CHAPTER - III

THE PROBLEM AND PROCEDURE

3.1 Introduction:

Among the various subjects, Mathematics has been considered a necessary part of general education by every group that has deliberated on what the content of general education should be, and it is a required subject in the school curriculum. Mathematical knowledge is of great social significance in that, in jobs in which work is based heavily on quantification and measurement like that of scientists, engineers, statisticians and accountants, a knowledge of Mathematics is necessary to an understanding of the theory of the primary subject matter. Even for laymen, Mathematics is of vital importance in their day to day life. Besides the knowledge aspect, a study of Mathematics would help to develop in the learners certain abilities like logical thinking, problem solving, accuracy and precision which are necessary to meet the challenges of daily life. But Mathematics is a stumbling block for many, and students who find it hard to understand and grasp mathematical concepts, offer the teacher a great challenge. Thus, to prevent the learning process from becoming dull, the Mathematics teacher has the great responsibility of looking around for ways and means of improving the methodology of teaching this subject.

Furthermore, the curriculum of school mathematics has undergone a change to meet the needs of a highly scientific and technological society. It could even be said that there is a step-up in the standard of school mathematics syllabus which in turn emphasises on the need to modernise Mathematics instruction in school. As the importance and influence of Mathematics has increased considerably in the present century and today almost all the disciplines need a strong foundation in mathematics, the development of concepts at elementary level is more important. Hence knowing the importance of mathematics at the elementary school level and considering 'Education' as a purposeful activity, a fundamental task in education is to develop strategies which will take into account individual differences in such a way as to promote the fullest development of the individual. Keeping this view in mind; an attempt has been made in the present study to achieve the fullest development of the learner, through the development of mastery learning strategy in fifth-grade geometry.

I. Statement of the Problem: The present study is entitled "A Strategy for Mastery Learning in Fifth-grade Geometry".

II. Research Hypothesis: The strategy for mastery learning will be effective in leading most of the pupils to the mastery level. Here by the term 'most of the pupils' means at least 75 percent of the pupils under the experiment.

III. Objectives: The study is designed to achieve the following objectives.

1. To develop a strategy for mastery learning in Geometry for the pupils of fifth grade.

2. To validate the effectiveness of the developed strategy.

IV. Definition of the terms used:

(i) Mastery Learning: For this study mastery learning is defined as follows:

Mastery learning indicates the level which each pupil attains when he/she is able to give atleast 80 percent correct response on a formative/summative test that has been constructed based on instructional objectives with respect to that unit/course which each pupil is expected to achieve.

(ii) Most of the pupils means at least 75 percent of the pupils under the experiment.

(iii) Instructional Strategy: Development of the instructional strategy to attain mastery learning is the main task of the present investigation.

This strategy comprises various components which are to be used accordingly to the demands of the teaching learning situation. The components are as follows which were to be employed in suitable combinations in the strategy. (1) Introduction (2) Structured lecture (3) Discussion session (4) Problem solving (5) Mathematical models (6) Individualised tutorial (7) PLM (8) Text books and work books (9) Small group study sessions (10) Mathematical games (11) Review and practising (12) Assignments

(13) Feedback session (14) Formative and summative tests.

The present study is basically a developmental effort in that the instructional inputs hypothesised to have the potential to yield definite results in terms of pupil's achievement were selected, organised and validated. So before discussing about the research design it will be better here to discuss about the significance of developmental research.

3.2 Significance of Developmental Research:

The significance of developmental research is two fold. Such research not only increases the applicability of educational practices in specific situations, but also helps in generating better insight into the instructional process. Quite a number of researchers and practitioners have high-lighted the significance of developmental research in increasing the applicability of practical models of educational interventions as well as generating better insight into the interplay of various variables in the context of intervention under study. It may be mentioned that terms like field experiments (Wiles, 1972), 'a - experimentation' (Guba, 1971) etc. have been used referring to developmental research.

Wiles (1972) suggests the use of field experiments in educational research in order to increase the applicability of fairly stable models, inputs, etc. developed in controlled conditions. In these experimentations, which are carried out in real settings, the researcher may manipulate certain variables of his interest but does not control all unwanted variables, such as environmental. Although the presence of a large number of variables makes the replication of the study difficult, the field experimentation is more realistic and life like. A similar view point is put forward by Guba (1971) when he discusses on 'methodological strategies for educational research'. He opines that the transition from the findings of fundamental research to the development of some new and improved practice calls for field studies and would enable these findings to be tried out and modified to suit specific sets of conditions. He suggests the conduct of 'a - experimental' studies for this purpose.

It may be seen from the various views that there is the necessity to conduct experimentations in real conditions for effective applications of generalisations. Such experimentations would lead to the development of systematisation of instructional strategy. However, it may not be concluded that formal laboratory type research is not necessary at all; instead such research would provide

the basis for arriving at models, strategies, etc.; which are to be tried out in real conditions, with no controls, over a long period of time longitudinally and also cutting across similar and differing conditions. Such research in less controlled situations would make application and practice more feasible.

More than putting results of laboratory research into practice and thus making them more realistic and feasible, research in real situations would help in gaining increased understanding of the relationship existing among numerous variables in an instructional situation. Such an understanding of the explicit and subtle relationships among variables gained through long range studies in one situation and large number of studies in similar situations would move towards evolving theorisation in instruction. According to Banner (1964), Maccia (1967) and Travers (1966) conducting research in real conditions where all related variables will function in a natural fashion is very much significant and is of great importance. A complex interplay operating among these variables would provide new patterns of relationships possibly different from those which are arrived at from research in controlled conditions. Even a mere description of such relationships inherent in various educational processes, helps to draw out certain implications towards the generation of better understanding about the educational process.

3.3 Designing Developmental Studies:

The developmental type of investigations provide facility to bring instructional process under scientific scrutiny and has shown great possibility of understanding the complex interplay of the process in real instructional situations. The conduct of developmental type of research although increases the applicability as well as the insight into the instructional process, there is an apparent decrease in the scientificity of the investigation. Sophisticated designs of investigation would be less suitable for studies in real situations. This is not to argue that in such investigations the scientificity may be sacrified; rather the efforts should be to identify or develop designs suitable for developmental studies. Designing developmental research should help to answer questions like how high a score is reached by the end of a fixed present period of instruction rather than how long it will take by one form of instruction or another to get students upto some present minimum level of proficiency. This would necessiate the evaluation devices to be designed and scheduled in such a way that they may be utilised at different steps or units of instruction. Further, the evaluation may have to be comprehensive enough to include all instructional objectives. The devices should provide a valid indicator that the criterion level has been reached at different stages of instruction.

