CHAPTER IV

METHODOLOGY

Introduction

Hypotheses

Objectives of the Study

Method adopted

Sample

Variables

Identification of Learning Disabled

Instruments Used for the Experiment

Experiments Conducted

Statistical Methods Adopted
CHAPTER IV

Methodology

This chapter describes the methodology adopted in this study. The hypothesis, the objectives of the study, the data essential for the study, the sample, the design, the tools and techniques used and the procedure of statistical analysis adopted in the study are detailed in this chapter.

Many a study shows that twenty percent of children in our schools experience learning disabilities in one form or other. Special attention is required when a child has significantly greater difficulty than most children of his age do or a disability, which either prevents or hinders him from making use of the educational facilities of a kind generally provided in schools. Individualized Education Programme is found successful in other countries. In India within the limits of the resources available, we may tackle the problem through individualized instruction, especially for those with mild disabilities related to learning skills.

A good number of strategies have been developed for individualized learning. Most of them are in accordance with the learner characteristics and study environments in the developed countries. They should be modified or tested for their efficiency in the Indian conditions for the benefit of the learning disabled and the normal learners as well.
In India, one cannot do away with traditional class teaching dominated by teacher talk all on a sudden. The transformation from the traditional lecture method to individualized learning should be gradual or else the students and teachers would find it difficult to adjust with the transformed strategy.

The investigator collected the particulars of the available modules, programmed learning materials and guided inductive enquiry lessons prepared in the same topic selected for the present study so that they could be used for the experiment. But the lessons and the modules available were prepared for other topics and classes. It is in this context that the investigator decided to develop self-study materials and guided inquiry lessons on the same topic in Biology for the pupils of standard IX. Even though some studies conducted earlier indicate the effectiveness of individualized instructional strategies for non-disabled, it is necessary to compare their effectiveness for the learning disabled. The following hypotheses were formulated in this direction.

**Hypothesis I**

There is no significant difference in the initial and the final achievements of the secondary school students with learning disabilities when self-study approach and modern instructional strategies are adopted for their teaching.

**Hypothesis II**

The self-study approach and the modern instructional strategies do not differ significantly from the conventional lecture demonstration method in their effectiveness in minimising the learning disabilities of the secondary school students.
**Hypothesis III**

The self-study approach and the modern instructional strategy do not differ significantly from the conventional lecture demonstration method in the achievement of non-disabled (ND) students of secondary schools.

**Hypothesis IV**

The progress of the learning disabled (LD) students of the self-study approach and modern instructional strategy groups do not differ considerably from the achievement of the LD students and the ND students.

**Hypothesis V**

There is no significant relationship between the extraneous variables and the achievement of the learning disabled (LD) and non-disabled (ND) students in the self-study approach groups and modern instructional strategy groups.

**Objectives**

The following are the objectives formulated to carryout the study:

1. To find out the effect of programmed learning, supervised learning module and the guided inductive inquiry method in the achievement of biology of secondary school students with learning disabilities.

2. To find out the effect of programmed learning, supervised learning module and the guided inductive inquiry method in comparison with that of the conventional lecture demonstration method in minimising the learning disabilities of secondary school students in learning biology.
3. To compare the achievement of LD students and ND students when they are taught biology using programmed learning material, supervised learning module and guided inductive inquiry model.

4. To compare the progress in the achievement of LD students and ND students when programmed learning material, supervised learning module and guided inductive inquiry model are used.

5. To compare the objective-wise achievement of LD students and ND students when they are taught using programmed learning material, supervised learning module and guided inductive inquiry model in learning biology.

6. To find out the relationship of achievement motivation, study habits, home learning facility and socio-economic status of parents in the learning of LD and ND students when they are taught using self study materials and modern instructional strategy.

**Method Adopted**

The main purpose of the study was to determine the effectiveness of self-instructional materials and modern instructional strategies over traditional lecture demonstration method in learning biology. The experimental method was found appropriate for the present study. The experimental method, which is the most exacting and difficult of all methods and most important from the strictly scientific point of view was adopted to compare the effectiveness of self-study approach by selecting Supervised Learning Module and Programmed Learning Material and one modern instructional strategy namely Guided Inductive Inquiry.
Model with the conventional Lecture Demonstration Method in minimising learning disabilities of students in secondary schools.

**Experimental Design**

The design selected should be able to accommodate the testing of the effectiveness of some instructional strategies with that of the conventional teacher centred approach in minimising learning disabilities of students in secondary schools.

Equivalent group design would have been the most suitable design for the study. In Kerala it is administratively difficult for the investigator to arrange equivalent groups by matching the students because the matched pairs may belong to different batches in different schools. Bringing them together for the purpose of the experiments by disturbing the routine class work is very difficult in the Indian conditions.

There are statistical techniques like Analysis of Covariance to overcome this difficulty, even if we do the experiment in the natural classroom groups, which are normally non-equated groups. The investigator therefore decided to conduct the experiment in intact non-equated classroom groups. The non-equivalent pretest posttest design was selected for the study.

**Sample Selected for the Experiment**

For the experiment adopted for the study, experimental and control groups of students were selected from four educational institutions following the state syllabus. The initial sample consisted of all the students studying in IX standard in the selected schools (N=895). All these schools were matched on instructional
variables, viz., medium of instruction, qualification of teachers and teacher pupil ratio. The institutions chosen and the number of students in each of the experimental groups is given in Table 1

Table 1

School-wise break-up of the sample selected

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of the School</th>
<th>Management</th>
<th>Grade/Div</th>
<th>No. of students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>School, Kottayam.</td>
<td>Urban</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>J. M. Higher Secondary</td>
<td>Private/Aided</td>
<td>IX B, C, D</td>
<td>220</td>
</tr>
<tr>
<td></td>
<td>School, Vakathanam.</td>
<td>Rural</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td></td>
<td>School, Mundakayam.</td>
<td>Rural</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td></td>
<td>School, Kottayam.</td>
<td>Urban</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td>895</td>
</tr>
</tbody>
</table>

Altogether sixteen batches of students each having 55 to 65 from four schools were involved in the experiment. The intact classroom groups were selected for the experiments. This helped the investigator not to disturb the natural setting of the classes and class schedules. Thus the design is a quasi-experimental design i.e. a randomized control group pretest posttest design (Koul, 1998)

Variables

In experimental studies the condition that is varied is referred to as the dependent variable. If the effect of the teaching strategy is measured by means of
achievement test, then the scores on the test is referred to as the dependent variable (Travers, 1964 p.130). In the present study, the programmed learning material and the supervised learning module for self-study and the guided inductive inquiry lessons for modern instructional strategy were to be tested experimentally for their effectiveness by comparing with that of the conventional lecture demonstration method. Therefore the independent variable (experimental variable) is the teaching strategy with four levels of treatments viz.,

**Experimental Variables.**

Programmed Learning Material (PLM)
Supervised Learning Module (SLM)
Guided Inductive Inquiry Model (GII)
Lecture Demonstration Method (LDM)

Student performance (achievement) is the dependent variable. There is every chance of many extraneous variables to affect the experiment. Among them achievement motivation, study habits, home learning facility and socio-economic statuses of the parents were statistically analysed as to their influence on the achievement. All the students selected were of average to above average intelligence.

**Criteria for Identification of the Learning Disabled Students.**

To identify LD students studying in regular schools, the investigator plotted a regression graph with IQ as the independent variable and the first terminal biology test scores as the dependent variable. From the regression graph
those falling below the regression line were initially selected as LD students and those above as ND students. The regression graph is given as figure.1.

