a Test on Problem Solving Ability in Solid Geometry. The test aims to assess the Problem Solving Ability in Solid Geometry of Secondary School Students in totality and not the degree of ability in each stage of Problem Solving. Besides, Solid Geometry involves plenty of higher order problems, which were included in the Test, the solution of which requires passing through the stages of Problem Solving. So, Problem Solving Ability was measured as
the Total Score obtained in the Test which contains only higher order problems.

The Test on Problem Solving Ability in Solid Geometry contained 30 questions and was conducted in two sessions, each of one hour duration. The Test included questions from five Topics. The details regarding the distribution of questions on Problem Solving Ability under the Topics in Solid Geometry are given in Table 4.4.

<table>
<thead>
<tr>
<th>Section</th>
<th>Topics</th>
<th>Question Numbers</th>
<th>Number of Questions</th>
<th>Time in minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 1. Rectangular Prisms, Square Prisms and Cubes</td>
<td>1,2,3,4,5,6,7</td>
<td>14</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>2. Triangular Prisms</td>
<td>8,9,10,11,12,13,14</td>
<td>16</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>B 3. Other Prisms</td>
<td>15,16,17,18,19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Cylinders</td>
<td>20,21,22,23,24,25,26</td>
<td>16</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>5. Combination of Solids</td>
<td>27,28,29,30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>120</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Objective Type items were prepared to maintain objectivity of the Test. Multiple Choice test items were used for testing Problem Solving Ability and special care was taken in preparing distractors so that there is least problem of guessing. The scoring scheme of the Test was to give ‘one score’ for each correct response and ‘zero score’ for incorrect response.
Validation of the Test

The Test was validated by a panel of experts (Appendix B) regarding the structure and quality of questions.

**The Test on Problem Solving Ability in Solid Geometry – English and Malayalam Versions, its Response Sheet and Scoring Key** are provided as Appendix F.

4) **Test on Achievement in Solid Geometry**

Mathematics is included as a compulsory subject at secondary school level because knowledge of Mathematics is essential for a basic living. So it is imperative that students should achieve the curricular objectives of the subject. Teachers should check the attainment of the objectives in the different domains of learning through tests.

The Investigator, with the help of valuable suggestions from her Supervising Teacher, prepared and standardized a Test on Achievement in Solid Geometry, keeping in view the Taxonomy of Educational Objectives suggested by McCormack and Yager (1989). The Test was prepared on Chapter 13 Prisms of the Standard IX Mathematics Textbook of Kerala State Syllabus. The details of different stages of preparation of the Test are detailed below.

**The Draft Test on Achievement in Solid Geometry**

The number of items decided for the Test was fixed as 38. The items were distributed among the three Domains of Learning.

Objective type items were prepared to maintain objectivity throughout the Test. Multiple Choice type items were used for testing Achievement. Utmost care was taken in preparing distractors so that the chances for guessing the answers are nil. The language and figures used were given due care while preparation to maintain objectivity.
The items were organised in the order of their level of difficulty. Clear instructions were provided in the question paper.

The Scoring Key of the Draft Test was prepared, in which correct response against each item number was noted, so that scoring can be done in an objective way. The scoring scheme of the Test was to give ‘one score’ for each correct response and ‘zero score’ for incorrect response.

The Test on Achievement in Solid Geometry (Draft Form) – English and Malayalam Versions, its Response Sheet and Scoring Key is provided as Appendix G.

Try out of the Draft Test

The items were tried out on eight Secondary School students and the wordings used in the question paper were modified to make the test clearer and avoid ambiguity from the students’ point of view. Then the Draft Test was administered on 385 students selected by random sampling procedure. Separate Response Sheets were provided to the students. The average time taken by the students to answer all questions was noted to estimate the time required for the Final Test. More than 97% of the students completed the test and the answer scripts were collected and valued. Incomplete Response Sheets were rejected and thus 370 Response Sheets were taken for analysis.

