METHODOLOGY

Jayasree N. “Effect of direct instruction model on achievement in select mathematical skills of upper primary pupils of Kerala” Thesis. Department of Education, University of Calicut, 2004
CHAPTER 3

METHODOLOGY

- Selection of Variables
- Objectives
- Hypotheses
- Procedure
METHODOLOGY

The methodology followed at the various phases of the investigation is described in this chapter and presented under the following sections.

3.1 SELECTION OF THE VARIABLES
3.2 OBJECTIVES
3.3 HYPOTHESES
3.4 PROCEDURE

3.1. SELECTION OF THE VARIABLES

The review of related studies had given a clear idea of the theoretical outline of Direct Instruction Model of teaching. It helped the investigator to identify in the selection of the independent variables, the dependent variables and the variables to be controlled. Accordingly variables, which are related to achievement in mathematics, were selected and categorised for the study. A brief description of the variables selected for the study is given below.

3.1.1. Independent Variables

Two sets of variables based on methods and paradigms of teaching were selected as independent variables.

3.1.1.1 Direct Instruction Model

Direct Instruction Model belonging to Behaviour Family is a teacher directed model of teaching. According to Engelmann (1960) it increases pupils achievement through carefully focused instruction. It develops the ability to perform a skill independently without any error. According to Rosenshine (1986) 'Direct Instruction Model of teaching is a systematic method of presenting materials in small steps, pausing to check for student
understanding and eliciting active and successful participation from all students'. Many studies in the western countries reveal that by using the Direct Instruction Model as an instructional strategy, slow learners and students with difficulties in learning can overcome their problem and can have high achievement in their future.

3.1.1.2. Objective Based Instruction

The second method of instruction used for the study was Objective Based Instruction. It was based on Bloom's Taxonomy modified and adopted by National Council of Educational Research and Training. It was one of the methods adopted by Government of Kerala in the primary and secondary schools and was recommended by Department of Public Instruction.

3.1.2. Dependent Variables

The focus of the present study was on to explore how effective the Direct Instruction Model will be for Achievement in select Mathematical skills and retention of these over a period of time. Skills in the cognitive domain were only considered for the study. Hence skills in knowledge category, comprehension category and application category were taken. In the application category only skills in the fundamental operations were included. Thus Achievement in Mathematical Skills (Objective wise and Total score) was treated as Dependent Variable. Specific variables coming under these categories are listed below.

- Knowledge category
- Comprehension category
- Application category
- Achievement in Mathematical Skills (Total Score)
3.1.3. Control Variables

Variables controlled in the present study are the following.

(i) Previous Knowledge of the Subject Matter.
(ii) Non-Verbal Intelligence
(iii) Numerical Ability.

3.2. OBJECTIVES

The present investigation was intended to explore whether Achievement in Mathematical skills vary when Direct Instruction Model of teaching is adopted in conventional classrooms without disturbing very much the usual classroom organisational set up. The study was therefore designed as a quasi-experimental study. The design adopted was Pre-Test-Post-Test Equivalent Group design.

'Direct Instruction Model' has been selected as the Experimental Variable. The changes in Achievement in Mathematical Skills (Dependent Variable) if any, have been explored in comparison with 'Objective Based Instruction.' Other variables namely 'Previous Knowledge of the Subject Matter,' 'Non-Verbal Intelligence' and 'Numerical Ability' had been treated as Control Variables. One group was treated as Experimental Group I, taught through Direct Instruction Model only, the second group was treated as Experimental Group II, taught through Direct Instruction Model and Objective Based Instruction alternately and that third group was treated as Control Group, which was taught through Objective Based Instruction only. The objectives formulated for the present investigation are given below.
3.2.1. To Compare the mean scores of Achievement in Mathematical Skills Post test I (tested immediately after the treatment) of Control Group and Experimental Group I and between Control Group and Experimental Group II.

3.2.2. To Compare the mean Gain scores of Achievement in Mathematical Skills (Post-Test I minus Pre Test) of Control Group and Experimental Group I and between Control Group and Experimental Group II.

3.2.3. To Compare the mean Retention scores of Achievement in Mathematical Skills Post-Test II (tested two months after experimentation) of Control Group and Experimental Group I and between Control Group and Experimental Group II.

3.2.4. To compare the mean Gain scores of Achievement in Mathematical skills (Post Test II minus Pre Test) of Control Group and Experimental Group I and between Control Group and Experimental Group II.

3.2.5. To study the main effect and interaction effect of Methods of Teaching (Direct Instruction Model and Objective Based Instruction) and Previous Knowledge of Subject Matter on Achievement in Mathematical Skills Post-Test I for Total Sample, Boys and Girls.

3.2.6. To study the main effect and interaction effect of Methods of Teaching (Direct Instruction Model and Objective Based Instruction) and Non-Verbal Intelligence on Achievement in Mathematical Skills Post-Test I for Total Sample, Boys and Girls.

3.2.7. To study the main effect and interaction effect of Methods of Teaching (Direct Instruction Model and Objective Based Instruction) and Numerical Ability on Achievement in Mathematical Skills Post-test I for Total Sample, Boys and Girls.
3.2.8. To study the main effect and interaction effect of Methods of Teaching (Direct Instruction model and Objective Based Instruction) and Previous Knowledge of Subject Matter on Achievement in Mathematical Skills Post-Test II for Total Sample, Boys and Girls.

3.2.9. To study the main effect and interaction effect of Methods of Teaching (Direct Instruction Model and Objective Based Instruction) and Non-Verbal Intelligence on Achievement in Mathematical Skills Post-Test II for Total Sample, Boys and Girls.

3.2.10. To study the main effect and interaction effect of Methods of teaching (Direct Instruction Model and Objective Based Instruction) and Numerical Ability on Achievement in Mathematical Skills Post-Test II for Total Sample, Boys and Girls.

3.2.11. To study the relative effectiveness of Direct Instruction Model on Achievement in Mathematical Skills when initial difference in select variables namely 'Previous Knowledge' of Subject Matter, Non-verbal, 'Intelligence' and Numerical Ability' of the subjects are controlled one by one.

3.3. HYPOTHESES

The hypotheses formulated and tested for the study are the following.

3.3.1 There will be significant difference in the mean scores of Achievement in Mathematical Skills Post-Test I (tested immediately after treatment) between Control Group and Experimental Group I and between Control Group and Experimental Group II.

3.3.2 There will be significant difference in the mean Gain scores of Achievement (Post-Test I minus Pre Test) between Control Group and
Experimental Group I and between Control Group and Experimental Group II.

3.3.3 There will be significant difference in the mean Retention scores of Achievement in Mathematical Skills Post-Test II (tested two months after treatment) between Control Group and Experimental Group I and between Control Group and Experimental Group II.

3.3.4 There will be significant difference in the mean Gain scores of Achievement in Mathematical Skills (Post Test II minus Pre Test) between Control Group and Experimental Group I and between Control Group and Experimental Group II.