While discussing the necessity to evolve new methodology to carry out developmental studies, which he calls as a - experimentation, Guba (1965) comes out with various ways of designing studies. He describes a technique of continuous time analysis of data that might enable the field investigator to identify crucial events in the processes he is studying. He gives an example of the use of educational films as an instructional device. The criterion measurement may be done continuously over a period of time and plotted against time. The time series experiment, a quasi-experimental design propounded by Campbell and Stanley (1963) is very similar to what is discussed by Guba (1965). The essence of the time-series design is the presence of a periodic measurement process on some group or individual and the introduction of an experimental change into this time series of measurements, the results of which are indicated by a discontinuing in the measurements recorded in the time series.

Yates (1971) suggests another technique for developmental studies. Technique of retrospective interviewing might be used to trace the origins of observed phenomenon. There is no opportunity in such methods to control variables or to restrict the number that are examined. Such a technique would serve a starting point for developing and refining methods appropriate to developmental studies in specific settings.

Various suggestions have been made regarding the design of developmental research by different educationalists. It may be mentioned here that all these are not well defined and tried out methods and thus would need further modifications in order to utilize in specific research situations. And, all these methods may not find a place in single investigation in education. According to the needs of specific investigations one or more methods of research may be adopted for maximising the generation of knowledge through these researches.

3.4 Research Design:

The major question to be answered by the present investigation is the extent to which the pre-prescribed instructional objectives are achieved by the strategy developed for mastery learning. In order to answer this question it had been decided that instruction through the developed strategy for mastery learning in Geometry be conducted in a group of learners of fifth-grade available in a given system without adopting any sophisticated sampling procedures. The study is basically developmental effort in that, the instructional inputs hypothesised to have the potential to yield definite results in terms of pupils' achievement, were selected, organised and validated. This effort has been carried out in the actual context without disturbing the setting for experimental purposes

so that all the variables which are normally at play in teaching learning situations are operative during the investigation. In this way the investigation was designed as per the requirements typical of an a'- experimental study where the concern is to carry out investigations under actual field conditions. Although the study was confined to only two groups in two different schools; with which the developed strategy was experimented, for comparison purpose, two comparable groups (one in each school where experiment was conducted), designated as control groups were employed on the rationale that they too underwent the same course; although not through the developed strategy. Thus in all there were four groups of fifth grade pupils selected from two schools; two in each school such that one group was treated as experimental group and the other as control group. The experimental and control groups were matched for mean and standard deviation of IQ of both the groups. Thus the design employed for the study had control groups even though these were not constituted in the strict sense that they would be, had the study been pure experimental. However, treatment comparison was in accordance with ways adopted in experimental designs. The matched groups were compared to study the effectiveness of the developed strategy in terms of scholastic achievements Also the relationship between intelligence level and achievement were studied from i.e. data obtained.

It had been decided that the performance of the learners would be continuously assessed by administering a formative criterian test after learning through each unit of the geometry course in the developed strategy. It had been also decided to administer a summative criterion test when all the units of Geometry course (of fifth grade) are completely taught. These criterion tests were diagnostic in nature. A descriptive analysis of these criterion test scores would be able to reflect the effectiveness of the developed strategy in achieving instructional objectives. Measures like mean, S.D., t-value, percentiles etc. of the criterion test scores would be computed for indicating the extent of performance of the learners. A summative test has been provided at the end of the Geometry course in order to assess the overall performance of the learners.

3.5 Sampling:

The sample for initial field tryout consisted of 55 pupils in the experimental group and 55 in the control group during the month of August and September in the academic session 1984-85, from the Convent of Jesus & Mary School.

In the final field tryout sample consisted of 51 pupils of experimental group and 43 pupils of control group during the month of November and February of the

academic session 1984-85; from the Baroda High School.

It was thought worthwhile to adopt two field tryouts mainly due to two reasons. One is, replication of the tryout has been considered significant towards obtaining better insight regarding the instructional process generated by the developed strategy for mastery learning. The second is, every replication of the tryout helps in further refining the strategy.

3.6 Procedural details of the Study:

The study was conducted under three phases as explained below:

Phase 1: The investigator observed the actual teaching learning process in Mathematics class (only in Std.5th) in schools having English and Gujarati mediums of instruction; for three weeks.

During this observation the investigator observed different methods employed by the teachers in mathematics teaching and discussed about the difficulties arising during the teaching learning process in Mathematics with the subject teachers.

This type of observation and discussion was helpful to the investigator to develop appropriate

instructional strategy in phase 2.

Phase 2: During this phase the investigator taught in the fifth-grade of an English medium school namely The Convent of Jesur & Mary.

Before actual teaching in the fifth-grade, the entire geometry course content was arranged in proper sequence and also the general and specific objectives were formulated.

As it is impracticable to set up groups in which subjects have been matched person to person, the investigator has done matching of the groups in terms of mean and standard deviation. The matching variable used here is intelligence. The two groups were matched upon an intelligence test developed by Dr. G. B. Shah. Then teaching learning process was started with pupils of experimental group (i.e. group A) in fifth-grade. After the completion of each unit a formative criterion unit test was administered(which was diagnostic in nature) which helped in checking the learning progress of each pupil and provided feedback to the investigator and learner. Before administering any test; the subject experts were consulted at the time of formation of each test in the Geometry course by the investigator. Based on these tests the individual learning difficulties

were diagnosed and accordingly the specific remedy was prescribed. Here correctives were alternative learning resources such as use of different texts, PLM, preparing Mathematical models etc.

Thus, with the results obtained from this formative test each student got prescription of what more needs to be done to master the material in that unit. After the corrective process was completed, a second formative test was administered to check on the success of corrective work and to assure mastery achieved by the pupils before introducing the next unit. As the investigator had to take into consideration the time limit given by the school authorities, not more than two formative tests were conducted for each unit.

Instructions for all other units were organised in a similar way utilising a suitable combination of techniques and input materials. To maintain the pupils' learning over a long period of time, review and practice were conducted at some intervals. Then summative evaluation was done through the summative test after completion of all units of Geometry course in fifth-grade.