Item Analysis

Item Analysis is the process of examining the students’ response to each item to determine the quality and merit of the Test. The procedure suggested by Ebel and Frisbie (1991) was used for this purpose. Accordingly, the Response Sheets were arranged in the order of their total scores from high to low. The Upper Group (the 27% from the higher level) and the Lower Group (27% from the lower level) were separated. These two Groups were used for item analysis. The two important characteristics, the Difficulty Index (DI) and Discriminating
Methodology

Power (DP) were found out and the suitability of the item for the final test was established. DI and DP were given by the formulae

\[ DI = \frac{U + L}{2N} \quad \text{and} \quad DP = \frac{U - L}{N}, \]

where 

U is the number of correct responses in the Upper Group, 
L is the number of correct responses in the Lower Group, and 
N is the number of students in each Group.

The Final Test

The items with DI values falling between 0.4 and 0.6 and DP values 0.4 and above were selected for the Final Test. Thus, 20 questions were selected for the Final Test 18 items were rejected. The Difficulty Index and Discriminating Power of items in the Draft Test on Achievement in Solid Geometry are provided as Appendix H.

The time limit for the Final Test was fixed as 60 minutes.

The details of weightages assigned to the Domains of Learning and the Units of Solid Geometry follow.

Weightage to Domains

In order to ensure objective-basedness and validity of the Test, the three Domains of Cognitive Learning, viz. Knowledge, Process and Application were given due weightage. The details of weightages assigned to Domains of Learning in the Test on Achievement in Solid Geometry are given in Table 4.5.
Table 4.5
Weightage to Domains of Learning in the Test on Achievement in Solid Geometry

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Domains of Learning</th>
<th>Marks</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Knowledge</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>Process</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Application</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>20</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Weightage to Units of Solid Geometry

For coverage of content, the total chapter was divided into five units and items in the Test were distributed to each Unit according to their relative importance. The details of weightages assigned to the Units of Solid Geometry in the Test on Achievement in Solid Geometry are given in Table 4.6.

Table 4.6
Weightage to Units of Solid Geometry in the Test on Achievement in Solid Geometry

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Units of Solid Geometry</th>
<th>Marks</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rectangular Prisms, Square Prisms &amp; Cubes</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>Triangular Prisms</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Other Prisms</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>Cylinders</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>Combination of Solids</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>20</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Difficulty Level of Items

The items in the Achievement Test were classified into easy, average and difficult on the basis of their level of difficulty. Majority of the items were placed in average level of difficulty, since majority of students in a common
class are average in their cognitive behaviour. The details of the weightages assigned to Difficulty Level of Items in the Test on Achievement in Solid Geometry are shown in Table 4.7.

**Table 4.7**

Weightage to Difficulty Level of Items in the Test on Achievement in Solid Geometry

<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>3</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Average</td>
<td>13</td>
<td>65</td>
</tr>
<tr>
<td>3</td>
<td>Difficult</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>20</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

The Blue Print

Blue Print, the three dimensional chart conveying a fair idea about the different aspects of the Test on Achievement in Solid Geometry, shows the distribution of items with regard to three dimensions, viz. Domains of Learning, Levels of Difficulty and Units of Solid Geometry. The Blue Print is given as Table 4.8.
### Table 4.8
Blue Print of the Test on Achievement in Solid Geometry

<table>
<thead>
<tr>
<th>Domains of Learning</th>
<th>Knowledge</th>
<th>Process</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Levels of Difficulty</td>
<td>Easy</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>Units of Solid Geometry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Rectangular Prisms; Square Prisms &amp; Cubes</td>
<td>Easy</td>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>2. Triangular Prisms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Other Prisms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Cylinders</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Combination of Solids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub Total</td>
<td></td>
<td>(3)</td>
<td>(2)</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
</tbody>
</table>

N.B. Numbers inside brackets indicate number of questions. Numbers outside brackets indicate marks.