After the initial selection it was further confirmed using the following exclusion–inclusion criteria. Sharma (1991) and Mahajan (1994) used this method of identification.

**Exclusion Criteria.**

a) Children having sensorial handicaps

b) Children scoring below 25th percentile on Raven's Progressive Matrices A, B, C, D & E

c) Children scoring 50% or above on the Diagnostic Test of Learning Disability (DTLD)

d) Children scoring below 50% on Pupil Behaviour Rating scale

e) Children scoring below 50% on Learning Problem Checklist

**Inclusion Criteria.**

a) Those falling below the regression line in the regression plot

b) Children scoring above 25th percentile on Raven's Progressive Matrices A, B, C, D & E

c) Students scoring below 50% on the DTLD

d) Students scoring above 50% on the Pupil Behaviour Rating Scale.

e) Children scoring above 50% on Learning Problem Checklist
Fig. 1: Scatter Plot of Biology Marks against IQ

$y = 12.127 + 0.442x + \varepsilon$
Those satisfied the inclusion criteria were chosen as learning disabled. Since the study was also a comparison of LD with the ND students on the effectiveness of self-study approach, ND students had to be identified.

Children scoring above 25th percentile on Raven's (1960) Progressive Matrices A, B, C, D & E, those scoring above 50% on DTLD, and those scoring below 50% for Pupil Behaviour Rating scale and Learning Problem Checklist and those lying above the regression line on the scatter plot were identified as non-disabled.

From the sample of 895 students, 338 students were screened initially as learning disabled with the help of the regression plot. After applying the inclusion-exclusion criteria there were 248 LD students. Even though the number of students in each group formed from the intact class differed, only the minimum number of LD students obtained in one of the groups was fixed as the number of students in all the experimental and control groups. It was fixed as 51 in each group. This equalisation was made for the convenience of statistical calculations. Thus 204 LD students with 51 in each of the groups were selected for the study. From the 557 students identified as ND students from the regression plot, after applying the inclusion-exclusion criteria there were only 404 ND students. From this group 204 students were selected for the experiment.

In order to compare the performance of the disabled and non-disabled students and their progress when they are taught using self-study approach and modern instructional strategies, allocating 51 students in each of them also
formed four groups of non-disabled students. The design is presented in Figure 2 and Figure 3.

<table>
<thead>
<tr>
<th>Experimental Groups</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLM N=51</td>
<td>LDM N=51</td>
</tr>
<tr>
<td>SLM N=51</td>
<td></td>
</tr>
<tr>
<td>LD</td>
<td>LD</td>
</tr>
</tbody>
</table>

**Figure 2**

Experimental and Control Groups of LD students

<table>
<thead>
<tr>
<th>Experimental Group</th>
<th>PLM N=51</th>
<th>SLM N=51</th>
<th>GII N=51</th>
<th>LDM N=51</th>
</tr>
</thead>
<tbody>
<tr>
<td>LD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ND</td>
<td>PLM N=51</td>
<td>SLM N=51</td>
<td>GII N=51</td>
<td>LDM N=51</td>
</tr>
</tbody>
</table>

**Figure 3**

Experimental and Control Groups of LD and ND students

PLM: Programmed Learning Material, SLM: Supervised Learning Module

GII: Guided Inductive Inquiry, LDM: Lecture Demonstration Method

**Instruments used for the Experiment**

Programmed Learning Material (Developed by the Investigator).

Supervised Learning Module (Developed by the Investigator).

Guided Inductive Inquiry Lessons (Developed by the Investigator).

Achievement Test in Biology (Developed and Standardized by the Investigator).

Diagnostic test to identify Learning Disability (Standardized by the Investigator).

Pupil Behaviour Rating Scale (Standardized by the Investigator).

Learning Problem Checklist (Standardized by the Investigator).
Raven's Progressive Matrices sets A, B, C, D& E.

Study Habits Inventory by Rao.

Home Learning Facility Inventory by Nair, & Nirmala.

Achievement Motivation Scale by Shah.

Socio-economic Status Scale (Revised).

**Programmed Learning Material**

The investigator referred to different available programmed learning materials in Biology. Since the topic "Reproduction in Plants" was not found among them she decided to prepare it by analysing the content to suit the needs of the children with learning disabilities.

The content was analysed in terms of behavioural objectives. In order to test the pre-requisite knowledge of the students a test of entering behaviour was prepared. The learning material was then divided into frames. Each frame was a small segment of subject matter that called for particular student responses. The student was asked to make the response in every frame. The correct responses were provided at the end of the material for the students to refer to after each response. Prompts were provided on the programme frame to guide the student for making correct responses.

The programme was shown to three subject experts, a language expert and checked the inaccuracies in the content. It was then edited and tested on twenty students of St Joseph's High School Kottayam. Responses were studied in detail and the programme was finally edited. A number of books were consulted
in preparing the Programmed Learning Material on Reproduction in plants. Some of them are:


A number of examples and activities, as far as the content permits, have been included to help pupils for better understanding and better retention. The technique adopted for description would prevent, as far as possible, rote learning. It, on the other hand, would encourage meaningful learning embedded with logical thinking and reasoning.

**Development of Programmed Learning Material.**

The steps taken to develop the material are given below:

(i) selection of topic, (ii) formulation of broad objectives, (iii) specifying objectives in behavioural terms, (iv) development of control outline, (v) analysis of objectives, (vi) analysis of content, (vii) development of the frames, (viii) tryout of the programme, (ix) provision for student activities, and (x) feedback.

**Selection of Topic:** It was decided to develop programmes on the topic Reproduction in Plants as prescribed for the students of Grade IX of State syllabus. They were to be based on Biology Textbooks.
Formulation of Broad Objectives.

The students should be able to know the different types of reproduction, different methods of asexual reproduction, artificial and natural ways of propagation, parts of a flower, pollination and fertilization. They should understand the process of pollination and fertilization.

Specific Objectives.

Based on the broad objectives, specific objectives in terms of observational and behavioural outcomes were formulated. For example, for the topic Reproduction in Plants, the specific objective knowledge is that the students identify the mode of reproduction of a given plant.

Development of Content Outline.

After the behavioural objectives were developed, the content outline suitable for the attainment of objectives has been developed. The content selected is given below.

A living organism has the ability to reproduce its own kind. Its purpose is to perpetuate life. There are two types of reproduction in plants. They are sexual and asexual.

Asexual reproduction in plants and lower organisms is through fission, spore formation, regeneration and fragmentation. Natural method of vegetative propagation is through roots, stems and leaves. Artificial methods of vegetative propagation are layering, budding and grafting.
Flower is the reproductive part of the plant. A flower has four parts. Stamens and Pistil are the sexual reproductive parts. Reproduction occurs through pollination and fertilization.

**Analysis of Objectives.**

The objectives were analysed in terms of their sequence to discover whether there were any gaps or overlaps among the objectives.

**Analysis of Content.**

The content was analysed and arranged sequentially. Parts of a flower, for example, were discussed at length before discussing pollination and fertilization.

**Development of the frames.**

It was decided to follow linear programming as given by B.F. Skinner. The frames consisted of stimuli that called for a specific action or set of actions, the learner was to perform after learning from the programme. Example of a frame: There are four parts in a typical flower as shown in the figure. Label the parts in the diagram given. Identify these parts in a flower in your garden. In this frame they have to label the parts of the given diagram as well as observe the parts from a fresh flower.

**Try out of the Programme.**

The programmed material was tried out on a group of twenty students of St. Joseph's High School, Kottayam. This enabled the investigator to improve the material on the basis of the suggestions received from the students and teachers. The programme was finally edited.
**Provision for Student Activities.**

The material was provided with activities and experiments to be performed by the students so that the scientific attitude and critical thinking will be developed. These activities also encourage them to have interaction with the teacher and his classmates.