At the same time in other group of fifth-grade (i.e. control group) of the same school (this other

group was matched with previous one); the same summative test was given to find the difference between achievement of pupils. (Experimental group) of fifth-grade taught by the investigator (using developed strategy) and those (of control group) who were taught by conventional (lecture) method only, by the other teacher. Then on the basis of IQ the experimental and control groups were compared for their scholestic achievement in Geometry.

Phase 3: In this phase the investigator taught Geometry in fifth-grade to a new group of pupils in another English medium school namely the Baroda High School. The strategy which was evolved during second phase was validated in the third phase. The experimental and control groups were matched in terms of mean and standard deviation of IQ in the same way as was done in phase-2; using non-verbal intelligence test developed by Dr. G. B. Shah. Also at the time of formation of any test in the Geometry course; the subject experts were consulted by the investigator as was done in phase-2.

Before actual teaching of Geometry, the pupils were oriented toward mastery learning and the parents of the pupils were given some instructions and made aware of the goal to be achieved. Also the parents of the pupils were made aware of the same by sending cyclostyled

copies to them mentioning about the goal of the investigator (which is given in appendix).

Formative evaluation was an inbuilt aspect of the instructional material. On the basis of these formative criterion unit tests feedback was obtained and accordingly correctives were provided using the appropriate instructional combination of the strategy developed in the second phase, with modifications wherever needed. Those pupils who have achieved mastery standard on a particular unit were engaged with suitable enriched material till that particular unit was completed and mastery was attained by the remaining pupils. To maintain the pupils' learning over a long period of time, review and practice were conducted at some intervals. Summative evaluation was done at the end of the completion of the Geometry course as it was done earlier in the second phase.

Also the same summative test was given to the control group of fifth-grade in the same school who were taught by the school teacher using lecture method only. This was done for the comparison of scholastic achievement of both the groups who were taught by the different methods.

3.7 Course Content and Task Analysis:

To achieve the first objective of the present study that is to develop a strategy for mastery learning in fifth-grade Geometry; it is very much necessary to know the course content of Geometry of fifth-grade, to sequence the topics of the course logically, to decide the objectives to be achieved and then accordingly to identify the learning experiences.

Following is the course content of Geometry of fifth-grade as given in the textbook of fifth-grade prescribed by the 'Gujarat State Board of School Text Books, Ahmedabad'.

Geometry Course Content in Fifth-Grade

The text book of fifth-grade is divided into three sections out of which the third section is containing Geometry course content, which is given as under:

Chapter	Content
Chapter 12	Geometry - an Introductory Idea 1. Introduction 2. A point 3. A Line 4. Plane

Chapter	Content
Chapter 13	Line Segment, Ray, Angle 1. Representation of points and Lines 2. How to Distinguish Points and Lines 3. Line Segment 4. Ray 5. Angle 6. Tools of the Geometry Box
Chapter 14	Types of Angles 1. A Right Angle 2. Angle at a Point 3. An Obtuse Angle 4. An acute Angle
Chapter 15	Parallel Lines 1. Parallel Lines 2. How to Draw Parallel Lines

Before teaching this Geometry course content to the experimental group, it was logically sequenced in ~~the~~ three units by the investigator as under

Logically Sequenced Course Content

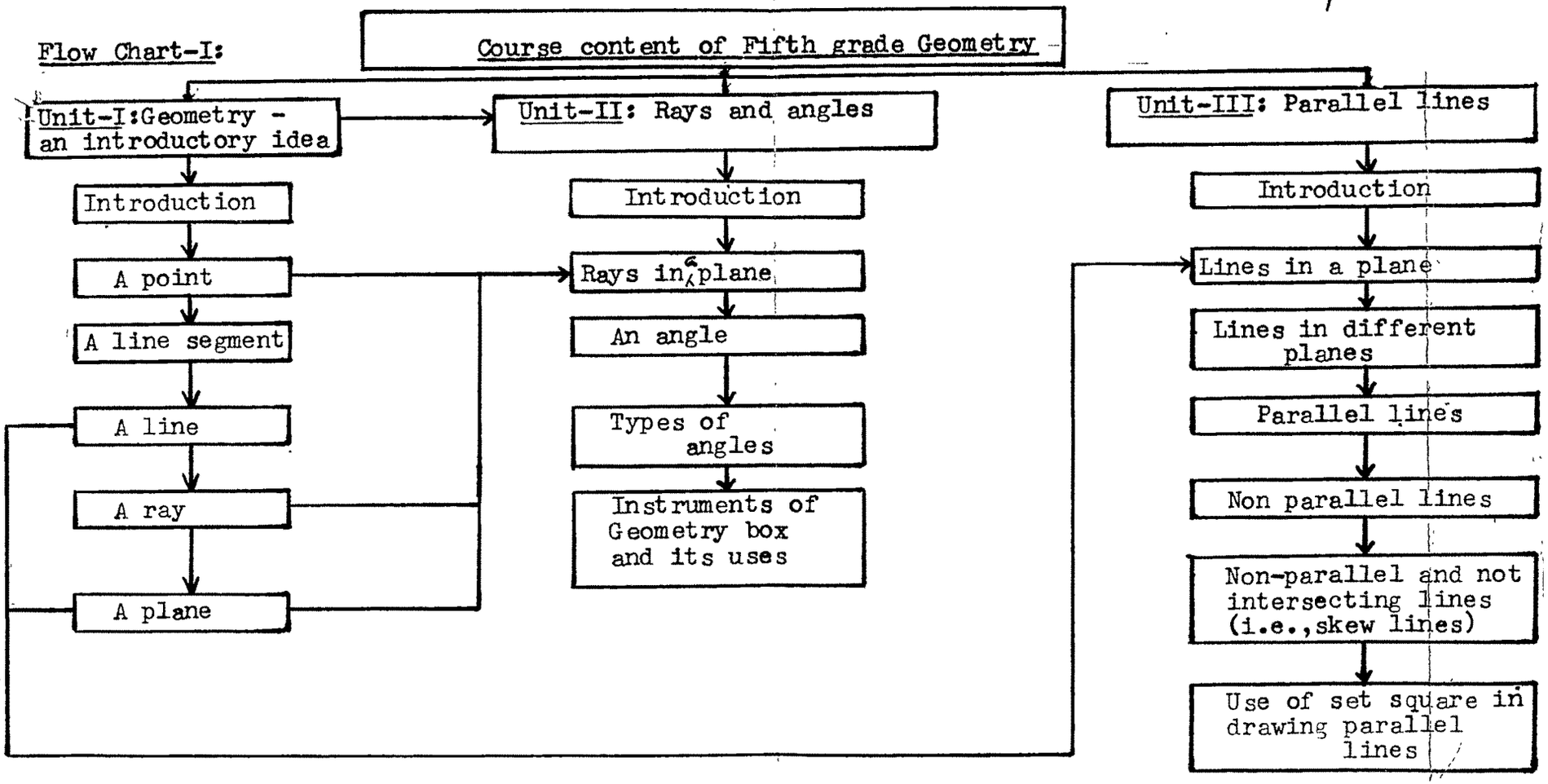
for Fifth-Grade Geometry

Unit I	Geometry - an Introductory Idea 1.1 Introduction 1.2 A Point 1.3 A Line Segment 1.4 A Line 1.5 A Ray 1.6 A Plane