3.3.5 There will be significant Main effect and Interaction effect of Methods of Teaching (Direct Instruction Model and Objective Based Instruction) and Previous knowledge of Subject Matter on Achievement in Mathematical Skills Post-Test I for Total Sample, Boys and Girls.

3.3.6 There will be significant Main effect and Interaction effect of Methods of Teaching (Direct Instruction Model and Objective Based Instruction) and Non-Verbal Intelligence on Achievement in Mathematical Skills Post-Test I for Total Sample, Boys and Girls.

3.3.7 There will be significant Main effect and Interaction effect of Methods of Teaching (Direct Instruction Model and Objective Based Instruction) and Numerical Ability on Achievement in Mathematical Skills in Post-Test I for Total Sample, Boys and Girls.

3.3.8 There will be significant Main effect and Interaction effect of Methods of Teaching (Direct Instruction Model and Objective Based Instruction) and Previous Knowledge of Subject Matter on
Achievement in Mathematical Skills Post-Test II for Total Sample, Boys and Girls.

3.3.9 There will be significant main effect and interaction effect of Methods of Teaching (Direct Instruction Model and Objective Based Instruction) and Non-Verbal Intelligence on Achievement in Mathematical Skills in Post-Test II for Total Sample, Boys and Girls.

3.3.10 There will be significant Main effect and Interaction effect of Methods of Teaching (Direct Instruction Model and Objective Based Instruction) and Numerical Ability on Achievement in Mathematical Skills in Post-Test II for Total Sample, Boys and Girls.

3.3.11 Pupils taught through Direct Instruction Model will have high mean Achievement in Mathematical Skills in Post Test I and Post Test II than pupils taught through Objective Based Instruction when the initial difference in Previous Knowledge of Subject Matter were controlled.

3.3.12 Pupils taught through Direct Instruction Model will have high mean Achievement in Mathematical Skills in Post-Test I and Post Test II than pupils taught through Objective Based Instruction when the initial difference in Non-Verbal Intelligence were controlled.

3.3.13 Pupils taught through Direct Instruction Model will have high mean Achievement in Mathematical Skills in Post Test I and Post Test II than pupils taught through Objective Based Instruction when the initial difference in Numerical Ability were Controlled.
3.4. PROCEDURE

The research design adopted for the study, procedure of selection of sample, conduct of experimentation, data collection procedure and techniques used for processing the data are described in this section.

3.4.1 The Research Design

The experimental design used in this study was Pre Test – Post Test Equivalent Group Design. The graphical representation of the design is as follows.

\[
\begin{align*}
G_1 & \quad O_1 \quad X_1 \quad O_2 \\
G_2 & \quad O_3 \quad X_1 \quad C \quad X_2 \quad O_4 \\
G_3 & \quad O_5 \quad C \quad O_6 \\
O_1 \quad O_3 \quad O_5 & \quad - \quad \text{Pre-Test} \\
O_2 \quad O_4 \quad O_6 & \quad - \quad \text{Post Test} \\
O_2 \quad - \quad O_1 & \quad - \quad \text{Gain Score} \\
O_4 \quad - \quad O_3 & \quad - \quad \text{Gain Score} \\
O_6 \quad - \quad O_5 & \quad - \quad \text{Gain Score} \\
G_1 & \quad - \quad \text{Experimental Group I} \\
G_2 & \quad - \quad \text{Experimental Group II} \\
G_3 & \quad - \quad \text{Control Group I} \\
X_1 \quad X_2 & \quad - \quad \text{Application of Experimental Treatment} \\
C & \quad - \quad \text{Application of Control Treatment}
\end{align*}
\]

The design of the study is represented in the form of Flow chart and is given below.
Flow chart of the experimental design

Allocation of experimental & Control Group

Selection of topic for treatment

Preparation of Instruction Materials

Tools

Pre Test

Experimental Group -I

Experimental Group -II

Control Group

Treatment

Experimental Group -I teaching through DIM

Experimental Group -II teaching through DIM & OBI

Control Group teaching through OBI

Post test - I
Testing immediately after teaching

Post Test - II
(testing after two months)

Scoring and consolidation

Statistical techniques

Analysis and Interpretations
3.4.1.1. Sample of the Study

The population of the present study covers the Upper Primary Pupils of Kerala. But the investigator decided to confine the conduct of the experiment to pupils of standard VII since they are at the terminal stage of upper primary section. Care was taken to ensure that the subjects selected were equivalent in many respects. It was decided to select coeducational schools where the medium of instruction is English for experimentation. It was also ensured that almost equal number of boys and girls were included in the sample. Instructional efficiency of the school was ascertained on the basis of the examination results of three previous consecutive years in the common Secondary School Leaving Certificate Examination (2000-2002). The statistics kept in the office of the District Educational Officer helped for this purpose. Schools with above average instructional efficiency, that is pass percentage of about fifty to fifty five for the consecutive years were included in the sample. For the smooth conduct of the experiment and for other practical reasons it was decided to select schools from urban area. Based on these criteria, schools from three revenue districts of Kerala were selected. One school from each district was selected at random for experimentation. It was also ensured that the schools are easily accessible and amenable for the investigator to conduct the experiment and are located in such a way that the subjects in the select school, where experiment was conducted do not consult each other and exchange study materials.

Assuming that each class of the select schools consists of approximately thirty pupils, two English medium class divisions from each school were selected. It was also decided to select the sample for the experiment consisting of 180 pupils of standard VII from three different schools (60 pupils were treated as Experimental Group I, 60 pupils were treated as Experimental Group II and 60 as Control Group). The actual
number of sample in each group at the entry stage of the experiment is shown in the following break-up.

<table>
<thead>
<tr>
<th></th>
<th>Experimental Group I</th>
<th>Experimental Group II</th>
<th>Control Group</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>90</td>
</tr>
<tr>
<td>Girls</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>90</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>180</td>
</tr>
</tbody>
</table>

3.4.1.2. Allocation of Experimental Groups and Control Group

It would be difficult to carry out an experimental study on a large sample. Since the random assignment to subjects in Experimental and Control groups will not be plausible in an organised set up of the schools and to get a more natural setting for the conduct of the study it was decided to select intact class groups. Two classes were therefore considered as the unit of study. The schools were allocated as Experimental and Control groups by taking a lot. Details of the schools are given in the following break-up.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the School</th>
<th>Nature of Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Devaswam Board Higher Secondary School, Kavumthakom</td>
<td>Experimental Group I</td>
</tr>
<tr>
<td>2</td>
<td>St. Teresa's Higher Secondary School, Vazhappally</td>
<td>Experimental Group II</td>
</tr>
<tr>
<td>3</td>
<td>Nair Service Society K.P. Thampan Higher Secondary School, Ottapalam</td>
<td>Control Group</td>
</tr>
</tbody>
</table>
3.4.1.3. Selection of the Topic for Treatment

The investigator carefully examined the syllabus and text books on mathematics prescribed for the upper primary schools of Kerala. It was felt that topics which require mastery of basic essential concepts that have carryover value, are worthwhile for experimentation. The investigator consulted a few subject experts of three colleges of Teacher Education and two experts of State Council of Educational Research and Training, and a few Mathematics teachers of both primary and secondary level for this purpose. It had been pointed out that fractions, decimals and percentages are the most difficult areas faced by the learners at primary level. Moreover these topics have maximum application in day-to-day life and have linkage with other subjects. Trend reports of evaluation in mathematics also support the selection of these topics.