**Feedback.**

After each sub-unit, formative evaluation questions were given so that the students could check themselves whether they have attained mastery over the material before proceeding to the next unit. The programmed learning material is given as Appendix A.

**Supervised Learning Module**

In the schools in Kerala the module as a learning material is not used. Being a self directed study, module is suggested to be used by the students without depending on the teacher. This type of self-study is unknown to the students in the State. So the investigator decided to develop a Supervised Learning module on 'Reproduction in Plants'.

**Construction of the Modules.**

a) The topic 'Reproduction in Plants' was selected and broken into several manageable units.

b) Performance objectives for the modules were formulated.

c) The level of mastery or competency needed by the learner to begin the activities was determined. For this a prerequisite test was administered.
d) The prepared modules were compiled in the form of a booklet, which contained the title, overview, instructions to the users, objectives, learning activities and formative tests.

Another feature of the module is that as far as possible activities to be undertaken are included. Guidelines to direct the activities of students are also given. Since it is a supervised learning module the students can discuss with the teacher the results of their activities and experiments and draw conclusions.

The subject and language experts examined the modules and the suggested modifications were made in them. For instance, some activities to illustrate spore formation in bread mould were included.

The prepared modules were tried out with twenty children of grade IX and their difficulties were noted and analysed. It was pointed out that getting Begonia leaves to illustrate asexual reproduction through leaves was not possible. Some seeds mentioned in the module were not available. Needed changes were made.

The modules were modified according to the observations made by the investigator and comments of the students, teachers, educators and colleagues.

A number of books were consulted in preparing the Supervised Learning Module on Reproduction in plants. Some of them are: Introduction to Educational Technology (Sampath, 1990), Modern Science Teaching (Sharma, 1997), Programmed Learning (Chauhan, 1978) Understanding Science for Class IX (Purang,1998), Science for class ninth (Sharma, 1998), Biology for Life;

**Details of Entry Behaviour for Learning.**

The cognitive entry behaviours expected of the learners at the commencement of the fresh academic year in Grade IX with reference to Biology would be sufficient for learning reproduction in plants through modular approach. Hence a detailed description of the previously learned Biology in lower grade was avoided. A test was given at the beginning to test the prerequisite knowledge required for the study of the module.

**Specific Outcomes of Learning.**

The specific outcomes of learning with reference to the unit 'Reproduction in Plants' were listed by examining the prescribed syllabus for Grade IX, the recommended textbook and through discussions with teachers handling the classes. The instructional objectives and expected outcomes of learning were made known to the pupils to facilitate effective learning.

**Sequencing Instructional Events.**

The course study comprising the unit 'Reproduction in Plants' was broken into two modules that were again divided into three sub-units. They were further analysed into facts and concepts to form a learning hierarchy.

**Feedback.**

In the sub-units, whenever questions were asked correct responses were provided in the same section as guidelines. Towards the end of a unit formative
evaluation questions were given with the direction to the students to correct their errors and attain mastery of the content.

**Concept Learning.**

Appropriate learning activities were formulated by adopting guided discovery approach for concept learning with reference to the identified concepts in the topic, Reproduction in plants. Depending upon the nature of the learning tasks some of them were structured for meaningful rote learning and some others for discovery learning. The learners would also be involved in the process of 'finding out' the relevant data through inquiry-oriented experiments provided in the different units.

**Conceptual Analysis.**

The self-study material is composed of two interrelated modules each consisting of three sub modular units with many activities for learners to learn by doing. The learning activities included in the two modules were formulated on the basis of the objectives stated at the beginning of the booklet.

The booklet was prepared in Malayalam since the study was conducted for Malayalam medium students. The English version of it is given as Appendix B. They are briefly described below.

**MODULE 1: REPRODUCTION**

In this module reproduction, its meaning and the need for perpetuating the species is highlighted. Different methods by which organisms reproduce are vegetative, asexual and sexual.
Unit I: Asexual Reproduction

Unicellular organisms like amoeba reproduce asexually through fission, binary and multiple fission. Asexual reproduction also takes place through spore formation, fragmentation and regeneration.

Unit II: Vegetative Propagation

The vegetative parts of a plant are roots, stems and leaves. When new plants are produced from any one of these vegetative parts, that type of reproduction is known as vegetative propagation.

Unit III: Artificial Methods of Propagation

In the field of agriculture and horticulture a number of artificial methods of propagation have been employed. They are cutting, grafting, layering, tissue culture etc.

Module II: Sexual Reproduction

This module discusses in detail the process of sexual reproduction. When a new organism is formed as a result of the union of two sex cells namely male and female gametes, sexual reproduction occurs. Flowers are the sexually reproducing parts of the plant.

Unit I: Parts of a Flower

A typical flower has four parts. They are sepals, petals, androecium and gynoecium. Androecium and gynoecium are the essential parts of the flower.

Unit II: Pollination

The transfer of pollen from the anther to the stigma is known as pollination. There are different types of pollination namely self and cross-
pollination. The agents that help pollination are wind, water, insects and birds. The characteristics of flowers pollinated by wind, water and insects are discussed.

**Unit III: Fertilization**

The process of fertilization is discussed. There are mainly two types of fertilization: internal and external. Appropriate learning activities are provided to make the students understand fertilization.

One important feature of the supervised learning module is that the teacher discusses with the students the outcomes of their activities after each day's self-activity. This enables the students to have clarity as to what they are doing and avoid any misinterpretations in their findings.

One of the activities in module I of unit I, for example, students are asked to sow different types of seeds, manure and water them. They are asked to report their observation in a table provided in the booklet. If the students have observations not in accordance with the clues given in the booklet, they can clarify the point with teacher.

**Teaching Learning Techniques Applied.**

As many learning techniques as possible have been included in the module for learning. The researcher used the following learning techniques.

(a) Explanation: This is the main technique used, because this particular content demands explanation.

(b) Observation: The students were asked to do experiments. Activities were provided for observation and recording. This helps them develop skill in observation.
(c) Discussion: The technique of discussion among students and with the teacher was used in these modules to enhance correct concept formation. It helps to develop sociability that is otherwise neglected in self-study approach.

(d) Independent Study Task: The study material was prepared for self-study. The students could learn at their own pace doing the activities themselves. This helps to develop their skill in doing experiments.

(e) Most of the activities presented in the module are easy for the students to do themselves. Thus students learn through their own experience and develop problem-solving skills. For example, students are asked to do layering, budding and grafting.

(f) Concept Learning: Appropriate learning activities were formulated by adopting guided discovery approach for effective concept learning.

(g) Discrimination Learning: Students are helped to discriminate the characteristics of different types of flowers, the mode of reproduction by different plants and the different ways of vegetative propagation.

(h) Memorisation: Learning by memorisation cannot be avoided. Students learn the concepts of reproduction, pollination, fertilization and vegetative propagation and the like by memorising. We cannot call it rote learning because students have understood their meanings and needs.

(i) Meaningful Verbal Learning: The reasons for differences in the size, shape and colour of flowers, the mode of pollination and fertilization have been explained on the basis of experimental evidence.
(j) Students are free to seek the assistance from the teachers whenever a doubt arises either in understanding or in doing experiments.

(k) Feedback: Students were informed whether their answers were correct or not. If their answers were wrong, they would be led to the mastery of the correct answers through discussions with their classmates or teacher.

(l) Assessment: Provisions were made for formative assessment at the end of each unit and the summative assessment at the completion of the whole study material.