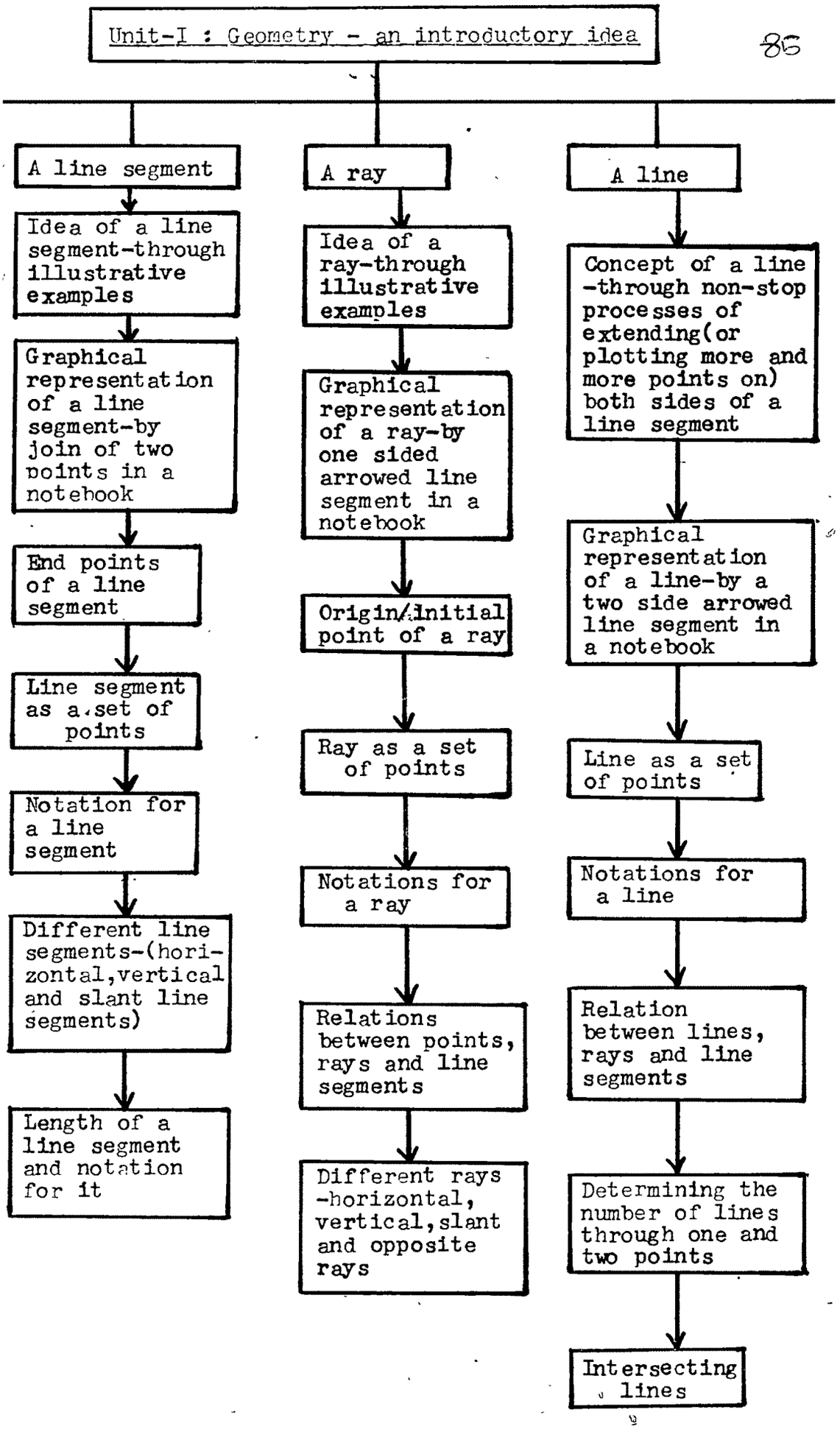
Unit II	Rays and Angles
	2.1 Introduction
	2.2 Ray in a Plane
	2.3 An Angle
	2.4 Types of Angles
	2.5 Instruments of Geometry Box and
Unit III	Parallel Lines
	3.1 Introduction
	3.2 Lines in a Plane
	3.3 Lines in Different Planes
	3.4 Parallel Lines
	3.5 Non-parallel Lines
	3.6 Non-parallel and non-intersecting Lines (i.e. skew lines)
	3.7 Use of Set Square in Drawing Parallel Lines