According to the Trend report (Ronad, 1990) acquisition of concept of fractions and decimals has been a thorny problem for learners. The National Assessment of Educational Progress confirms that fractional concepts are particularly problematic for many students. According to Kouba (1988) quoted by Gupta (1991) for third grade students about one-half of the sample could write the symbol for three-fourths. But only one in four knew the number of fourths that make a whole. About forty percent of seventh grade students could identify the point on a number line that represented a simple fraction, and a fewer than forty percent were able to identify both the largest and smallest of four fractions in a simple problem situation." The National Council for Teaching Mathematics standards focuses in the development of concepts fractions (and decimal fractions). They recommended only concrete, explanatory experiences with fractional operations. For higher grades, application of the concepts, including operations and broadening of the concepts are stressed. According to the National Council for Teaching
Mathematics reported by Riedesel (1990) the sequence for fraction instruction are:

- Concept \(\rightarrow\) what is a fraction?
- Equivalence \(\rightarrow\) what are the different ways of representing an amount?
- Comparison, Sequencing \(\rightarrow\) How are fractions ordered?
- Operations \(\rightarrow\) How are fractions combined?

Twenty five teachers teaching mathematics in MCD Model School in New Delhi were contacted by Kusum Bhatia (1998) to discuss the mathematics syllabus at primary schools. They were asked about the areas of mathematics in which students of class V face more difficulties. More than eighty five percent teachers selected decimals as one among such topics. The concept of decimal is extremely useful in day-to-day life and for transaction. This is extremely useful in learning the concept of measurement and business. Due to constrain in time, percentage was not incorporated in the experimental study. Finally the investigator made sure that the topics selected namely fractions and decimals were well amenable through Direct Instruction Model of teaching.

3.4.1.4 Preparation of Instructional Materials

The investigator prepared separate instructional materials for Experimental and Control treatment for topics selected for treatment.

A. Planning of lesson formats

The content under the selected topics fractions and decimals were categorised into subunits as given below.

Fraction:

- Concept of fraction
Equivalent fractions
Ordering of fractions
Addition and subtraction of fractions
Multiplication and Division of fractions

Decimals

Concept of decimal
Ordering of decimal
Uses of decimals
Fundamental operations with decimal

After deciding the subunits under each topic the investigator ascertained the duration required for teaching the subunits and the number of written lesson plans to be prepared for each sub unit using Direct Instruction Model and Objective Based Instruction were fixed as given below.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Subunit</th>
<th>Number of lesson plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Concept of fraction</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Equivalent fractions</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Ordering of fractions</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Addition and Subtraction of fractions</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>Multiplication and Division of fractions</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Concept of decimal</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Ordering of decimals</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Uses of decimals</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Fundamental Operations with decimals</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>Simplification of Numerical Expression</td>
<td>1</td>
</tr>
</tbody>
</table>
It is to be noted that the instructional objectives for each subunit were same for the two methods of teaching adopted as treatment variable.

B. Lesson Plans Based on Direct Instruction Model

Four lesson plans based on Direct Instruction Model of teaching were prepared. Lesson plans suggested by Robert Slavins Direct Instruction Model (1998), Rosenshine's Direct Instruction Model (1989) Mandeline Hunter Direct Instruction Model (1999) and Engelmann's Direct Instruction Model (2001) are the most popular among the varied lesson formats of Direct Instruction Model. Among these, the format suggested by Engelmann (2001) was found to be suitable by the investigator for teaching mathematics. Other formats were also referred for preparing the lesson plans (formats).

Before preparing the lesson plans it was found necessary to select the instructional objectives to be attained, by analysing the content and also to fix the standards of performance expected to be attained by the pupils at the level of mastery. The different phases of the syntax of Direct Instruction Model prepared by Engelmann is given below.

- Attention and Focus
- Orientations
- Model
- Lead
- Test
- Delayed test and Weekly Review

Altogether twenty four lesson plans were prepared, fifteen for fractions and nine for decimals. For each sub unit a formative test was also prepared, thus finally nine formative tests – five for fractions and four for decimals were developed. Formative tests were given only for experimental treatment. No formative test was administered to control group during experimentation.
Try Out

Three lesson plans were prepared initially for the subunit fractions and two lesson plans for decimals as per Direct Instruction Model. It was decided to try out the lesson plans to ensure the time required for the completion of teaching that sub unit covering all the phases of teaching. The difficulties faced while implementing this method in the usual classroom set-up was noted. The concerned class teacher of mathematics for that class and an expert in the field of mathematics education were also present as observers throughout the class during tries. Based on the reactions and responses by pupils and the opinion of teacher observers were noticed. The lesson formats were further scrutinised and revised by the investigator based on the suggestions of observers and reactions of pupils. Slight modifications were made on the lesson plans. These lesson plans were again scrutinised by two experts in mathematics education from the college of Teacher Education. Thus lesson plans for Direct Instruction Model were finalised. Lesson plan based on Direct Instruction Model (one each in fraction and decimal) together with the format for observation lesson during the tryout stage is presented as Appendix IA, IB and IC.

C. Lesson Plans Based on Objective Based Instruction

For Control group twenty four lessons were prepared on the basis of Instructional Objectives of Bloom's Taxonomy adopted by National Council of Educational Research and Training. For this purpose the content of fractions and decimals were thoroughly analysed on the basis of which the objectives that are to be attained in the cognitive domain. These objectives are again analysed into observable and measurable behavioural changes (specifications) that are to be taken place in the learner. These specification acts as the basis for planning lessons for control group. The terminal behaviours were then identified and written as instructional objectives. Based
on the blue print of the lesson format, lessons were prepared. This format of lesson plans is being used in the schools under the general education department of Kerala State for last three decades. It is to be noted that along with this lesson format, the primary schools of Kerala have also introduced instruction under District Primary Education Programme, Minimal Level Learning, Sarva Siksha Abhayan and the like.

The format of Objective Based Instruction is given below.

**Preparation**

- Reviewing the previous knowledge
- Motivating the learner to learn the new ideas
- Why he/she is going to learn these ideas

**Presentation**

- Presenting the new materials
- Providing provisions for students for activity
- Active participation of students
- Evaluation at appropriate time

**Application**

- Applying the newly learned content or skill in different situations

**Reviewing and Assignments**

- Reviewing newly learned materials.
- Drill work and home assignments.

The sample lesson plan is given as Appendix II A and II B.