**The Question-wise Analysis of the Final Test**

The Question-wise Analysis of the Final Test is presented in Table 4.9.
Table 4.9
Question-wise Analysis of the Test on Achievement in Solid Geometry

<table>
<thead>
<tr>
<th>Qn. No.</th>
<th>Unit</th>
<th>Domain</th>
<th>Difficulty Level</th>
<th>Marks</th>
<th>Expected time in minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>Knowledge</td>
<td>Easy</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Knowledge</td>
<td>Easy</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>Knowledge</td>
<td>Easy</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>Knowledge</td>
<td>Average</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>Knowledge</td>
<td>Average</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>Process</td>
<td>Average</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>Process</td>
<td>Average</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>Process</td>
<td>Average</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>Process</td>
<td>Average</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>Process</td>
<td>Average</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>Application</td>
<td>Average</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>Application</td>
<td>Average</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>Application</td>
<td>Average</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>14</td>
<td>4</td>
<td>Application</td>
<td>Average</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>Application</td>
<td>Average</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>16</td>
<td>3</td>
<td>Application</td>
<td>Average</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>17</td>
<td>1</td>
<td>Application</td>
<td>Difficult</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>18</td>
<td>4</td>
<td>Application</td>
<td>Difficult</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>19</td>
<td>5</td>
<td>Application</td>
<td>Difficult</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>Application</td>
<td>Difficult</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total</td>
<td>20</td>
</tr>
</tbody>
</table>

Administration and Scoring of the Final Test

The Test on Achievement in Solid Geometry was administered on 192 students under ideal conditions. The time limit of 60 minutes was strictly followed. The answer scripts were valued strictly according to the Scoring Key prepared and total scores were arrived at.

Validity of the Test

Validity accurately reflects the concepts it is intended to measure. Validity of the Test was taken care of while giving weightage to content and
objectives. Also, during preparation of items, opinions of experts (Appendix B) were given due importance. Thus content validity of the Test was ensured.

The Test was correlated with the scores of recently conducted Mathematics Test, which were collected from the class teachers and the Coefficient of Correlation estimated using Pearson’s Product Moment Method was 0.87. Thus it can be seen that the empirical or statistical validity of the Test is high.

Reliability of the Test

Reliability refers to the degree of consistency in the performance of the examinees. The reliability of the Test was established using the Test-Retest Method. Three weeks after conduct of the Final Test, the same Test was readministered on the same set of students. Correlation coefficient between these sets of scores was found to be 0.94, which shows that the Test is highly reliable.

Objectivity and Practicability

Objectivity demands definiteness in the answer expected. The Test was made cent percent objective by including only objective type items and by taking meticulous care in preparation of the distractors so as to avoid the probability of guessing. Besides this, the Test was conducted under ideal conditions and the Response Sheets were valued strictly according to the Scoring Key by the investigator. So objectivity was ensured to its fullest extent.

Practicability is the feasibility of the Test. The time fixed for the Test was one hour, which was sufficient. The Test Booklets were reusable, since the Response Sheets were provided separately. Thus practicability of the test was ensured.
Determination of Norms

Norms provide average standards of specific groups, with a view to make comparisons and thereby take instructional as well as other decisions. The values of Arithmetic Mean and Standard Deviation were 10.64 and 4.28 respectively, on the basis of which three groups were formed, viz. upper, average and lower groups. The norms of the Test on Achievement in Solid Geometry were calculated as follows:

Upper Group : Students with scores 15 and above
Average Group: Students with scores from 7 to 14
Lower Group : Students with Scores below 7

The Test on Achievement in Solid Geometry (Final Form) – English and Malayalam Versions, its Response Sheet and Scoring Key are provided as Appendix I.

5) Multimedia Instructional Package on Solid Geometry

The Investigator incorporated the five phased, Analysis-Design-Develop-Implementation-Evaluation (ADDIE) Model, for the development of the Multimedia Instructional Package on Solid Geometry.

The details of each phase in the development of the Multimedia Instructional Package on Solid Geometry follow.

Phase 1: Analysing Phase

The content selected for developing the Multimedia Instructional Package on Solid Geometry was Chapter 13: ‘Prisms’ of Standard IX Mathematics Textbook of Kerala State Syllabus. Task Analysis was done and the following instructional problems were identified.