**Principles used in the Module.**

(a) Self Pacing: The prepared study modules were developed as self-study materials for the students of class IX following the State syllabus which is prescribed in most of the schools in Kerala and all the schools where the medium of instruction is Malayalam. The pupils can learn the materials on their own. They can use them in the school as well as at home, they can study at their own will at any time. The fast learner can complete the course in a shorter span of time; the slow learners are not left midway in the learning process, as is the case with the traditional textbook method where the slow learners usually lag behind the fast learners in the heterogeneous class rooms.

(b) Sequencing: The modules and sub-modular units were arranged in the logical order based on (i) inter-relationship between different concepts, and sub concepts, and (ii) similarity and gradation of knowledge.
(c) Formative Evaluation: At the end of each sub unit a set of formative evaluation questions were included. These questions are based on a single related concept and would lead the student to the next unit.

(d) Summative Evaluation: At the completion of learning the self-study material, composed of two modules with three sub units each, a standardized achievement test was given. The same test was administered at the beginning before the students entered the modular course. The achievement score was used for finding the effectiveness of the modules by comparing with the control group taught in the traditional method by the investigator.

Guided Inductive Inquiry Model

The investigator followed the model given by Arora & Narang (1996, p.757) (Eds.) in preparing the lessons in guided inductive inquiry model for teaching the topic "reproduction in plants". Before elaborating the content under the six steps, an analysis of the content was made.

(a) Analysis of the content: The content was analysed into concepts to be learnt, terms and facts to be familiarised and generalization to be arrived.

(b) Formulation of objectives: On the basis of the content the objectives to be realised were formulated. Knowledge, Understanding, Application and Skills were the objectives that could be included as instructional objectives while learning the topic 'Reproduction in Plants'. Since the long-term objectives like appreciation and evaluation could not be tested through objective type questions, they were not included as specific objectives. Appropriate learning activities that
enable the students to follow the steps in Guided Induction were included. The steps are as follows.

1. Identification of problem.
2. Formulation of hypothesis.
3. Collection of data.
4. Interpretation of data.
5. Development of tentative conclusions.
6. Replication which involves obtaining new data and revising original conclusions.

(c) Each concept is dealt with in such a way that the students are asked to identify a problem and formulate hypothesis. To teach asexual reproduction, for example, students are shown different types of plants that reproduce sexually and asexually and pose them a problem as to the differences between the two plants and gradually come to the conclusion that they have two distinct modes of reproduction.

(d) Formative evaluation: After each concept learning, questions related to it are asked to ensure that the students have acquired the stated objective with regard to the concept learned.

(e) Summative Evaluation: It is done after teaching the whole unit to assess how far the stated objectives have been realised. The same test was given at the beginning of the experiment to measure the difference between the two achievement scores. Lesson plans are given as Appendix C.
**Elements of Teaching Learning Techniques in Guided Inductive Inquiry.**

(a) **Questioning:** The technique of questioning plays an important role in Guided Inductive Inquiry. It enables the student for reflective thinking.

(b) **Active Participation of Students:** Students become more active since there is inquiry. They formulate hypothesis, conduct experiments and come to generalization. They may also suggest additional experiments. In the process of asexual reproduction for example they may suggest number of plants that reproduce asexually apart from the ones discussed in the class. They can also compare the characteristics of flowers pollinated by insects with those of flowers pollinated by wind while learning Pollination.

(c) **Scientific Attitude:** Guided Inductive Inquiry model enables the learner to develop scientific attitude by inquiring into the solution of the problems presented.

(d) **The creative talent of students is instilled in the process of Guided Inductive Inquiry.** Each student may think creatively to chalk out relevant experiments or activities to collect data for generalization.

(e) **Classroom becomes a learning laboratory:** The student reacts to the specifics of the lesson, the events, data, materials or objects and attempts to structure a meaningful pattern based on his/her observations and on those of others in the class.

(f) **Co-operation:** The teacher encourages each student to communicate his generalizations to the class so that others may benefit from individual perception.
Reliability and Validity of the Programmed Learning, Supervised Learning
Module and Guided Inductive Inquiry Lessons (Developed by the
Investigator)

The self-instructional materials namely Programmed Learning and
Supervised Learning Module and Guided Inductive Inquiry lesson which is a
modern instructional strategy were developed by the investigator by strictly
following the techniques and mechanics suggested by the educationists.

**Programmed Learning.**

It followed the linear style of programming proposed by B. F. Skinner.
The principles involved are (i) the learner works with the materials individually
at his own pace, (ii) the students learn through a variety of carefully ordered
sequence of materials which ask him to respond in some way or the other, (iii) the
material is so designed that the student makes few errors, and (iv) the learner is
immediately informed at every step whether his response is right or wrong.

**Supervised Learning Module.**

The supervised learning module was prepared based on the principles of
programmed learning. It followed the linear style structure as suggested by Leith
in Arora & Narang (1996) “A linear structure is one in which each unit of a course
depends upon and builds upon the previous one.” In the module appropriate
activities are included for the students to undertake and learn by themselves
through observation, reflective thinking and generalization.

The development of Programmed Learning Material and Supervised
Learning module consisted of different steps. The appropriate topic was selected;
broken down into manageable units and sub units and a pre-requisite test was administered to find out the level of competency needed for the learner. The learning activities and formative evaluation tests are provided in the PLM and SLM materials. Guidelines to direct the activities of students are included in SLM.

**Guided Inductive Inquiry Model.**

As the name indicates this followed inductive inquiry process which is guided by the teacher. It is as old as Socrates, Plato and Aristotle who are known as the masters of inquiry process. The lessons prepared are based on the model provided by Shulman as cited in Arora & Narang (1996) in using guided inductive inquiry process. It involves six steps namely:

1. Identification of a problem.
2. Formulation of Hypothesis
3. Collection of data
4. Interpretation of data
5. Developing tentative conclusion
6. Replication.

These steps are used in the preparation of the lessons. All the lessons do not follow all these steps strictly. The principles underlying Guided Inductive Inquiry are: (i) learning by doing, (ii) reflective thinking, (iii) inculcation of scientific attitude, (iv) self learning through questioning the information available, (v) induction that is psychologically sound principle on learning is
used, and (vi) the processes of observation, inference, classification, formulation of hypothesis and prediction are all sharpened by the experience provided.

The development of the lesson involved selection of topic, deciding different learning activities to guide the inquiry process of students and collecting specimens, pictures and other materials required for presentation of concepts. Formative evaluation questions were also prepared. Content analysis and formulation of specific objectives were done prior to the development of the lesson.

Different aspects like problem solving approach, details of entry behaviour for learning, specific outcomes of learning, conceptual analysis, provision for programmed learning and different teaching learning techniques were considered in developing the PLM, SLM and GII materials. This procedure helped to establish the construct validity of the programmed learning material, supervised learning module and guided inductive inquiry lessons. The materials were prepared according to the standard IX Kerala syllabus. These materials were evaluated by a number of experts in science education, educational technology and postgraduate teachers in biology (Appendix D). This ensured the content validity of the materials prepared by the investigator.

The reliability of the supervised learning modules, programmed learning material and guided inductive inquiry lessons were established using the three Evaluation Schedules (Appendices E, F & G) by the teachers who evaluated the learning materials, and lessons plans. Analyses of their observations clearly indicate that the instruments developed are highly reliable and practicable. The
reliability and validity of the Programmed Learning Material, Supervised Learning Module and lessons on Guided Inductive Inquiry are again confirmed by the appreciation recorded by the experts while evaluating the self-learning materials and lessons.