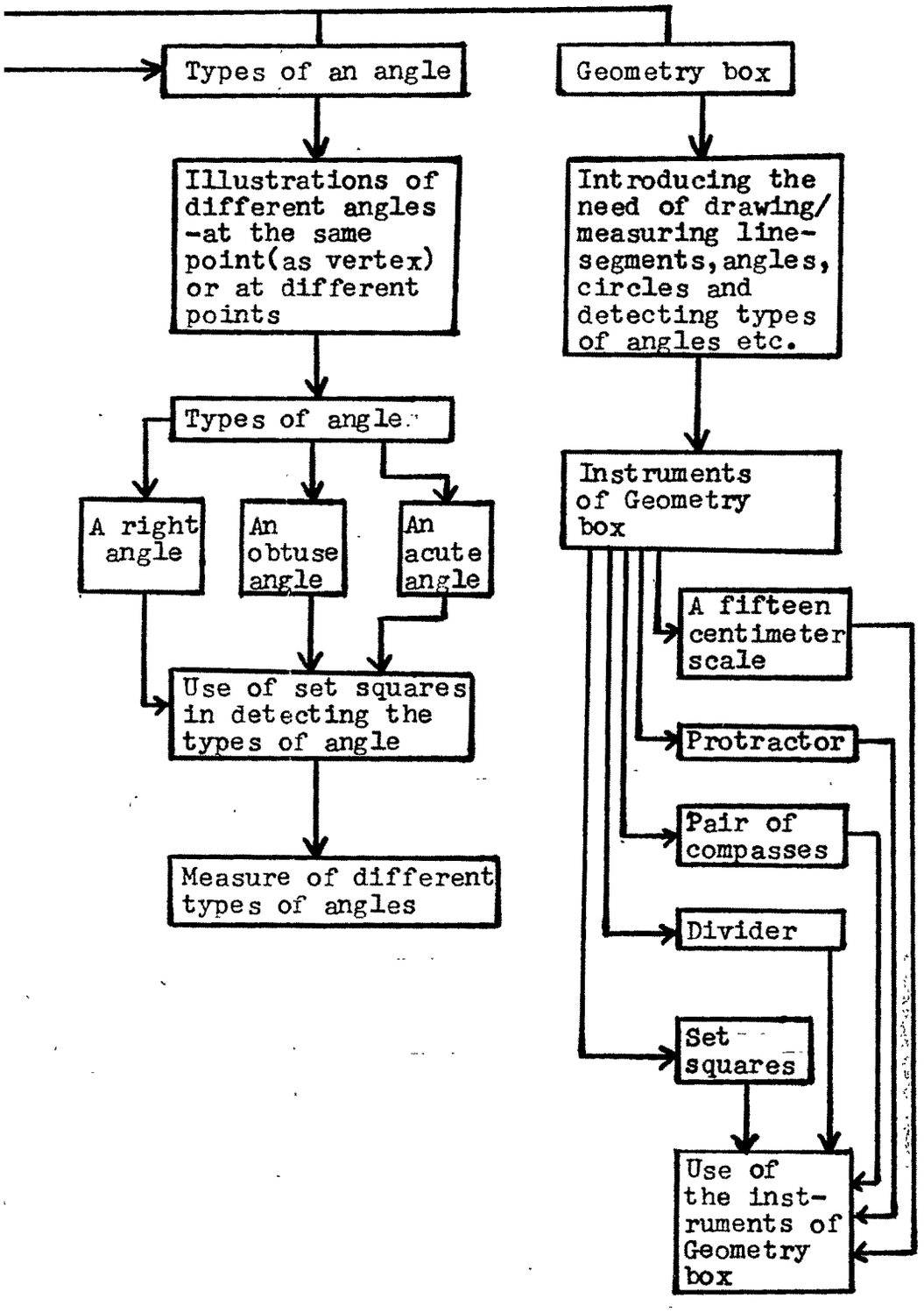
Further, this geometry course content is described in detail with the help of four flow charts which enables to tell how each subtopic of the course is related with each other. It also describes the sequence of each subtopic and the concepts in each unit of the course which was taught by the investigator. After the presentation of these flow charts, objectives of teaching each unit of the Geometry course in fifth-grade are listed.

Flow Chart-I:

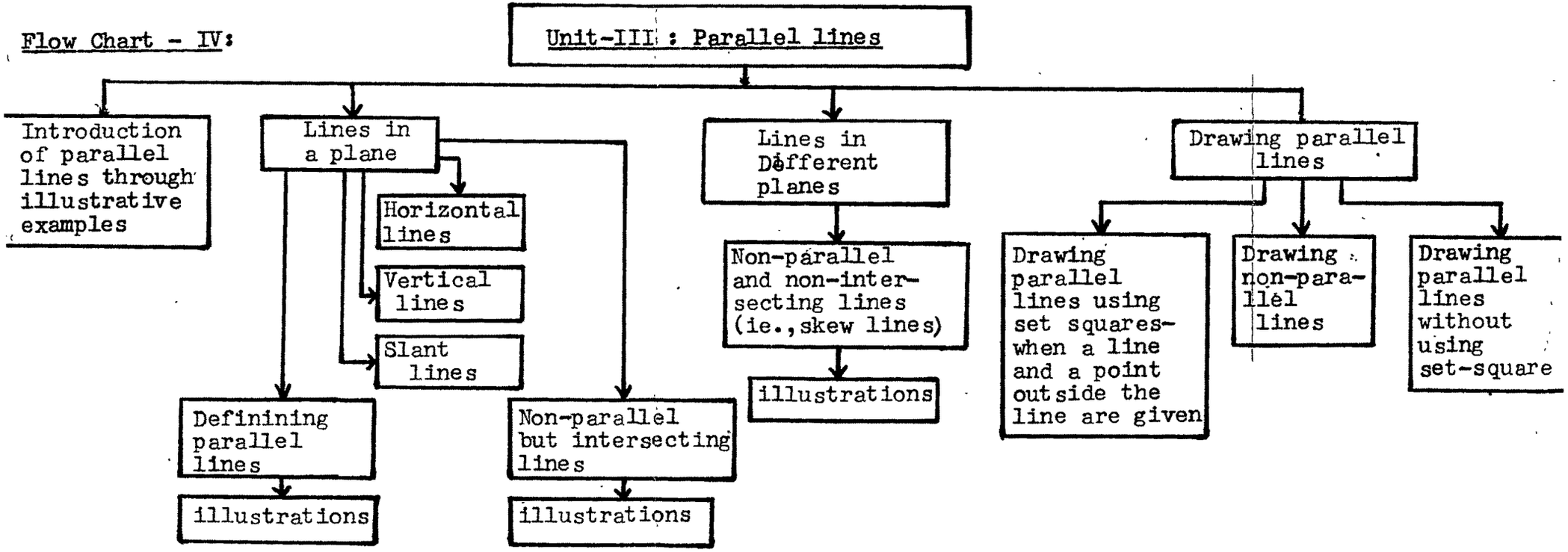

Course content of Fifth grade Geometry
Unit-I:Geometry - an introductory idea
Introduction
A point
A line segment
A line
A ray
A plane
Unit-II: Rays and angles
Introduction
Rays in a plane
An angle
Types of angles
Instruments of Geometry box and its uses
Unit-III: Parallel lines
Introduction
Lines in a plane
Lines in different planes
Parallel lines
Non parallel lines
Non-parallel and not intersecting lines (i.e.,skew lines)
Use of set square in drawing parallel lines

Unit-I : Geometry - an introductory idea




Types of an angle
Geometry box
Illustrations of different angles -at the same point(as vertex) or at different points
Introducing the need of drawing/ measuring line-segments, angles, circles and detecting types of angles etc.
Types of angle
Instruments of Geometry box
A right angle
An obtuse angle
An acute angle
A fifteen centimeter scale
Protractor
Pair of compasses
Divider
Set squares
Use of set squares in detecting the types of angle
Use of the inst-ruments of Geometry box
Measure of different types of angles

Flow Chart - IV:



In view of the above course content the investigator kept the following objectives in her mind at the time of development of the strategy.