Difference between Direct Instruction Model and Objective Based Instruction are as follows:
**Direct Instruction Model**

**Introduction Stage**
- Consists of 2 phases
  - Attention & Orientation
- Grouping of class – Pupils will be categorised in 5-6 homogeneous groups based on ability/subject competency
- Motivating pupils to learn by giving the abbreviated version of specific objectives of lesson
- Linking the days lesson with previous work
- List the specific content and skills to be mastered
- Agenda of the class is provided
- Techniques of presentation such as story telling/Question-answer/narration
- Time allotment is seven minutes

**Development Stage**
- This stage is also known as *Model*
- Learning tasks are given to groups.
- Carefully designed *formats* were used for demonstration
- Rate of learning for group as well as individual were monitored
- Individual participation within each group is assured by the teacher and bonus points are given to group activities.
- Prompts are given
- Time allotment is about 15-20 minutes

**Objective Based Instruction**

**Introduction Stage**
- No separate phase for introductory stage.
- No specific grouping during learning

**Development Stage**
- Motivating and sustaining interest through the situations creation to present the learning task
- Linking days lesson with previous work
- Techniques such as question answer, story telling
- Time allotment is seven minutes
- Learning tasks are given to whole class
- Expository techniques and illustrative talks
- Individual progress is not noticed. Only sample progress is assured
- Usual prompts are given
- Time allotment is 15-20 minutes
Application Stage

- This stage is known as 'Lead' or 'Guided Practice'.
- Confirm that the students are firm and fluent before moving to next stage
- Individual remediation if necessary will be provided by the teacher
- Teacher and pupil work together during class time
- Time allotment is eight minutes

Review and Assignments

- It is also known as 'Test' or 'Independent Practice'
- Worksheets are provided to each student
- Mastery of each student is ensured.
- Weekly review will be done using unit tests which are followed by remediation of necessary
- Students are regrouped on the basis of performance in unit test
- Pupil progress is recorded
- Feedback is compulsory to ensure mastery
- In general all lessons are neither amenable through DIM of teaching nor recommended.
- Class is not assessed before moving to next stage
- If necessary general remedy will be given to whole class.
- Usually teacher directs.
- Time allotment is eight minutes
- Only general overview will be done
- Random evaluation in the class will be done.
- Few class assignments and home assignments are given.
- Weekly review is not a must
- Unit tests are not attempted.
- Remedies are not common/compulsory
- Recording of individual progress is not necessary and feed-back is not given.
- All lessons are amendable through OBI.
3.4.1.5. Tools used for Measuring Control Variables

The other tools selected were to measure the control variables such as Non-Verbal Intelligence, Numerical Ability and Previous Knowledge of the Subject Matter.

A. Standard Progressive Matrices (Ravens, 1958)

Non-verbal Intelligence of the subjects were measured by administering the standard form of the Raven Progressive Matrices Test. This test is intended to estimate the subject's ability to discern and utilise a logical relationship presented by non-verbal materials. The test consists of five subtests of twelve items each. In each item a part of the geometrical design is missing. For each item the key consists of six or eight alternatives and only one belongs to the missing part. The test is a popular measure of 'g' factor of Intelligence.

Validity of the test has been studied in a variety of usual ways when Stanford-Binet test was used as the criterion, correlation varied from 0.50 to 0.86. The reliability coefficient as reported by Raven varies from 0.80 to 0.90. In a study conducted by Nair (1972) in Kerala, the reliability coefficient was found to vary from 0.70 to 0.86 by split-half method and from 0.84 to 0.91 by test-retest method.

Scoring sheet of Raven's Progressive Matrix is given as Appendix III.

B. Numerical Ability Test

A Numerical Ability Test was developed by the investigator under the guidance of her supervising teacher and consulting with some experts in mathematics. The numerical ability of an individual comes under cognitive tasks. It includes a number of stages as given below.
• Classification – the ability to sort and group objects by some similar characteristics.

• Seriation – the relationship among objects as they place them in a logical order or sequence.

• Number Concept – number concept involves more than rote counting, it concerns rational counting as well as the ability to correctly attach a numeral name to each item in a group of objects.

• Temporal concepts – the ability to place a series of events in the order of their occurrence.

• Spatial Concepts – it is concerned with relation of objects to each other in space.

The investigator includes all the above tasks except spatial concepts and the fundamental operations with whole numbers. Hence the test is able to measure the ability of individuals in handling numbers. The test consists 50 items under ten sub sections, of five items each. For each item four choices were given, indicated by A, B, C & D. Among them only one answer is correct.

In section A subjects have to identify the correct place value of the underlined digit of the given number.

Eg: 165802793

[A. lakh B. ten lakh C. crore D. ten crore]

In section B subjects choose the correct answer from the bracket.

Eg: One lakh = ------ hundreds.

[A. 1000 B. 10000 C. 100000 D. 1000000]
Section C consists of addition of numbers. By adding the numbers correctly subjects will find out the correct one from the given.

Eg: 731034 + 10991 + 327897

[A. 969922  B. 1069922  C. 1068922  D. 1069822]

Subtraction of numbers is given in section D. By subtracting the smaller one from the larger the correct answer can be identified.

Eg: 10001 - 99

[A. 9802  B. 9901  C. 9902  D. 8902]

In section E, items included intend to find out the correct answer subjects have to multiply the given numbers.

Eg: 325 x 15

[A. 4450  B. 4875  C. 5200  D. 3400]

Subjects are to find out the quotient by dividing the numbers in section F.

Eg: 1989 ÷ 9

[A. 219  B. 221  C. 231  D. 211]

In section G subjects have to pick out the correct symbol to fill the blank in each case.

Eg: 583456 ............ 583564

[A. ≤  B. <  C. >  D =]

For each item in section H, subjects choose the correct predecessor from the bracket.
\textit{Eg:} 10000

\begin{itemize}
  \item [A.] 10001
  \item [B.] 99999
  \item [C.] 999
  \item [D.] 99999
\end{itemize}

Carefully studying each series subjects identity the correct missing number in section.

\textit{Eg:} 3727 3728 3729 \ldots

\begin{itemize}
  \item [A.] 3730
  \item [B.] 3739
  \item [C.] 3829
  \item [D.] 3720
\end{itemize}

In section J subjects have to find out the correct answer to fill the blank so as to make the units correct.

\textit{Eg:} 1 \text{hectometre} = 10 \ldots

\begin{itemize}
  \item [A.] kilometre
  \item [B.] decametre
  \item [C.] metre
  \item [D.] decimetre
\end{itemize}

A draft test consisting of 100 items were prepared initially and field tested to select valid items to be included in the final test of numerical ability. Test was administered to 130 pupils of standard VII selected randomly.