**Achievement Test in Biology for Standard IX**

Since no specific achievement test in the selected topic was available to test the effectiveness of the treatments on students' performance in biology, an achievement test in biology for standard IX on the topic Reproduction in Plants was prepared by the investigator. This was used as the pretest and posttest. The test items were prepared based on a blueprint.

**Preparation of the Blueprint.**

The blueprint is the three dimensional chart showing the coverage of content, objectives and form of questions. It is a document that gives a complete functional picture of the test. It shows the distribution of questions and marks for different objectives, various aspects of the content and the forms of questions corresponding to each content item and the specific objective. Preparation of the blueprint helped the investigator to have an objective based achievement test giving due weightage to objectives, content and form of questions. More than the required numbers of items were included in the test under each objective and content sub-unit. This was done to get enough items for the final test. Table 2 shows the blueprint for the final test consisting of fifty items.
Table 2
Blueprint of the Achievement test in Biology for Grade IX

<table>
<thead>
<tr>
<th>No</th>
<th>Content / Objectives</th>
<th>K</th>
<th>U</th>
<th>A</th>
<th>S</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reproduction</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Asexual Reproduction</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Vegetative Propagation</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Artificial Propagation</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>Parts of a flower</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>Pollination</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>Fertilization</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>12</td>
<td>15</td>
<td>13</td>
<td>10</td>
<td>50</td>
</tr>
</tbody>
</table>

K = Knowledge, U = Understanding, A = Application, S = Skill

Construction of Test Items.

A draft question paper consisting of 70 multiple-choice items was prepared. Majority of the items was intended for average pupils, but neither the intelligent nor the dull were ignored. Items were scrutinised by experts for suggestions for improvement. Modifications were made accordingly. For example, some of the questions were prepared in the form of filling in the blanks. It was suggested to change into statement/question.

Question before modification: _______ is an example of a unisexual flower.

Question after modification: Which among the following is a unisexual flower?

The items were arranged according to their expected level of difficulty. The easiest items were included in the beginning for motivating pupils. The draft was printed in the form of a booklet. Necessary directions were printed on the first page. Figures were drawn neatly against the corresponding items. Separate
answer sheets were printed. One hundred and twenty copies of the test and answer sheets were printed for try out. The copies of the draft test and the answer sheets are given as Appendix H and Appendix I.

**Procedure Adopted to Standardize the Achievement Test**

**Tryout**

For tryout the test was administered to a group representing the whole population. The students' answers were examined with a view to locating the changes needed in the test. The modified test was administered to a stratified sample of 100 students of standard IX from two schools in Kottayam District. Table 3 gives the details of the schools and sample selected for tryout.

**Table 3**

<table>
<thead>
<tr>
<th>Name of Institution</th>
<th>Boys/ Girls</th>
<th>Urban/ Rural</th>
<th>Govt/ private</th>
<th>Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Govt. Higher Secondary</td>
<td>Boys</td>
<td>Rural</td>
<td>Govt</td>
<td>50</td>
</tr>
<tr>
<td>School, Puthupally, Kottayam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mt. Carmel Higher Secondary</td>
<td>Girls</td>
<td>Urban</td>
<td>Private</td>
<td>50</td>
</tr>
<tr>
<td>School, Kottayam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total                                                                                       100

Enough time was given to the students so as to enable them to complete the test. The average time used was forty minutes and it was fixed as the time limit for the final test. The scoring was done giving one point credit for each correct response.
Item Analysis

It is the process of establishing the suitability of an item for inclusion in the final test. The quality of each item was ascertained by analysing two important characteristics of the item namely (i) Difficulty index and (ii) Discriminating power. For the present study Kelley’s (1939) method was used to calculate the difficulty index and discriminating power (pp. 17-24). Based on the scores obtained, pupils were arranged in descending order or magnitude i.e., from the highest to the lowest. Then the first 27 papers and the last 27 papers were used for item analysis. The difficulty index and discriminating power were calculated.

Items having difficulty index between 0.25 and 0.75 and discriminating power above 0.25 were selected for the final test. The details regarding the difficulty index and discriminating power of each item are given as Appendix J.

Distractor Analysis

Since the test consists of multiple choice items, there is every chance for guessing answers. If the distractors are properly given, guessing can be eliminated. So distractor analysis was done to eliminate defective distracters based on the difficulty index and discriminating power.

Preparation of the Final Test

Out of the 70 items included in the tryout 50 items were selected for the final test based on the difficulty index and discriminating power of the items. The selected items were arranged according to the difficulty level. The time limit for answering the test was fixed to be 45 minutes. The final test was printed with
all necessary instructions. Separate answer sheets were printed for answering the test. A sample achievement test, answer sheet and its scoring key are given as Appendix K and Appendix L and Appendix M.

**Reliability of the Achievement Test**

In the present study, split half method was used for determining the reliability of the test. In this method the score obtained for each individual was divided into two groups by pooling the odd number items and even number items. The reliability was determined by using the Kuder Richardson formula. The obtained score is 0.86. This shows that the test has high reliability.

**Validity of the Achievement Test**

As far as an achievement test is concerned, content validity and empirical or statistical validity is important.

**Content validity.**

Content validity is the representative or sampling adequacy of the content, the substance the matter and the topics of a measuring instrument (Mark, 1996, p.289). To ensure content validity the different sub units of the content were carefully examined and from each of the sub units, items were included. The content validity was established by the judgement of experts in biology test construction.

**Concept or construct validity.**

The construct validity of a test is the extent to which the test may be said to measure a "theoretical 'construct' or trait" (Anastasi, 1961, p.145). The problem of preparing a test that has concept or construct validity is that of
bridging the gap from broad general concept to specific tangible tasks or test items. For this the test items must be specific, concrete and precise. They must consist of definite limited tasks. The mental construct of the teacher who writes the test items determines the construct validity of a test. Tests should satisfy an analysis of ‘effective expression’. Thorndike and Hagen (1955, p.112) identified the following seven components for an analysis of effective expression: (i) selection of ideas to be presented, (ii) organisation of ideas for presentation: (a) arrangement in logical (b) subordination of details to main ideas, (iii) paragraphing: use of paragraphs to bring out the organisation of ideas, (iv) writing effective sentences: (v) effective use of words: (vi) adaptation to style to message: exposition, narration, etc., and (vii) adaptation to form to audience: in style and word choice.

The investigator tried to follow almost all the above seven components in the present test. The topic selected was ‘Reproduction in Plants’. The content was organised in a logical order. Adequate representation was given to sub concepts. The sentence styles varied in variety and length. Incomplete sentences were avoided and instead, sentences that convey a single complete idea were incorporated. Selecting the precise meaning and variety made effective use of words. Narration in proper style with simple words constituted easily readable and comprehensible sentences. Thus the achievement test prepared by the investigator fulfilled the requirements for effective expression. Hence the test has good construct or concept validity.
Empirical or statistical validity.

The empirical validity of the test was calculated by correlating the scores of the test with marks obtained for the first terminal biology examination. The correlation coefficient obtained was 0.83. The obtained value shows that the test has good empirical validity.

Objectivity.

The objectivity of a test affects both the validity and reliability of it. In the achievement test prepared, inclusion of only objective type items ensured objectivity. Using scoring key for evaluation also ensured objectivity.

Practicability.

The practicability of a test is maintained by means of the ease of administration, readiness of interpretation, economy in initial cost, probability of securing materials, time required for scoring and analysing the results. The prepared achievement test was easy to administer. It was economical, as it was reusable, since the answer sheets were provided separately. Time needed for scoring was limited as the window stencil method was adopted. Hence the test has good practicability.

