CHAPTER TWO

DEVELOPMENT OF THE PROGRAMME
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This chapter describes the procedure followed for the development of the programme on "vegetative reproduction in plants". The entire presentation is divided into three stages. Each stage is further discussed in a number of sub-steps. The following are the three stages:

- Preparation
- Writing
- Testing and revision.

The first stage concerns the preliminaries required for developing the programme. The second stage indicates how the programme was written. The third stage presents an account of the developmental and validation testing.

2.1

PREPARATION Preparation stage is the most crucial stage and challenging to the programmer. Preparation or planning of a programme means taking a number of vital decisions. These concern the topic to be selected for developing a programme, the learner for whom it is intended, description of terminal behaviour and the nature of criterion test.
Consequently, a good part of time spent on preparing the draft programme was devoted to the preparation stage. Various steps followed at this stage are as under.

2.2

**SELECTION OF THE TOPIC**

While selecting the topic, "vegetative reproduction in plants" the investigator kept in mind the following criteria laid down by Lysaught and Williams (1963):

- The programmer's own field of study.
- Ease of treatment
- Length
- Depressed level of learning
- Logical order of material
- Special students' needs.

**THE PROGRAMMER'S OWN FIELD OF STUDY**

The investigator had been a student of biology and he studied the subject up to Master's degree. He therefore, had basic understanding of the subject. Hence the choice of topic justified in terms of his own background.

**EASE OF TREATMENT**

The content selected for the development of the programme is definite, precise unambiguous and rather simple in structure and as such could be programmed with ease and efficiency, meeting thereby the criterion of ease of treatment.
LENGTH

The programme teaches the characteristic features of vegetative propagation and its important methods. As the content pertains to only vegetative reproduction in plants, hence, it is not expected to take unduly long time to complete.

DEPRESSED LEVEL OF LEARNING

Our schools lack not only efficient teachers in biology but also suitable text books in the subject. Moreover, the traditional methods of teaching science, often become hurdles for the learners in achieving mastery. The investigator, on the basis of his own experience and on the basis of students' views on the content of vegetative reproduction in plants felt that this particular topic is one of the stumbling blocks to learners and can be better taught by programming. Therefore, choice of the content viewed in this perspective is quite defensible.

LOGICAL ORDER OF MATERIAL

Biology as a subject is perhaps more suitable to programming than most other major areas of study, since its subject matter is systematic and logical. This is specially true in the case of vegetative reproduction in plants.

SPECIAL STUDENT NEEDS

The content selected forms a very significant part of the syllabus in biology and general science prescribed at the Secondary and Pre-University level. The topic has a special
relationship to the course of study and serves as an enrichment material for students who intend to join agricultural courses and wish to work in fields and orchards.

2.3

ASSUMPTIONS
ABOUT LEARNER'S ENTERING BEHAVIOUR

There are always certain necessary components which must pre-exist in the learner's behaviour before he is able to achieve a set of given objectives. If these entering behaviours upon which subsequent performance is based do not exist in the repertory of a student, he cannot derive full benefit from the course of study. Entering behaviour describes the present status of the student's knowledge and skill in reference to a future status (terminal behaviour) the programmer wants him to attain.

No concept of science can be taught in isolation, it has to be developed from the simpler concepts. Therefore, a certain level of entering behaviour in biology is required. On the basis of this requirement, the following assumptions about the learners have been made, keeping in mind their average age and grade. The students can:

- Name various parts of the flowering plant like root, stem, leaf and flower.
- Classify the parts of a flowering plant into vegetative and reproductive parts.
- Differentiate between vegetative and reproductive parts of a flowering plant.
- Describe the main functions of vegetative and reproductive parts of a plant.

2.4

DEFINING OBJECTIVES IN BEHAVIOURAL TERMS

A key factor in programmed instruction is the detailed specification of objective terms of instruction in behavioural terms.

Mager (1962) provides excellent guidance regarding writing of objectives in behaviour terms. He contends that a statement of instructional objectives requires each of the following:-

- Identification of terminal performance which the instruction attempts to produce.
- Define the important conditions under which the behaviour is expected to occur.
- Define the criterion of acceptable performance.

Taking into account the three above mentioned requirements, a detailed list of objectives in terms of terminal performance was drawn up. The content was split up into four units and the objectives for each unit were written in terms of specific outcomes and in clear and unambiguous language. The detailed unitwise list of objectives is as follows:
OBJECTIVES

UNIT-I

The learners:

- Define the term 'Reproduction'.
- Identify the correct definition of the term reproduction out of the given four definitions.
- Complete the incomplete definition of the term reproduction.
- Identify the term which best suits the given definition out of the four technical terms given, in a list.
- Define the term vegetative reproduction.
- Identify, the correct definition of vegetative reproduction out the given four definitions.
- Complete the incomplete definition of the term vegetative reproduction.
- Given the names of four plants, identify, the plant which does not develop from some vegetative part of the plant.
- Given four statements, identify the statement which describes the process of vegetative propagation.
- Given an incomplete statement, complete the statement to describe the process of vegetative propagation.
- Write at least two advantages of the process of vegetative propagation.
- Give at least one disadvantage of the process of vegetative propagation.