- What are the tasks associated with Solid Geometry?
- What do students need to be successful in learning Solid Geometry?
Methodology

- What are the previous knowledge and skill levels of the students related with Solid Geometry?
- Which delivery methods are suitable to learn Solid Geometry?
- What technology is available to instruct Solid Geometry?
- How much time, money and other resources are available?

After identifying the instructional problems, a list of general objectives and the specific objectives were listed.

Phase 2: Designing Phase

The structure of the package was designed so as to include various experiences. The design and colour combinations used in the screen were selected carefully so as to attract students to the objectives of the Package. Animations of different figures were planned. Appropriate exercises, interaction, activities, and testing items were included to enhance learning. The Package was divided into seven Blocks and 18 Units. Each Unit was designed to pass through four stages, viz. Objectives, Learning Experiences and Activities, Review and Evaluation. The details of the Blocks and Units included in the Multimedia Instructional Package on Solid Geometry are shown in Table 4.10.
Table 4.10
Details of the Blocks and Units in the Multimedia Instructional Package on Solid Geometry

<table>
<thead>
<tr>
<th>Blocks</th>
<th>Units</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Solids and Prisms</td>
<td>1</td>
<td>Solids</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Prisms</td>
</tr>
<tr>
<td>2. Rectangular Prisms, Square Prisms &amp; Cubes - Total Surface Area</td>
<td>1</td>
<td>Total Surface area –Rectangular Prisms</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Total Surface area –Square Prisms</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Total Surface area –Cubes</td>
</tr>
<tr>
<td>3. Rectangular Prisms, Square Prisms &amp; Cubes - Volume</td>
<td>1</td>
<td>Volume-Rectangular Prisms</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Volume-Square Prisms</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Volume-Cubes</td>
</tr>
<tr>
<td>4. Triangular Prisms</td>
<td>1</td>
<td>Total Surface Area</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Volume</td>
</tr>
<tr>
<td>5. Other Prisms</td>
<td>1</td>
<td>Quadrilateral Prisms</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Pentagonal Prisms</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Hexagonal Prisms</td>
</tr>
<tr>
<td>6. Cylinders</td>
<td>1</td>
<td>Total Surface Area</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Volume</td>
</tr>
<tr>
<td>7. Combination of Solids</td>
<td>1</td>
<td>Total Surface Area</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Volume</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Some Relations</td>
</tr>
</tbody>
</table>

**Phase 3: Developing Phase**

The Package was developed on par with the decisions made in the Analysing and Designing Phases. The assistance of a computer expert was taken at some stages of development of the Package. The Package was developed using the software Adobe Flash Player CS 5.
The Package was exposed to a **Pilot Study**. A small group of the intended target, six or seven students of standard IX, were selected for the purpose. The Package was validated by senior Teachers of Mathematics using a Pro forma (See List of Experts in **Appendix B**). The Pro forma used for validating the Package is provided as **Appendix J**. The Package was **finalised** by making modifications on the basis of the students’ response during the Pilot Study and the suggestions made by Senior School Teachers of Mathematics.

**Phase 4: Implementing Phase**

The Multimedia Instructional Package was effectively used by the students. It helped the students to have visual experiences on different dimensions of Solid figures. The total chapter was covered in 18 periods, each of 40 minutes duration.

**Phase 5. Evaluating Phase**

Evaluation of students to check their attainment of objectives was done. Feedback was sought from Secondary School Mathematics Teachers during the Implementation Phase of the Multimedia Instructional Package on Solid Geometry, with a view to incorporate any suggested changes for wider use. But, all the aspects in the Package were appreciated by the Teachers.

**Classroom requirements for using the Package:** The Package can be used on computer systems with supporting facilities like LCD projector, white screen and audio system. The computer system may have any of the operating systems - Microsoft Vista, XP, 7 or 8, Adobe Flash Player 10 or above, 1GB RAM with graphic support and CD drive.