Diagnostic Test of Learning Disability.

Since no diagnostic test for identifying learning disabilities present in the high school students in Kerala was available the investigator constructed a test consisting of four sections. This was used to categorise children as learning disabled and non-disabled. The test items were prepared based on a blueprint.
giving proper weightage to the objectives, the content chosen and the form of questions.

**Content**

The content for the diagnostic test was determined by taking into consideration the areas of academics and language (Smith, Polloway, Patton and Dowdy, 1998) that the learning disabled will lag behind in their intellectual ability. The seven areas recognised by the Ohio Department of Education (Orlansky, 1992) are oral expression, reading skills, written expression, listening comprehension, reading comprehension, Maths calculation and Maths reasoning. Most of the definitions of learning disabilities agree that the learning disabled has difficulty with reading, writing and arithmetic. The investigator has chosen five areas namely written expression, listening comprehension, reading comprehension, Mathematics calculation and Mathematics reasoning. The other two areas are included in the learning problem checklist prepared and used by the investigator for gathering information. It is a well-accepted fact that these seven areas strongly influence the achievement in content acquisition specially biology. Comprehension is a basic skill that heavily influences almost all aspects of educational achievement and students with learning disabilities demonstrate deficits in this crucial skill. All the steps in developing a standardized test were meticulously followed by the investigator. During the planning stage, an outline was prepared after analyzing the minimum levels of learning in the content areas selected for the diagnostic test. The content chosen was analysed in the light of
the different instructional objectives and due weightage was given to each of the objectives.

**Preparation of the Blueprint**

The blueprint is a document that gives a complete picture of the test. It shows the distribution of questions and marks assigned for different objectives and the various aspects of the content namely the learning skills. It helps the test constructor to prepare appropriate questions to suit the purpose of test construction. Thus the blueprint was prepared showing the distribution of questions and scores for different objectives, various aspects of the content namely written expression, listening comprehension, reading comprehension and mathematical computation. The details are given in Table 4.

**Construction of the Test Items**

A draft test consisting of 100 questions were prepared. The items were prepared taking into account the minimum levels of learning required for an eighth grade student in each of the selected areas. The items were intended to measure the written expression, reading comprehension, listening comprehension, mathematical computation and mathematical reasoning ability of students. The prepared items were scrutinised by experts and modifications were made according to their suggestions. For instance, some items measuring the ability to recall the content of the class texts were included in the draft test. Since the objective of the test was not to measure the rote memory but the learning ability, such items were discarded.
The items were arranged according to their expected level of difficulty. The draft was printed. It consisted of five sections. Necessary directions were printed on the first page of each section. Separate answer sheets were provided. Two hundred copies of the question papers and answer sheets were printed for try out. The copies of test and answer sheet are given as Appendix N and Appendix O.

**Table 4**  
**Blueprint of the Diagnostic Test of Learning Disability**

<table>
<thead>
<tr>
<th>No.</th>
<th>Content/Objectives</th>
<th>K</th>
<th>U</th>
<th>A</th>
<th>S</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Written Expression</td>
<td>1a(2)</td>
<td>1(5)</td>
<td>1b(3)</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Reading Comprehension</td>
<td>5(1)</td>
<td>5(1)</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Listening Comprehension</td>
<td>5(1)</td>
<td>5(1)</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Mathematical Computation</td>
<td>5(1)</td>
<td>5(1)</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Mathematical Reasoning</td>
<td>5(1)</td>
<td>5(1)</td>
<td></td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>7</td>
<td>20</td>
<td>15</td>
<td>8</td>
<td>50</td>
</tr>
</tbody>
</table>

K = Knowledge  
U = Understanding  
A = Application  
S = Skill

Number outside the brackets indicates number of questions and the number within outside the brackets indicates marks assigned to each question.

**Procedure Adopted to Standardize the Test.**

The prepared test consisted of five sub tests measuring five different content areas. It was decided to conduct the test and do item analysis separately for each section. The procedure adopted for standardization of Achievement Test in biology was strictly followed for the standardization of the Diagnostic Test of Learning Disability.
**Tryout.**

For tryout the test was administered to a group representing the whole population. The student's answers were examined with a view to locate the changes needed in the test. Accordingly changes were made. The modified test was administered to a stratified sample of 200 students of standard IX from four schools in Kottayam District. Table 5 gives the details of the schools and sample selected for try out.

**Table 5**

Schools and Sample selected for Tryout

<table>
<thead>
<tr>
<th>Name of Institution</th>
<th>Boys</th>
<th>Girls</th>
<th>Urban/Rural</th>
<th>Govt/private</th>
<th>Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Govt. Higher Secondary School, Puthupally</td>
<td>Boys</td>
<td>Rural</td>
<td>Govt</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Govt. Higher Secondary School, Kudamaloor</td>
<td>Boys/Girls</td>
<td>Rural</td>
<td>Govt</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>St. Mary's Girls' High School, Athirampuzha</td>
<td>Girls</td>
<td>Rural</td>
<td>Private/Aided</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>St. Joseph's Girls' High School, Kottayam</td>
<td>Girls</td>
<td>Urban</td>
<td>Private/Aided</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>200</strong></td>
</tr>
</tbody>
</table>

Enough time was given to the students so as to enable them to complete the test. The average time used was noted to fix the time limit for the final test. The scoring was done giving one point credit for each correct response. The essay questions were given 5 credits. The 5 credits were distributed equally for
the following aspects. Correct use of grammar, spelling, vocabulary, expression of ideas and good handwriting.

**Item Analysis**

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

For the present study Kelley’s (1939) method was used to calculate the difficulty index and discriminating power (pp.17-24). The answer sheet of each section of the test was analysed separately. Items having difficulty index between 0.25 and 0.75 and discriminating power above 0.25 were selected for the final test. The details regarding the difficulty index and discriminating power of each item are given as Appendix P.

**Distractor Analysis**

Since the test consists of multiple choice items, there is every chance for guessing answers. If the distractors are properly given, guessing can be eliminated. So distractor analysis was done to eliminate defective distractors based on the difficulty index and discriminating power.

**Preparation of the Final Test**

Out of the 100 items included in the tryout 42 items were selected for the final test based on the difficulty index and discriminating power of items. The selected items were arranged according to the difficulty level of the items in each section. The time limit for answering the test was fixed to be 40 minutes. The
Reliability of the Diagnostic Test of Learning Disability

In the present study, split half method was used for determining the reliability of the test. In this method the scores obtained for each individual for the test were divided into two groups by pooling odd number items and even number items. For the study, 100 papers were selected using the random sampling method. The reliability was determined by using the Kuder Richardson formula. The obtained score in each section of the test is given in Table 6.

Table 6
Values of Reliability Coefficients

<table>
<thead>
<tr>
<th>Tests</th>
<th>Reliability Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written Expression</td>
<td>0.65</td>
</tr>
<tr>
<td>Reading Comprehension</td>
<td>0.78</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>0.67</td>
</tr>
<tr>
<td>Mathematical Computation</td>
<td>0.58</td>
</tr>
<tr>
<td>Mathematical Reasoning</td>
<td>0.62</td>
</tr>
</tbody>
</table>

Validity of the Diagnostic Test of Learning Disability

The principal method of establishing validity involves “the appraisal of theoretically expected patterns of relationship among item scores or between test
scores and other measures (Messick, 1995, p.743). As far as a diagnostic test is concerned, content validity, construct validity and empirical validity or statistical validity are important.