\textbf{Item Analysis}

Item analysis of the items in the Numerical Ability Test was done using the method suggested by Ebel and Frisbic (1991). The answer sheets of 120 students were scored. For the correct answer one score was given. No score was given for incorrect answer. Fully answered 100 answer sheets were taken for item analysis. All the 100 response sheets were arranged in the descending order of total marks. From this twentyfive response sheets having highest score were taken as the upper group and the twentyfive sheets having the lowest score as the lower group. The response sheets of upper and lower groups were separated from the total group.
The difficulty index and discriminating power were computed using the formula suggested by Ebel and Frisbie (1991).

\[
\text{Index of Difficulty} = \frac{U + L}{2N}
\]

\[
\text{Discriminating Power} = \frac{U - L}{N}
\]

Where,

U = Number of correct responses in the upper group.
L = Number of correct responses in the lower group.
N = Number of subjects in any of the group.

The difficulty index and discriminating power of 100 items were computed. The Test of Numerical Ability Test, Item analysis chart, final Test of Numerical Ability and Scoring Sheet of Test of Numerical Ability are given as Appendix IV A, IV B, IV C and IV D respectively.

C. Achievement Test in Mathematical Skills

Achievement Test in Mathematical Skills developed by the investigator was used as Pre-Test. A parallel test of this test from the same blueprint was prepared as Post-Test. This parallel test was used as Post-Test I and Post-Test II. Steps in the construction of the test are described in the following sections.

(i) Planning of the Test

For preparing an achievement test in fractions and decimals the investigator studied the syllabus of primary classes having these topics. The books referred for preparing the test were given below:

- Let's Learn Maths (Guptha, V.P. et al., 1991).
It was decided to prepare test in fractions and decimals of multiple-choice items only, having 100 items which can be administered for a duration of maximum one and a half hours. The test was intended to measure abilities of cognitive domain only. The content selected were thoroughly analysed into terms, facts, concepts, principles and problem solving skills.

(ii) Preparation of the Test

Items for the Achievement in Mathematical Skills were prepared confining to the three basic objectives of cognitive domain namely Knowledge, Comprehension and Application. Items to check the mastery of concept of fractions and decimals, their ordering, uses, fundamental operations and the like were included in the test. Appropriate weightages were given to objectives. Equal weightage was given to each subunit. Only multiple choice items were included in the test. Weightage to level of difficulty was considered while the items were selected.

(iii) Preparations of Blue Print

A blue print ensuring weightage to objectives and content were prepared. The form of questions was already fixed as to include only the multiple choice items.
A two-way grid specifying weightage to objective and content was prepared as a blue print for the final test and is given in Table 3.1.
iv) **Item Writing**

Based on the blue print an initial pool of 150 items were prepared to be included in the draft test so as to get enough number of items of proved psychometric properties in the final test. For each item four answers were given of which only one is the correct answer and other three are distractors. Seventy five items were prepared from the topic fractions and the remaining seventy five from decimals. The items were scrutinied by experienced mathematics teachers and teacher educators. On the basis of their suggestions some items were modified. Illustration of each item under each objective is given below.

<table>
<thead>
<tr>
<th>Content</th>
<th>Knowledge</th>
<th>Comprehension</th>
<th>Application</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>--</td>
<td>--</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>--</td>
<td>7</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>5</td>
<td>--</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>--</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>--</td>
<td>3</td>
<td>7</td>
<td>10</td>
</tr>
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<td>6</td>
<td>10</td>
<td>--</td>
<td>--</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>--</td>
<td>--</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>5</td>
<td>--</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>--</td>
<td>--</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>10</td>
<td>--</td>
<td>--</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>35</strong></td>
<td><strong>30</strong></td>
<td><strong>35</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
• Knowledge Category

Fraction → Write the fraction of the shaded portion in the given figure

![Figure]

3 2 1 4

[A. --- B. ---- C. --- D. ----] 4 4 3 1

Decimal → Find the correct decimal to the fraction 9 ---

10

[A. 91.0 B. 9.01 C. 9.1 D. 0.91]

• Comprehension Category

Fraction → Find the fraction in between --- and --- having 32 as denominator.

5 3

8 4

18 22 20 42

[A. ------ B. ------- C. ------- D. ------]

32 32 32 32

Decimal → 10 thousandth = 1 ---------------

A. tenth B. hundredth C. Thousandth D. one

• Application Category

Fraction → Add 5 --- + 4 ---

4 5

1 1

[A. 9 ------- B. ------- C. 9 ---- D. 9 ----]

9 20 4 5
Decimal → Multiply 6.03 x 1.0

[A. 0.603   B. 6.03   C. 60.03   D. 600.3]

V. Pilot Testing

A draft test consisting of 150 items with general instruction and specific instruction for answering the questions was prepared according to the blueprint. The test was administered to ten students of standard VII selected randomly. Oral instructions were also given besides the written instruction whenever necessary to clear doubts. Time taken for completion of test by each student was also noted. Scoring was done on the basis of already prepared scoring key. Observation of students taking test and analysing the problems faced by students who took the test, slight changes were made in the instructions. Thus preliminary test was prepared.

(vi) Try-out of the Draft Test

The draft test prepared consisting 150 – multiple choice items were administered to a sample of 120 students of standard VII. Before administering the test the investigator approached the administrators and pupils to make clear the purpose of the test. The test was administered under ideal conditions. The test together with response sheet was given to subjects. General guidelines were given before the test started. Specific guidelines were given at appropriate time and additional information whenever necessary.

The response sheets were collected and scored using the already prepared scoring key. One score was given for the correct answer and no score was given to wrong answers.
(vii) Item Analysis

Item analysis was undertaken using the method suggested by Ebel and Frisbie (1991). 100 response sheets were taken for item analysis. In complete sheets and manipulated sheets were discarded. For the analysis the response sheets were arranged in the descending order of total marks obtained by the subjects. The top twenty five scores were selected as upper section and those twenty five who scored the lowest marks were selected as lower section. The response for each item by the two groups was noticed. The index of difficulty and discriminating power of each item were computed using the formula suggested by Ebel and Frisbie (1991).

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

Difficulty Index of item, \(D_i = \frac{U - L}{N}\)

Discriminating power of item, \(D_i = \frac{U - L}{N}\)

Where,

\(U = \) Number of right responses in the upper group.
\(L = \) Number of right responses in the lower group.
\(N = \) Number of subjects in any of the group.

The item difficulty and discriminating power of each item was calculated.

Achievement Test in Mathematical Skills, Item Analysis, Achievement Test in Mathematical Skills Post Test I and Score Sheet are given in Appendix V A, V B, V C, V D respectively.

Difficulty index ranging between 0.30 and .80 with discriminating power above 0.30 were readily selected for the final test. However a few
items with .28 and .80 were also selected to match with the blue print. Thus final test with 100 items was prepared with necessary instructions to respond. This test was then put to test for validity and reliability.

**Validity**

The validity of the Achievement Test in Mathematics was established in two different ways.

Subjecting the test items for experts' criticism content validity of the test was ensured. As per the evaluation of experts, the test content agrees with the treatment content in both the dimensions objective basedness and comprehensiveness.

Criterion validity was established by correlating the scores on Achievement Test in Mathematical Skills obtained by seventy students of Class VII in Palakkad district with their marks obtained in mathematics in the previous terminal examination. Pearson's product moment formula was used for this purpose. The correlation coefficient was found to be 0.68.