General Objectives:

Pupils will -

i) acquire knowledge of basic concepts of Geometry

ii) development interest in Geometry

iii) apply their knowledge of geometry in solving different problems.

Further these objectives were specified more clearly in behavioural terms for each unit as under:

Specific Objectives for Unit I

Unit I: Geometry - An Introductory Idea

Pupils will be able to -

i) explain the meaning of the terms point, line-segment, ray, line and plane, giving at least two examples of each.

ii) prepare the mathematical models for point, line-segment, ray and line.

iii) draw and write the notational forms for the given point, line-segment, ray and line.

iv) recognise point, line-segment, line, ray and plane from the given group of geometrical figures.

v) distinguish between the different elements of line such as point, line-segment, ray.

vi) draw and measure the line-segment

vii) apply their knowledge in solving different problems of Geometry.

Unit II : Rays and Angles

Pupils will be able to -

i) recall the meaning of term ray, with two illustrative examples

ii) draw opposite rays

iii) define an angle with at least three illustrative examples

iv) identify the vertex and sides of any given angle

v) draw an angle stating the notational form of that angle

vi) define right angle, obtuse angle and acute angle

vii) draw and lable different types of angles showing their vertices and sides

viii) prepare mathematical model of an angle

ix) recognise the different types of angle among given group of angles

x) recognise tools of Geometry box

xi) state uses of tools of the Geometry box

Unit III : Parallel Lines

Pupils will be able to -

i) draw horizontal, vertical and slant lines in a given plane

ii) draw horizontal, vertical and slant lines in different planes

iii) recognise the difference between lines in one plane and lines in different planes

iv) state the meaning of the term skew lines giving at least two examples

v) define parallel lines giving two examples

vi) distinguish between parallel and non-parallel lines

vii) draw parallel and non-parallel lines without using set- squares

viii) write parallel and non-parallel lines in notational forms

ix) draw parallel lines using set-squares

x) apply their knowledge of parallel lines in solving different problems.

For the development of the strategy, the investigator had to keep in mind the target population along with the objectives to be achieved. Hence it will be worth to talk of target population before discussing any thing about the development of strategy.

3.8 Target Population

As the course intends to provide basic concepts and skills in Geometry, the pupils are not expected to have any previous orientation in geometry. The target population would comprise fifth-grade pupils of the schools which use the text book of mathematics as prescribed by The Gujarat State Board of School Text-books, Ahmedabad'.

3.9 Development of the Strategy for Mastery Learning in Fifth-grade Geometry

Considering the various factors such as characteristics of the target population, nature of the content covered under each unit and feasibility of utilizing the strategy for mastery learning under the conditions obtained in a developingcountry like India, various instructional components for the different content units were selected.

The groups of pupils under experimentation were heterogeneous with respect to their IQs, (i.e. individuals of the group differ in their potential to learn or say they learn with different speeds), in light of this, the investigator had to select instructional components viz. Introduction, structured lecture, discussion session, problem solving, mathematical models, individualized tutorial, PLM, Text-books and work books, small group

study sessions, mathematical games, assignments, review and practicing, feedback session and criterion tests.

Significant details regarding specific rationale for selection of each component of the strategy over and above the general considerations, nature and structural features with respect to each selected instructional component have been presented in the following.

1. Introduction:

Every unit began with an introduction which provided a logical linkage to the unit which preceded. The purpose was to lead the learner from the known to unknown. The introduction was made by the teacher irrespective of whether the unit was self-instructional or otherwise. The mode of introduction made by the teacher varied across instructional units. The various concepts to be presented within a unit were logically linked and specific questions following one after another in a logical manner were raised by the investigator to arouse the intellectual curiosity of pupils and they were assured that the study of the particular instructional unit would enable them to find definite answers to these questions.

The bridging was done in a way that the basic mathematical concepts essential for students to attain

mastery level of the subject matter presented in the particular unit were highlighted. This treatment would facilitate focussing students' attention and concentration on the salient points of the unit with the necessary background needed to understand these points.

In the introduction of the first unit; enough care was taken to orient the students towards mastery learning, along with introducing the basic concepts of geometry.

2. Structured Lecture:

The popular method of instruction-lecture, has been found through researches an effective means for providing basic information to learners (Bligh 1972).

In certain topics where much information had to be provided, structured lecture supplemented with discussion as a mode of instruction was used. Considering the learners cognitive development, and the potential of structured lecture it was decided to utilize this technique as a component in the development of the strategy of the present study.

3. Discussion Session:

The technique of discussion involved interaction among a group of individuals. In techniques involving

group interaction, the learner is not only influenced by the group, but he/she influences the group too. Different ideas or opinions act as forces either supporting or contradicting each other. While the supporting view points help a participant in strengthening his view point, the contradicting ideas induce further thinking in him gradually leading to the development of higher cognitive abilities in him, like analytical and synthetical ability, creative thinking, etc. (Yadav et al 1979, and Menon and Bhat, 1983). Further, it is obvious that only through such interactions with contradictory ideas put forth by participants, affect attributes like tolerance, respect for others' idea, appreciation power, positive attitude towards group thinking, objective outlook etc. could be inculcated.

In fact target population under consideration of the present study consist of the pupils of age group between 10 to 12 years; for whom it is very much necessary to acquire the above mentioned features, which will add to their personalities in future. Also through discussion sessions they develop self confidence and stage fear is removed if at all it is there in them.

Thus these features of discussion session shows its significance as a component of the present strategy for mastery learning and justifies its inclusion in the strategy.

4. Problem Solving:

Geometry as a subject itself consists of many geometrical problems. This problem solving is very much necessary for the pupils from the view point of the course content as well as in general, as it develops the imagination power, abstract thinking and so many other good qualities like confidence, self evaluation, and so on among the pupils.

During the present study, pupils were supposed to solve geometrical problems at the end of each unit on their own. In the case of pupils who were not able to solve the problems on their own, some guidance in the form of hints was either given by the investigator or the proctor (the pupil who has achieved mastery) to them, only after knowing that some efforts to solve the problem were made by those pupils. This in turn helped them to be successful achievers.