**The Hard and Soft copies of the Multimedia Instructional Package on Solid Geometry used for the study** are provided as **Appendix K**.
6) **Lesson Transcripts on Solid Geometry based on Activity Oriented Method of Instruction**

Lesson Transcripts were prepared by the Investigator with the help of her Supervising Teacher based on the teaching method prevalent in the schools of Kerala state during the period of her data collection. Thus, 18 Lesson Transcripts based on Activity Oriented Method of Instruction on Chapter 13: ‘Prisms’ of Standard IX Textbook of Kerala State Syllabus were prepared. The Lesson Transcripts were validated by senior Teachers of Mathematics given in the List of Experts (Appendix B).

A **Model Lesson Transcript on Solid Geometry based on Activity Oriented Method of Instruction** is given as Appendix L.

7) **Test on Retention in Solid Geometry**

A Test on Retention helps to find out whether students are able to retain the learnt matter after a period of time. A Test on Retention in Solid Geometry was prepared by the Investigator with the help of her Supervising Teacher. This was done to assess Retention Capacity of students in their achievement in Solid Geometry. The Test was prepared almost equivalent to the Achievement Test prepared, i.e. with respect to the weightages assigned to the objectives, content and difficulty level with only a slight change in the order, wordings and measurements of the questions. The procedure of construction was also the same.

The Test on Retention in Solid Geometry – English and Malayalam Versions, its Response Sheet and Scoring Key are attached as Appendix M.

4.6 **Procedure for Collection of Data**

After finalizing the samples and tools to be used, the Investigator gathered data for the Survey and for the Experiment. The procedures adopted for the collection of data are given under two heads, viz. Data for the Survey and Data for the Experiment. The details follow.
A. Data for the Survey

The Questionnaire for Secondary School Teachers on Difficulties in Teaching Solid Geometry was administered on 225 Secondary School Teachers of Mathematics from four districts of Kerala. The teachers were briefed on the aim and scope of the study and their co-operation was ensured.

B. Data for the Experiment

The Investigator met the heads of the schools, class teachers as well as the teachers of Mathematics to ensure their co-operation for the experimental part of the study.

One division from each of the two schools was selected randomly and fixed as the Experimental Group and one as the Control Group. A short explanation of the aim and scope of the study was given to the Students and their cooperation was solicited. The Tests on Conceptual Clarity, Problem Solving Ability and Achievement in Solid Geometry were administered to students in both the Experimental and Control Groups. Necessary directions were given to both the Experimental and Control Groups. The rules and procedures prescribed for each of the Tests was strictly followed. The Response Sheets were collected after the prescribed time and were scored in accordance with the respective Scoring Keys.

The two divisions in the Experimental Group were exposed to the Multimedia Instructional Package while the two divisions in the Control Group were exposed to the Activity Oriented Method of Instruction. Each of the four divisions selected underwent 18 instructional periods of 40 minutes duration each in the same content area.

After completion of the experimental treatment, all the three Tests were again administered as Post-tests to both the Groups. The Test on Retention in Solid Geometry was administered on both the Experimental and the Control Groups after a lapse of three weeks. All the scores were then tabulated and subjected to statistical analysis.
4.7 Statistical Techniques Employed

Different statistical techniques were employed to analyse the data collected through survey and experiment.

**In the survey part of the study**, the responses from Mathematics Teachers from the various schools were tabulated systematically. These responses were analysed and the percentage against each item was found out.

**In the experimental part of the study**, the Pre-test and Post-test scores of the Experimental and Control Groups were consolidated for the following statistical analysis.

- A preliminary analysis was done using Critical Ratio (*t* test).
- The Analysis of Variance was used to compare the Pre and Post-test scores of the two samples.
- The Analysis of Covariance was used to find out the effectiveness of the Multimedia Instructional Package.

**In the final part of the study**, Paired *t* test was used to find out the effectiveness of the Multimedia Instructional Package in enhancing Retention in Solid Geometry.

The software Statistical Package for Social Sciences (SPSS) - Version 19 (developed by IBM), was employed to estimate the statistical values.

The details of analysis using these relevant statistical techniques have been compiled in the next chapter.