**Reliability**

The split half reliability was established on a sample of 70 students of VII in Palakkad District from which the test was validated. The total score for Achievement in Mathematical Skills was split into two—two sets of scores were obtained by splitting the total score into two for each student, by taking odd numbered as one set and even numbered questions a second set. The two sets of scores obtained were correlated using Pearson's product moment formula and applying the formula given below.
The reliability coefficient was found to be 0.82.

The indices of validity and reliability indicated that the Achievement Test in Mathematical Skills has acceptable psychometric properties to measure the Achievement in Mathematical Skills of standard VII pupils.

(X) Preparation of Post-Test I and Post-Test II

A parallel test was prepared on the basis of the same blueprint of Pre Test. This test was used as Post-Test I and retention test, that if Post Test II. The Test in Achievement in Mathematical Skills is given as Appendix VI

3.4.1.6. Data Collection Procedure

After finalising the selection of schools for the present investigation, heads of the schools were contacted through proper channel for getting permission for conducting the experiment. The investigator appraised the heads of the schools regarding the importance of the study and a schedule was fixed for experimental schools and control schools. The experimentation commenced on the month of July and completed on November, 2003.

3.4.1.6.1. Administration of Pre-Test

Prior to the introduction of treatment in the selected schools, data on Previous Knowledge of Subject Matter directly linked with the experiment, Non-Verbal Intelligence, Numerical Ability of the subjects were collected. For this purpose, Achievement Test in Mathematical Skills (Pre-Test), Raven Progressive Matrices Test and Numerical Ability Test were
administered. The procedure suggested in the manuel for the administration was followed especially for Raven Progressive Matrices Test. The data thus collected ensured the entry status of the students in terms of Achievement in Mathematical Skills; Non-Verbal Intelligence and Numerical Ability.

3.4.1.6.2. Procedure of Treatment

The Experimental groups and control groups were given different treatments. The investigator has identified that each class transaction (whether it be experimental or control) lessons can be broadly categorised into four phases. They are:

(i) Introduction
(ii) Development
(iii) Application
(iv) Review and Recitation

3.4.1.6.2.1 Control Group

The treatment procedure in the control group is described below.

Students of standard VII of Nair Service Society K.P. Thampan Higher Secondary School (English medium classes) form the control group. The data collection and treatment commenced on July, 2003. Without altering the organisational set up of the classroom the investigator herself taught the lessons through Objective Based Instruction. Only conventional teaching aids were used during the treatment. Twenty four lessons were given and it took three weeks to complete it. No formative/unit test was administered during the treatment. No separate grouping of class or rearrangement of seating of students was done for control group.
(i) Introduction

For each class the first seven minutes was spent for the introduction stage. During this stage the previous lesson was reviewed and also few introductory questions relevant to that days lesson were asked to motivate the pupils' and create interest in the class. Thus a favourable situation for learning was created. The day's lesson was presented in most classes in a problematic way.

(ii) Development

The second stage was the development stage. At this phase the investigator tried to develop the new concepts, rules and the like in an expository manner. It was done mostly through pupil activity or through illustrative talk. Though there were pupil activities they were mostly teacher directed and uniform for all students. Appropriate blackboard work was given by the teacher as visual supplement or summary of the lesson. Proper generalisation and discriminations were done through several examples.

In this group pupils were mostly passive observers and there were more teacher activity. Occasionally mass answering is allowed. Pupils do not get enough opportunity to participate actively in the learning process. About fifteen minutes was spent for this stage.

(iii) Application

The third stage is application stage. Here the subjects applied the newly learned concepts or principles in new and day-to-day situations. At first it was done with the help of teachers and then subjects will be allowed to do it by themselves. For Control Group the investigator gave no attention to group work. Only common individual work either as class work or homework. Individual mastery was ensured then and there. Only sample student-
mastery was noticed. No error rate measurement was done for this group and any individual remedies. General instructions were given as remedy if it was needed.

(iv) Review and Recitation

This was the last stage. About eight minutes was spent for this stage. Pupils recited silently the newly learned concepts, rules and the like. Teacher-directed evaluation was done during this stage. Class assignments, and procedure for home assignments were also given.

Twenty four lessons were taken in twenty four periods. No remedial teaching was attempted during treatment. But doubts were cleared during review stage.

3.4.1.6.2.2 Experimental Group I

The procedure of treatment given to Experimental group I is described below.

(i) Grouping of Students

Before giving treatment subjects were divided into six groups on the basis of their performance in the Pre-test. Each group consisted of five pupils getting almost same score in the Pre-test, thus making the groups homogeneous.

Twenty four lesson plans based on Direct Instruction Model were already prepared for Experimental Group I. The different phases of class teaching using Direct Instruction model is detailed below.

ii) Introduction

Classes started with the first phase of Direct Instruction Model called 'Attention and Focus'. It is the anticipatory set also called as "hook" which
helps to grab the students' attention, actions and statements to the objectives of the lesson. The teacher as an instructional leader began the lesson by explaining the objectives of the day's lesson for establishing a learning set. The teacher also gave an abbreviated version of the sub-objectives in a problematic manner. Attention signals suitable to each lesson such as the agenda to the class, questions to be probed, task to be performed and time schedule for each segment of the lesson were also listed. These were done to put student into a respective frame of mind, that is, to focus student attention on the lesson, to create an organizing framework for the idea, principles or information that are to be followed and to extend the understanding and application of abstract ideas. This was done with a view to help students to master the study materials and to get their activities to be more open ended and properly guided.

In phase-2, 'Orientation', the investigator pinpointed how the lesson builds on the prior work and how it can be connected to long-range objectives and they were written as teacher presentation scripts. From the second day onwards a short review of the previous lesson was also done. Providing the rationale and overview of any lesson is important, especially for skill-oriented lessons. These were done using selected techniques such as telling a story as in the case of introducing fraction, creating a problematic situation and the like which serve (as in the use of like decimals and unlike decimals) to arouse and sustain interest in the day's lesson. About seven minutes was allotted to complete these two phases. The introduction stage of Objective Based Instruction also includes these two phases.

iii) Development of the lesson

In phase-3, 'Model' of Direct Instruction Model, the investigator demonstrated or explained or illustrated the task to be performed by the subjects. Active student participation was ensured during this period. For
this purpose many paper cuttings, crayons, coloured papers, flannel board, charts and other teaching aids were used. Carefully designed demonstrations were followed. These are called 'formats'. Demonstrations were sequentially and logically arranged. Also the formats were carefully designed so as to eliminate ambiguous communication. In this phase students were kept busy as they participate in different activities. They were given different learning tasks to arrange the given materials/objects, classify or discriminate them, on the basis of which to identify new facts and concepts, develop principles and then verbalize it, symbolise it or define them and finally to develop skills in performing a particular principle depending on the demand of the day's lesson. When students were busy with the task in small groups the investigator closely supervised them and coached whenever necessary.