5. Mathematical Models:

Mathematical models are very much essential in mathematics teaching, especially in Geometry where the subject itself is very much abstract in nature as it deals with many abstract geometrical concepts. To teach the abstract concepts of geometry, it is very much necessary to develop and produce mathematical models before

the students while teaching, so that, they can imagine and understand each concept very well. Presentation of models also develops great interest in learning.

In the present study the investigator has developed and used mathematical models during teaching of the concepts point, line-segment, a ray, a line and an angle, during the teaching of the first two units of geometry course. After that, pupils had also prepared the same models showing great interest in that activity.

6. Individualized Tutorial:

After each unit, the tutorials had been introduced based on the topics covered in that unit. Tutorials include problems based on respective topics of that unit, involving its further application. At the time of introducing tutorials each individual was kept in mind and accordingly individualized tutorials were introduced.

7. Programmed Learning Material:

Programmed learning material as a technique for providing basic information has proved its potential at different levels of education (Goel 1970, Bhushan 1973, Pandya 1973, Govinda 1975, Seshadri 1980, Menon 1983). This provided the basis for selecting this technique

as an instructional component to provide basic information to the pupils in the first unit of geometry course in the present strategy for mastery learning.

Linear PLM was prepared and used by the investigator for presenting basic information of Unit-I of geometry course. This linear PLM style differed from the traditional Skinnerian PLM style. Similar styles have been used by Govinda (1975), Sansanwal (1977) Seshadri (1980), Menon (1983). The linear PLM used for the present study is kept in the Appendix.

8. Text Books and Work Books:

Looking at the time constraint it is not possible for the teacher to see in the class whether every individual has solved all problems of exercises of the text book and achieved mastery or they need more practice for the same. Hence in the light of this, the investigator instructed each pupil to refer to the text book of mathematics and do the home work assigned to him by the teacher (investigator) and also in addition to this pupils were given more exercises in work books (provided by the investigator to the pupils) which they were supposed to do on their own at home and then show to the teacher. Due to this pupils could get more practice of solving geometrical problems and the investigator could

check all the problems solved by the pupils; diagnose and understand their learning difficulties and accordingly find out a remedy for the same. Thus the use of the text book and the work book worked as an important component in the development of the strategy.

9. Small Group Study Session:

After the completion of third unit two small group study sessions were held. In these sessions pupils were divided in five small groups at random irrespective of their achievement scores. Then all the groups were given some activities, such as, solving geometrical problems, and preparing models for point, line-segment, ray, line and angle. In the beginning each pupil was supposed to do these things on his/her own. In case he/she found any difficulty in completing his work then only he/she was allowed to take the help from his/her group. During these small group study sessions the investigator was taking round in the class and was observing the activities of these groups. If any group had some problem or difficulty or confusion in doing the above mentioned activities, the investigator was guiding that particular group.

The small group study session developed qualities like cooperation, team spirit etc., among the pupils. Also they enjoyed to work in group together with great interest in the work given to them by the investigator.

10. Mathematical Game:

The following game designed by the investigator was applied as one of the components of the strategy for learning, after the completion of the second unit and the third unit.

For playing this game the class was divided into two groups, namely group I and II without disturbing their sitting arrangement and also irrespective of their scholastic achievement. Both the groups were assigned one leader each. Here a special care was taken in selecting the group leader by the investigator. These leaders were the pupils who attained the mastery in the units taught by the investigator. The game was restricted for 30 minutes only. For playing this game some rules were formed by the investigator which were explained to both the groups in advance. Then the game was started. During this game points gained by each group were counted and written by the investigator on the black-board.

Rules followed in playing the game

(1) During first 15 minutes of the game group I was supposed to ask the questions to group II and group II was supposed to give answer to these questions. For every correct answer one point was given to group I. In case of wrong answer

two points were given to group I.

(2) For asking the question also certain rules were followed. They are as follows:

i) Except the group leader, all pupils of the group I who wanted to ask question would raise their fingers. Then the leader of the group I only would decide as to who will ask the question.

ii) The pupil of group I who would ask the question to group II, will not put the question to group II in general but would also point out the pupil of group II who was supposed to give the answer.
(Here chances were more that question was asked to the lower achievers).

iii) If the answer given by the pupil of group II was correct one point was gained by the group II. But if answer was wrong then in this case two points were gained by the group I.

Further in this case of wrong answer given by the pupil of group II, the leader of group II would ask the pupils of group II to raise fingers who knew the answer for the same question asked by the pupil of group I. Then the leader of group II would take the decision who will give the answer from those who raised the fingers.

willingly to give the answer to the question earlier asked by group I. (Here most of the time, it was observed that the pupil selected by the group leader II for giving answer had mastery over the topic from which the question is asked). In this second attempt, if the answer given by the pupil of group II was correct then one point was given to group II.

In case, the answer given in this second attempt is also wrong then again two points were gained by the group I. Further in such case the last chance was given to group II to answer the same question. But in this third attempt, the chance for giving the answer was given only to the leader of group II. If in this third attempt the answer given was correct then one point was given to group II. But if in this case also the answer given by the leader of group II was wrong then three points were given to group I; and then the pupil from group I who asked the question was supposed to give the correct answer to his/her question. By chance, if at all the answer given by him/her is an incomplete answer or wrong answer then minus five marks were given to group I. Further in such case the investigator was supposed to give the correct answer to that question asked by group I and would explain fully about the question and the answers given by different pupils and the mistakes they committed in giving the answer. However such situation hardly arose.

(3) In case the answer given by the pupil of group II to the first question of group I was correct in the first attempt, then again the second question was asked by other pupil of group I to some other pupil of group II. If correct answer was given to this second question then one point was given to group II.

Then the third question was asked by other pupil of group I to some other pupil of group II and so on.

(4) Here in this process of asking question and giving answer a special care was taken that no pupil would get a chance more than once to ask the question and similarly the pupil to whom question was asked was also not asked again. Due to this almost all the pupils got chance to participate in the game.

(5) In case of any incomplete or wrong answer the same procedure as mentioned under 2 (iii) was repeated.

(6) During the whole game leaders were also supposed to control their group in the sense of discipline of his/her group. If he/she failed to maintain the discipline in his/her group, minus one point was given to that group who would make noise or disturb the class or behave in an undisciplined way. (Interestingly, hardly such situation arose due to the system of giving minus point).