**Content Validity**

Content validity is the situation included in the test which is representative of the group of situations that the test is supposed to sample. (Travers, 1964). To ensure content validity of the test, from the seven areas suggested by Smith, Polloway, Patton and Dowdy (1998), the following five were selected: Written expression, Listening comprehension, Reading comprehension, Mathematics calculation and Mathematics Reasoning. These areas strongly influence the achievement in the biology content. Equal weightage of 20 percent for each of the areas was given. The items related to all the areas were finalised on the basis of the suggestions of the experts in the subject. The content validity of the test was thus maintained.

**Concept or Construct Validity**

The problem of preparing a test that has concept or construct validity is that of bridging the gap from broad general concept to specific tangible tasks or test items. For this, the test items must be specific, concrete and precise. So specific, concrete and precise test items were prepared to ensure construct validity.

**Empirical or Statistical Validity**

The empirical validity of the first three sections of the test was calculated by correlating the scores of the test with marks obtained for the first terminal
examination in Language. The empirical validity of the last two sections was calculated by correlating the scores of the test with marks obtained for the first terminal examination for Mathematics. Table 7 gives the validity coefficients.

Table 7
Validity Coefficients

<table>
<thead>
<tr>
<th>Tests</th>
<th>Validity Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written Expression</td>
<td>0.75</td>
</tr>
<tr>
<td>Reading Comprehension</td>
<td>0.59</td>
</tr>
<tr>
<td>Listening Comprehension</td>
<td>0.67</td>
</tr>
<tr>
<td>Mathematical Computation</td>
<td>0.55</td>
</tr>
<tr>
<td>Mathematical Reasoning</td>
<td>0.62</td>
</tr>
</tbody>
</table>

Objectivity

The objectivity of a test affects both the validity and reliability of it. In the diagnostic test prepared, inclusion of only objective type items ensured objectivity. To measure written expression two essay type questions were included. The objectivity of these item were ensured using marking scheme for evaluation.

Practicability

Steps were taken to ensure practicability of the test. The prepared test was easy to administer as it was in the booklet form. It was economical, as it was reusable. The answer sheets were provided separately. Time needed for scoring was minimum as the window stencil method was adopted.
**Pupil Behaviour Rating Scale**

A rating scale was prepared by the investigator to measure the learning disability of the Grade IX students expressed through their behaviour. It was constructed based on the pupil behaviour rating scale standardized by Gearheart, Marsh & Gearheart (1978). The eight areas chosen for assessing the behaviour were spoken language, behaviour, orientation, spelling ability, arithmetic, reading, verbal communication and motor responses. The investigator prepared 30 items and after discussion with teachers the final test of 20 items was prepared. The rating scale is meant for the parents. It is a five-point scale.

**Validity and Reliability**

The principal method of establishing validity involves "the appraisal of theoretically expected patterns of relationship among item scores or between test scores and other measures (Messick, 1995, p.743). Thus the validity was ensured by correlation with the Learning Problem Checklist standardized by the investigator. The obtained value is 0.84. The split half method was used to determine the reliability of the test. The obtained value is 0.73. This shows that the test has high reliability. The draft and final form are given as Appendix T and Appendix U.

**Learning Problem Checklist**

The investigator interviewed some of the senior teachers and discussed the learning problems experienced by high school students in learning biology with a view to preparing the items for the leaning problem checklist. A checklist consisting of forty five items was prepared based on the discussions and in
consultation with the theories dealing with the learning problems of children. From the forty-five items twenty five were selected for the final checklist. These items were categorised under different areas of learning difficulties as given below.

1. Classroom behaviour

2. Academic Symptoms:-a) Reading b) Arithmetic c) Spelling d) Writing e) Speaking

3. Motor Response

Validity and Reliability

According to Moss (1992, p.233) the purpose of construct validity is to justify a particular interpretation of a test score by explaining the behaviour that the test score summarises. A simple construct validation procedure is to correlate scores on the test with scores on another established test measuring the same construct. Construct validity was established by correlation with the pupil behaviour rating scale standardized by the investigator. The value obtained is 0.84. The test has a retest reliability of 0.68. The draft form and the final checklist are given as Appendix V and Appendix W.

Measurement of Intelligence

The sample for the study is the learning disabled who have difficulty with language. So the investigator decided to use a non-verbal test of intelligence. Experts agreed upon that a good intelligence group test should have at least the following qualities: (i) it should be valid and reliable, (ii) it should be adjusted in difficulty to the age of the subjects, (iii) the test should be objective, (iv) the test
item should be graded properly, (v) the test should be adequately standardized on a representative sample of population, (vi) the test should be interesting to the subjects, (vii) the length of the test should be adequate, and (viii) the test should possess simplicity of responses and scoring.

Considering the above mentioned factors, the investigator decided to use Raven’s Progressive Matrices sets A, B, C, D and E for measuring the intelligence of pupils in the present study.

**Raven’s Progressive Matrices Sets A, B, C, D and E.**

This is a non-verbal group test administered to measure a person’s capacity to apprehend meaningless figures presented for observation, see the relations between them, conceive the nature of the figures completing each system of relations presented and so develop a systematic method of reasoning (Raven, 1960, p.1). The test is intended for pupils above 11 years of age. The test consists of 60 problems divided into five sets of 12 each. In each set the first problem is the easiest one and the consecutive problems become gradually difficult in each set.

The order of the test provides the standard training in the method of working. The five sets provide five opportunities for grasping the method and five progressive assessment of a person’s capacity for intellectual activity. The tests are meant to evaluate the person’s ability to discern and utilise a logical relationship presented by non-verbal materials. The problem requires in varying degrees, analytical and integrating operations of the kind called ‘insight through
visual activity'. The test is intended to cover the whole range of intellectual development of a child.

Everyone, irrespective of his age, was given exactly the same series of problems in the same order and was asked to work at his own speed, without interruption from the beginning to the end of the test. A person’s total score provides an idea of his intellectual capacity, whatever be his nationality or education.

In a study on the effect of timing on predictability on Raven’s test scores Tampuratti (1969) arrived at the conclusion that twenty minutes seem to be the most satisfactory time span to complete the test, for the purposes of prediction of the intelligence of pupils at the secondary level.

The test has retest reliability varying with age from 0.83 to 0.93. It correlates 0.86 with the Term and Merrill Scale, and has been found to have a ‘g’ saturation of 0.82. (Raven, 1960, p.2). This test is a popular measure used in Indian Schools.

**Study Habits Inventory**

The investigator made use of Rao’s Study Habits Inventory constructed and standardized by D Gopal Rao (1976). This tool is published by Agra Psychological Research Cell. The test consists of 40 items. This tool is meant to assess the study habits of high school pupils.

The split half reliability coefficient of the inventory is .84. It also possesses content validity and concurrent validity. The content validity of the scale is ensured by the method of collecting items within the universe of study
habits through interviews with various teachers, parents and experts in the field. The concurrent validity was determined by comparing the mean scores of 100 students having good study habits and 80 students having poor study habits. The difference between the mean scores of two groups was significant at .01 level, in favour of the students having good study habits. The tool is given as Appendix X.

**Home Learning Facility Inventory**

This is a ten-item inventory developed by Nair and Nirmaladevi (1981). This inventory consists of a list of the basic facilities required to respond to each item by marking their availability at home (using ‘Yes’ or ‘No’). Each ‘Yes’ response would receive a ‘unit’ score while a ‘No’ response would receive a zero score. The score of a subject is the sum of scores obtained by the subject in all the items of the inventory.