Investigator used prompts or cues for helping pupils for mastery. Some pupils required a more intense level of prompting inorder to accomplish a task. Prompts were given in the least instructive way, with an intention of fading them as soon as possible. One is not allowed to do the next part of a task until the prompt had been given. Gradually moving through levels of prompts students began to master each task. Pupils who were provided with support from a teacher or volunteer from the group rely on that person to give directions rather than responding to the direction. The prompts given were as follows:

- Physically assist the pupils to do the task.
- Physical assistance (if necessary) to complete the task.
- Given a gesture, or model the task, so that pupils can copy the action.
- Giving direct verbal prompt, such as :"Try to arrange it correctly."
- Giving indirect verbal prompt, such as: "what to do next?" or "How can you finish it?"
It is very important that all students are to master every concept, with no exception. To strengthen pupil's correct or improved actions and to correct every mistake on the spot, the investigator and subjects engaged and interacted continuously.

Performance of each subject in the group work was recorded. The grouping helped the investigator for easy recording. This phase is similar to the demonstration stage of Objective Based Instruction and it took about fifteen minutes to complete.

(iv) Application

The fourth phase of Direct Instruction Model – 'Lead', which is also known, as 'Guided Practice' is included in the Application category. Here an opportunity was given to each subject to demonstrate the grasp of new learning by working through a new activity or exercise selected other than the one given earlier and provided by the investigator under her direct supervision. The investigator and subjects worked together to find out the solution of the problem for those who cannot solve it independently. The investigator moved around the classroom to provide individual remediation. If students were not accurate, or if one among them hesitate to respond or respond incorrectly the whole group went through a brief correction procedure until all were firm.

(v) Review and Recitation

In phase 5 'Test' also called 'Independent Practice' occur immediately after the 'lead'. Investigator looked for accurate and quick (firm and fluent) actions from subjects in response to the investigator's signs. When subjects appeared firm, she gave opportunities for them to more independent use of concepts or principles they have learned in that class. Worksheets were
already prepared for each lesson and were distributed among subjects at this stage.

The following points were attended to during the independent practice.

- Independent practice was not assigned until it is assured that all students can do it.
- Independent practice assignments were kept as short as possible.
- Clear instructions were given for doing the practice tasks.
- Once students have begun the tasks they were not interrupted.
- Periodic monitoring of independent works was made for successful completion of the task.

Error rates were recorded for each student after the session. Class will not proceed to the next lesson until the subjects were below the prefixed error rate. Whenever necessary peer tutoring was given to minimise the error rates and maximize the mastery of the learning. This phase takes about fifteen to twenty minutes to complete.

Phase-6 is the 'Delayed Test' when a large number of students make a greater number of errors, the lessons were repeated once again. When the number of students who made the error was lesser then peer tutoring was given. Additional drill work, home assignments and new work sheets were given once more. Also mastery was ensured at this stage. The last and final phase is 'Weekly Review'. Weekly review was done after every subunit. That is after two or three lessons. A 'formative test' was given at this stage, to each and every student to ensure the mastery over that particular sub-unit. The investigator did not go to the next subunit until the mastery over the present subunit was clear. If mastery was not attained any of the remedial steps such as re-teaching peer-tutoring, drill work, home assignments and the like were provided again (depending upon the situation) until mastery was ensured.
These two phases were not provided to control group and the mastery was not strictly ensured for them.

This procedure was followed for teaching the predetermined content of the topics in fractions and decimals. Altogether twentyfour lessons were taught to Experimental Group I, as per Direct Instruction Model. Nine formative tests with duration fifteen to twenty minutes were given to this group. Five formative tests were scrutinised by the subjects themselves and four were scrutinised by the investigator. Time, after the completion of formative tests was used for guided remedial. Thirty periods were required for the completion of the treatment for Experimental group I.

In Direct Instruction Model of teaching the grouping of the class was made based on the Previous Knowledge of the Subject Matter as the result of Pre-test. The pupil mastery was determined on the basis of error-rates made in the work-sheets of previous class, achievement regrouping during the progress of the lessons that is students pace of learning and nature of reinforcement and the like. This ensures the principles of reaction inherent in the Direct Instruction Model.

**Support System**

The sequential and logical arrangement of the learning tasks, objectives and their acceptable level of performance, their relation with previous task, meaningful learning experiences, tailored activities, scripted lesson plans, rhythmic choral and individual responses, guided practice, independent practice, motivation from teacher, knowledge of performance of each class, confidence in mastering a skill or task and the like acted as the support system of Direct Instruction Model.
Social System

Social system it can be noted that even though this model is primarily teacher directed the learning environment was not strictly authoritarian. The task orientation was with high expectations from student accomplishment. Careful orchestrations were given while structuring the environment. The investigator and subjects identified the goals of each class in a manageable chunk. The teacher provided appropriate instructions and guidance during the activities carried by the learners. These are the social system in this model.

Instructional Effect

The highly structured instructional approach accelerated the learning. Student motivation was another instructional effect by this model. The most important effect was it helped to move students to mastery as quickly as possible and developed the ability to perform a skill independently without any error. Due to the self-pacing ability developed in student increased the achievement.

3.4.1.6. 2. 3. Experimental Group II

The procedure of treatment in Experimental Group II is described below.

St. Teresa's Higher Secondary School was taken as the Experimental Group II. Twentyfour lessons were taken to Experimental Group II also alternative subunits were taught through Direct Instruction Model and Objective Based Instruction. The second, fourth, sixth and eighth units were taught through Direct Instruction Model. The first, third, fifth, seventh and ninth units were taught through objective Based Instruction. The formative tests based on second, fourth, sixth, and eighth units were given to Experimental Group II.
Four formative tests – two from fractions and two from decimals – were given to this group. Guided remedies were given after formative tests when Direct Instruction Model was followed. No mastery was ensured for the lessons taken through Objective Based Instruction. Twenty six class periods of 45 minutes each were taken for the completion of the treatment for Experimental Group II.

3.4.1.6.3. Administration of Post-Test I

To quantify the terminal characteristics of the subjects in terms of Achievement in Mathematical Skills the investigator administered a Post-Test. The Post-Test data from the subjects in Control Group, Experimental Group I and Experimental Group II were gathered the next day after the completion of the treatments.

A parallel test of Pre-Test was prepared for this purpose. The Post-Test material was prepared before administering the test, all necessary guidelines and the purpose for which it is going to administer were explained to the subjects in each group.

3.4.1.6.4. Administration of Post-Test II

Two months after the treatment the investigator administered the Post-test once again to Control Group, Experimental Group I and Experimental Group II. The aim of this test was to explore the extent of retention of Achievement in Mathematical Skills of standard VII pupils.