(7) After the completion of the first 15 minutes, next ten minutes were given to group II for asking question to group I. During this second phase of 15 minutes, the same process as mentioned earlier for asking questions, giving answers and assigning the points was repeated, except that the role of group I and II was interchanged for asking the questions and giving the answers.

After the completion of the second phase of 15 minutes, the game was declared to be over and points gained by each group were counted by the investigator.

Throughout the game it was observed that the game involved the maximum participation of the lower achievers (i.e. the pupils who had not attained the mastery). All the pupils were eagerly waiting for their turn to participate in the game. Also all doubts regarding the wrong answers were cleared during the game. All pupils were very happy during the game, feeling confident while asking the questions and giving the answers and showed their interest in playing such games again and again. But due to time limitations only two times the same type of game was played in the class.

As this was the game played in group, team spirit was developed which encouraged the pupils for

healthy competition, which in turn made them aware of the fact that unless all had mastery over the topics taught, it was difficult to win the game. This awareness made them to learn more and attain a mastery over the topics taught.

Due to this game two purposes were served. The first was that too much interest was created in learning the course taught by the investigator and the second was that the pupils were motivated towards mastery learning.

A few questions are given below which were asked by the pupils during the game:

Q.1 Define the term angle, draw an angle on blackboard.

Q.2 What is the difference between line and ray ?

Q.3 State different types of angles with illustrative examples.

11. Assignment:

After the completion of all the units, assignments were given to the pupils. But all of them were not given the same assignments. From the results of criterion tests over three units; four lists were prepared. The first list was of those pupils who had not attained mastery only in the first unit, the second list was of those pupils who had not attained mastery in the second unit, the third list was of those pupils who had not attained

mastery in the third unit and the fourth list was of those pupils who had not attained mastery in more than one units. Then accordingly assignments were given to those pupils. The pupils who attained mastery over the whole course of Geometry were supposed to help these pupils in preparing their assignments. The pupils who did not attain mastery in the particular unit/units were told to write the summary of the respective unit/units after referring to the text book, PLM, class notes and other material related to that unit/units. Thus assignments were the summary to be written by the pupils for particular unit/units after the completion of learning of all units of Geometry.

Such assignments were given to the pupils for better understanding and improving their knowledge in what they had learnt in Geometry.

12. Review and Practising:

After the completion of each unit revision (review) was done in the form of short summary. Then some questions and problems were given to the pupils for practising purpose.

13. Feedback Session:

This is one of the most important components of the strategy. This component was intended to provide

corrective feedback to the learners on their performance in each criterion test. It was decided that the feedback could be provided through interaction during sessions in which certain content points, not well understood by the learners as indicated by the criterion test performance, be discussed and remedial, explanation etc. wherever required, provided by the teacher after each test.

These above mentioned instructional components were used in teaching Geometry course. All components were not used during teaching of each unit but considering the need of the particular topic with the time limit combination of instructional components mentioned above were used. The instructional components used in teaching the different units are given here, in this chapter on separate sheets.

Along with these instructional components criterion tests were also used after each unit which formed integrating parts throughout the strategy for mastery learning.

14. Formative and summative tests:

After review and practising of each unit the formative criterion test was given to the pupils to see whether they have attained mastery over the topic taught. These formative criterion tests were also of diagnostic nature hence they were also used to diagnose their learning

difficulties. Though these were formative tests, scores were assigned to each test of every pupil as pupils were not satisfied with the statements such as 'good', 'more work needed' etc. on their assessed test papers. In fact the scoring of each formative diagnostic test created healthy competition among the pupils to attain the mastery over each unit taught in Geometry.

Not more than two formative criterion tests were given for each unit as the investigator had also to consider the time limit given by the school authorities. After the assessment of each formative criterion test, the learning difficulties were diagnosed and discussed in the feedback session. Also based on this, the remedials were given in different forms such as some activity, assignment, exercise etc. accordingly to the need of each pupil.

After completion of all the three units of Geometry a test based on the items from all the three units was conducted. Based on the score of summative test the achievement level of each pupil was decided and accordingly the pupil was declared about his attainment of mastery level.

(i) Development of Formative Criterion Tests:

Each criterion test was developed keeping in mind the specific objectives for the concerned unit. The evaluation items were representing the specific objectives of the unit for which the test was given. These items intended to, judge the extent to which the specific objectives were achieved unlike an achievement test the purpose of criterion tests is not to discriminate between the high and low achievers but to detect whether the learner has acquired all the specific objectives or not. In the development of the strategy for mastery learning the criterion scores helped to validate the effectiveness of the strategy in terms of achievement of the specific objectives. Further the knowledge of non-achievement of certain specific objectives provided feedback which helped in deciding the remedials and thus in its turn the criterion tests worked as an important component of the strategy. Before employing these tests on the fifth grade pupils, the tests were also shown to the experts in mathematics, and only after their approval about the test items, tests were conducted during field tryout.

(ii) Summative Test:

After completion of all the three units of Geometry a test based on the items from all the three

units was conducted. All test items were shown to the subject experts and then they were included in the test taking into consideration all the specific objective stated earlier. This type of test is known as summative test which is very similar to the comprehensive tests in nature. Based on the score of summative test the achievement level of each pupil was decided and accordingly the pupil was informed about his attainment of mastery level. Thus summative test was an important component of the strategy which was decigive . about the mastery of each pupil.

All components mentioned above were used in different combination while teaching different units of Geometry. Following table shows the combination of these components during teaching the different units of geometry which formed the structure of the strategy for mastery learning in fifth-grade Geometry.

Unit No.	Name of the Unit	Combination of the Components of the Strategy
1	Geometry - An Introductory Idea	Introduction Structured lecture Discussion session PLM Textbook and work book review and practising. Formative criterion test Feedback session Individualised Tutorial Formative test

Unit No	Name of the Unit	Combination of the components of the Strategy
2	Rays & Angles	Introduction Mathematical models Problem solving Discussion session Individualised tutorial Formative criterion test Feedback session Mathematical game Text book & work book Review and practising Formative test
3	Parallel Lines	Introduction Discussion session Problem solving Individualised tutorials Work book & text book Formative criterion test Feedback session Mathematical game Formative test Small group study session Assignment Review & Practising Summative test

After completion of teaching of geometry course and assigning the grades of summative test, to know the reactions of the pupils about the developed strategy, a questionnaire was prepared and given to the pupils of experimental group in final tryout.

Then based on the data of formative and summative test and answers to the questionnaire, further analysis and interpretation was done which is given in the next chapter.