**Validity and Reliability**

The validity of the inventory has been answered in terms of the definition and representation given to the concept under measurement (construct and concurrent validity). The external validation of the tool was done by correlating the scores of the inventory with the total class achievement of 85 pupils of standard X in a selected secondary school. The correlation obtained was .41. The split half reliability coefficient of the test was .69. Thus the inventory is a valid and reliable instrument for measuring ‘home learning facility’ under Kerala condition. A copy of the inventory is given as Appendix Y.
**Achievement Motivation Scale**

The researcher has used the Achievement Motivation Scale constructed and standardized by Beena Shah (1986). This test is published by Agra Psychological Research Cell. In this Achievement Motivation Scale there are items belonging to four dimensions of achievement motivation. They are (1) need for academic success, (2) need for vocational achievement, (3) need for social achievement, and (4) need for skill achievement. Of these, the researcher has chosen the items pertaining to academic success.

Test-retest reliability coefficient with time variation for the dimension of 'Need for Academic Success’ is 0.86 after 15 days and 0.84 after 30 days. The reliability index is 0.92 after 15 days and .84 after 30 days. The test constructor also claims content validity, item validity and congruent validity. A copy of the inventory is given as Appendix Z.

**Socio-economic Status Scale**

The investigator used the updated socio-economic status scale prepared by Kuppuswamy (1962) and published by Manasayasn. Nair (1970), Pillai (1973), Sivadasan (1975), and Iyer (1977) used the same scale. The scale modified according to the pay scales existing at the time of administration of the tool (Appendix A₁). The socio-economic status of a student is determined in terms of three variables viz. education, occupation and income of parents. Each variable is classified into seven categories.
**Income: Classification and weightage.**

On the basis of monthly income also, people were classified into six categories. For the group having monthly income above Rs.8250/-, a score of ten is given. For the group having monthly income in the range of Rs.6351 to Rs.8250/-, a score of eight is given. For the group having monthly income in the range of Rs.4250 to Rs.6350/-, a score of six and for those having monthly income in the range of Rs.2000/- to Rs.4251/- a score of four is given. For the group having monthly income in the range of Rs.1000/- to Rs.2000/-, a score of two and for those having monthly income below Rs.1000/-, a score of one is given. The weightage given to the various categories are presented in the consolidated form in Table 8.

2. **Computation of socio-economic status of the families of students.**

Full weightage was given to the head of the family/father/mother. Half the credit was given to the other parent. If the elder sister/brother’s education, occupation or income is higher than that of parent’s, one point weightage is given and a maximum of two points if both the sister and brother are higher in education, occupation or income. If the sister or brother is unmarried or staying with the family after marriage a one point weightage is given. The total of the scores obtained for the three components of socio-economic status designated above yielded a composite score for each member. The sum of the composite score obtained for all the members in the family was taken as the socio-economic status of the family. Thus a maximum score of 48 is fixed for a student as the socio-economic status score of his family.
Table 8
Weightage given to Items in the Socio-economic status scale

<table>
<thead>
<tr>
<th>Education</th>
<th>Score</th>
<th>Occupation</th>
<th>Score</th>
<th>Income</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master's degree Professional Degree &amp; above</td>
<td>10</td>
<td>Professional</td>
<td>10</td>
<td>Above 8250</td>
<td>10</td>
</tr>
<tr>
<td>Bachelor's Degree</td>
<td>8</td>
<td>Semi-Professional</td>
<td>8</td>
<td>6351-8250</td>
<td>8</td>
</tr>
<tr>
<td>Pre-degree, Pre-University</td>
<td>5</td>
<td>Skilled Workers</td>
<td>7</td>
<td>4250-6350</td>
<td>6</td>
</tr>
<tr>
<td>S. S. L. C</td>
<td>4</td>
<td>Semi-skilled Workers</td>
<td>4</td>
<td>2000-4250</td>
<td>4</td>
</tr>
<tr>
<td>Up to Standard VIII</td>
<td>1</td>
<td>Unskilled Workers</td>
<td>2</td>
<td>1000-2000</td>
<td>2</td>
</tr>
<tr>
<td>Literate (complete lower primary)</td>
<td>0</td>
<td>Unemployed</td>
<td>2</td>
<td>below 1000</td>
<td>1</td>
</tr>
</tbody>
</table>

Experiments Conducted

As the present study is aimed at finding the effectiveness of self-learning materials namely programmed learning material (PLM) and supervised learning module (SLM) and a modern instructional strategy namely guided inductive inquiry (GII), the experimental method was adopted. Three experiments were conducted by comparing the effects of the methods selected for study with that of the lecture demonstration method (LDM) in the learning of LD and ND students. The details of the procedure adopted for the experiment are given below.
**The Details of the Procedure**

The design of the experiment was that of the three experimental groups for the three methods to be tested PLM, SLM and GI1 and one control group for the traditional lecture demonstration method (LDM). All the four groups consisted of 51 LD students and 51 ND students in each of them. The pretest and posttest non-equivalent group design was adopted to conduct the experiment.

The students on all the groups were pre-tested with the achievement test in biology for standard IX prepared by the investigator. The experiment and control groups were taught during the usual hours assigned for teaching science.

In the PLM group, the students were given the copies of the programmed learning material compiled in the form of a booklet. They were asked to learn at their pace the entire portion of "Reproduction in Plants" using the booklet. Some activities were conducted using the class hours with active pupil participation. Since the teacher's help was required for such activities. The students were allowed to carry the booklets home and study at their own pace.

In the SLM group, the students were given the copies of the three modules. They learned the module at their own pace. Since the investigator was supposed to supervise the learning modules, she discussed with the students the results of their activities. As done in the PLM some of the activities were done in the class under the supervision of the investigator. The students studied the major part of the module at their own pace.

In the GI1 group, unlike the other two groups, the investigator taught the unit using the lesson plans prepared in the inductive enquiry approach. The
entire topic “Reproduction in Plants” was divided into nine lessons. The investigator, instead of teaching directly, helped the students by guiding them in the process of their inquiry into new knowledge.

In the control group of lecture demonstration method, the investigator herself presented the lesson and explained the facts and concepts given in the prescribed textbooks. She confined her teaching to textual illustrations and examples whenever possible. This practice is an attribute of the traditional lecture demonstration method. The investigator has taken care to keep the standard of explanation of concepts in the conventional method of teaching.

The experiment was conducted for more than one month in the schools as detailed under the section ‘Sample’.

After the experiments students of all the four groups were tested using the same Achievement test. The tools of the extraneous variables were also administered.

**Statistical Methods Adopted**

The pretest scores and the posttest scores of the experimental and control groups were consolidated for statistical analysis along with the scores of intelligence, diagnostic test of learning disability, home learning facility inventory, study habits inventory, achievement motivation scale and socio-economic status scale.

Since the experiment required identification of learning disabled students, regression analysis was done with the intelligence scores and the first terminal examination scores in biology of the sample selected for the study. As the aim of
the study was to test the effectiveness of the self-learning materials and modern instructional strategy, paired ‘t’ test was done using the pretest and posttest scores. The important statistical measures pertaining to central tendency and dispersion of the pretest and posttest scores were calculated to study the nature of the scores.

Since the experiment was conducted using intact, unequated groups, Analysis of Covariance (ANCOVA) was applied for analysing the final scores. ANCOVA thus facilitates the researcher for statistical equating of groups.

In order to determine the influence of extraneous variables like home learning facility, study habits, achievement motivation and socio-economic status on the achievement of LD and ND students, Multiple Regression Analysis was computed. The details of the analysis of data are given in the following chapter. The important findings are reported and based on the findings the tenability of the hypotheses is tested. On the basis of the important findings necessary suggestions for the improvement of teaching Biology are given.
References