3.4.2. Scoring and Consolidation of Data

Scoring key was already prepared for scoring the response sheets. The investigator strictly followed the specific directions given in the manual for Raven Progressive Matrices Test; Punched scoring keys were used for Achievement Test in Mathematical Skills and Numerical Ability Test.
Incomplete score sheets and data obtained from students who had not regularly attended the experimental class sessions were not included for the analysis. Cases, which are complete in all respects, were taken into consideration. Thus data regarding final sample of 135 subjects were considered for final analysis. The break-up of the actual number of subjects falling under different category is given in Table 3.2.

**TABLE 3.2**

**Number of Subjects Under Different Groups**

<table>
<thead>
<tr>
<th>Name of Group</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Group I</td>
<td>22</td>
<td>23</td>
<td>45</td>
</tr>
<tr>
<td>Experimental Group II</td>
<td>22</td>
<td>23</td>
<td>45</td>
</tr>
<tr>
<td>Control Group</td>
<td>22</td>
<td>23</td>
<td>45</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>66</td>
<td>69</td>
<td>135</td>
</tr>
</tbody>
</table>

**3.4.3. Procedure Used for Analysis of Data**

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

**3.4.3.1. Classificatory Techniques**

Using median as cut-off point the subjects in different groups were categorised into two. Based on the scores of Pre-test subjects were categorised as Below – Average - Previous - Knowledge Group and Above – Average – Previous – Knowledge Group. In the experimentation the median of Previous – Knowledge was found to be 40.79. Subjects who scored 40 and below 40 were categorised as Below – Average – Previous – Knowledge.
(BAPK) group and those who scored above 40 were considered as above Average – Previous Knowledge (AAPK) group.

The actual number of subjects falling under the two category of Previous Knowledge (BAPK and AAPK) is given in Table 3.4.

**TABLE 3.3**

<table>
<thead>
<tr>
<th>Nature of Group</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BAPK</td>
<td>AAPK</td>
<td>BAPK</td>
</tr>
<tr>
<td>Experimental Group I</td>
<td>13</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Experimental Group II</td>
<td>15</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Control Group</td>
<td>13</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

The median of Non-Verbal Intelligence was found to be 33.93 for the total sample. Those who scored above 33 were considered as having Above Average Intelligence (AAI) and those who scored 33 and below were treated as Below Average Intelligence (BAI). The actual number of subjects falling under each category of Intelligence (BAI and AAI) is given in Table 3.4.
The median of Numerical Ability Test was found to be 33.92. Those who scored 33 and below were taken as having Below - Average - Numerical - Ability (BANA) and those who scored 34 and above were treated as Above- Average-Numerical-Ability (AANA). The number of subjects falling under BANA and AANA is given in Table 3.5.

**TABLE 3.5**

<table>
<thead>
<tr>
<th>Nature of Group</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BANA</td>
<td>AANA</td>
<td>BANA</td>
</tr>
<tr>
<td>Experimental Group I</td>
<td>12</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Experimental Group II</td>
<td>8</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>Control Group</td>
<td>10</td>
<td>12</td>
<td>16</td>
</tr>
</tbody>
</table>

**TABLE 3.4**

Number of Subjects under the category of Below-Average Intelligence and Above-Average Intelligence

<table>
<thead>
<tr>
<th>Nature of Group</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BAI</td>
<td>AAI</td>
<td>BAI</td>
</tr>
<tr>
<td>Experimental Group I</td>
<td>17</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Experimental Group II</td>
<td>12</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Control Group</td>
<td>11</td>
<td>11</td>
<td>12</td>
</tr>
</tbody>
</table>
3.4.3.2. Statistical Techniques Used for Analysis of Data

Statistical techniques employed in the study are given below:

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

To test the first four hypotheses the test of significance of difference between means of large and small independent sample was used. Experimental group I and control group and Experimental group II and Control group were compared with respect to their mean Pre-test, Post-Test-I, Post-Test II and Gain scores (Objective wise and Total Score) for Total Sample, Boys and Girls were done using this method.

The difference between means was tested using two-tailed test of significance and the results were interpreted using appropriate degrees of freedom.

B. Two-way Analysis of Variance (ANOVA) with 2 x 2 Factorial Design

To study the main effect and interaction effect of Direct Instruction Model on Achievement in Mathematical Skills of Upper Primary Pupils Two-way Analysis of Variance was employed. The two levels of methods of teaching were made by using the two levels of Previous Knowledge of Subject Matter, Non-Verbal Intelligence and Numerical Ability.

Subjects of the sample belong to anyone of the following four combinations based on method of teaching and Previous Knowledge of the Subject Matter.

(i) Direct Instruction with Below-Average Previous Knowledge of Subject Matter.
(ii) Direct Instruction with Above-Average Previous Knowledge of Subject Matter.

(iii) Objective Based Instruction with Below-Average Previous Knowledge of Subject Matter.

(iv) Objective Based Instruction with Above-Average Previous Knowledge of Subject Matter.

Again the subjects were categorised into four groups based on methods of teaching and Non-Verbal Intelligence and the groups are given below.

(i) Direct Instruction Model with Below-Average-Non-Verbal Intelligence.

(ii) Direct Instruction Model with Above-Average-Non-Verbal Intelligence.

(iii) Objective Based Instruction with Below-Average-Non-Verbal Intelligence.

(iv) Objective Based Instruction with Above-Average-Non-Verbal Intelligence.

Similarly subjects were grouped into four on the basis of the method of instruction and Numerical Ability. The groups are as follows.

(i) Direct Instruction Model with Below-Average-Numerical Ability.

(ii) Direct-Instruction Model with Above-Average-Numerical-Ability.

(iii) Objective Based Instruction with Below-Average-Numerical Ability.

(iv) Objective Based Instruction with Above-Average-Numerical Ability.

Two-way ANOVA with 2 x 2 factorial design was used to study the main effect and interaction effect of the two Independent variables on Achievement in Mathematical Skills (Post-Test I and Post-Test II).
Interpretation of the analysis was done on the basis of F-values – whether F-ratio is significant or not.

C. Two-way Analysis of Covariance (ANCOVA) with 2 x 2 Factorial Design

Using the two-way factorial ANCOVA, the effectiveness of Direct Instruction Model on Achievement in Mathematical Skills over Objective Based Instruction was examined. ANCOVA was employed with three covariates, 'Previous-Knowledge of the Subject Matter' (Pre-Test Scores), 'Non-Verbal Intelligence' and 'Numerical Ability' separately. Analysis of Covariance serves the purpose of statistically removing the effects of extraneous variables from the Dependent Variable (Ferguson, 1996). In the present study it is used to remove statistically the effects of Pre-Test scores, Non-Verbal Intelligence and Numerical Ability separately.

Analysis of Covariance is a statistical technique used to control or adjusts for the effects of one or more uncontrolled variables and permit there by a valued evaluation of the outcomes of the experiment (Ferguson, 1996). This techniques is applied when there are one or more correlated variables existed with the dependent variable. This statistical technique represents an extension of Analysis of Variance to allow for the correlation between initial and final scores. Also it is possible to effect adjustments in final or terminal scores which will allow for difference in same initial variable.