UNIT-II

The learners:

- Name at least one plant which propagates vegetatively by rhizomes.
- Given the names of four plants, identify the plant which does not propagate by rhizome.
- Given four statements, identify, the statement which explains the process of vegetative propagation by rhizomes correctly.
- Name at least one plant which propagates vegetatively by tubers.
- Given the names of four plants, identify the plant which reproduces vegetatively by tubers.
- Given four statements, identify, the statement which explains the process of vegetative reproduction by tubers correctly.
- Name at least one plant which reproduces vegetatively by corms.
- Given the names of four plants, identify the plant which reproduces vegetatively by corms.
- Identify the statement which explains the process of vegetative propagation by corms out of given four statements.
- Name atleast one plant which reproduces vegetatively by bulbs.
- Given the names of four plants, identify the plant which reproduces by bulbs.
- Given four statements, identify, the statement which explains the process of vegetative propagation by bulbs.
- Name atleast one plant which propagates vegetatively by aerial stems.
- Given four statements, identify the statement which explains the process of vegetative propagation by aerial stems.
- Given four statements, identify, the statement which tells the characteristic feature of runners.
- Given four statements, identify the statement which best explains the process of vegetative propagation in runners.
- Given the names of four plants, identify the plant which reproduces by runners.
- Name one plant which reproduces by runners.

UNIT-III

The learners:
- Define the term 'Grafting'.
- Complete the incomplete definition of grafting.
- Given four definitions, identify the correct definition of grafting.
- Define the term 'Stock'.
- Given four technical terms, identify, the term which is best associated with the given definition.
- Define the term 'Scion'.
- Given a list of technical terms, identify the term which best suits the given definition.
- Write the function of stock in their own words.
- Tell the function of Scion in their own words.
- Identify the function of stock out of the given four alternatives.
- Identify the function of Scion out of given four alternatives.
- Give the meaning of term 'Cambium'.
- Identify the correct definition of cambium out of the given four definitions.
- Give the function of Cambium.
- Identify the function of cambium out of given four alternatives.
- Identify correctly; the condition necessary for successful grafting out of the given four alternatives.
- Tell at least one condition necessary for a successful grafting.
- Give at least one advantage of grafting.
- Given four statements, identify the advantage of the process of grafting.
- Complete an incomplete statement to tell the advantage of the process of grafting.
- Given an example of the union of stock and scion of two different plants, write the quality of the plant which is expected to develop from this union.
- Enumurate two widely practised methods of joining stock and scion.
- Given one method of grafting, complete an incomplete statement by naming the other method.
- Given four statements, identify the statement which best describes the process of tongue grafting.
- Given four statements, identify the statement which best explains the process of wedge grafting.

UNIT - IV

The learners:
- Complete the incomplete definition of cutting.
- Define the meaning of the term 'cutting'.
- Identify the correct definition of cutting out of the given four definitions.
- Given three kinds of cuttings, identify the kind which is most commonly practised.
- Given four statements, identify the statement which best describes the process of cutting.
- Given an incomplete statement, complete the definition of layer.
- Give the meaning of the term 'Layer'.
- Given four definitions, identify the correct definition of Layer.
- Given four statements, identify the statement which best describes the process of Layering.
- Identify the kind of scion used in the process of budding out of the given list of four kinds of scion.
- Given four statements, identify the statement which best describes the process of budding.
- Complete an incomplete statement to tell the nature of scion used in the process of budding.
- Given the diagrammatic representations of various methods of grafting and also the names of techniques of grafting, match the appropriate technique with the diagram.
2.5 CONSTRUCTING THE CRITERION TEST.

The criterion behaviour entails the learning of skills and concepts related to achievement of objectives. Tests linked to this approach are generally referred to as criterion-referenced tests (Stones 1979). Criterion test is designed to evaluate mastery learning. It informs the programmer whether or not he has achieved his objectives. That is, has he, in fact, taught his pupils what he set out to teach them?

Criterion test is a test which the programmer develops before he starts on the instructional sequence in order to ensure that the test will be consistent with the programme objectives (Patricia Callender 1969).

Pipe (1966) is more precise in defining the criterion test. He has differentiated criterion test from achievement test. According to him criterion test is one that tests whether the students have attained the behavioural goals. It is not concerned with hard or easy items. It has nothing to do with the grading of learners. It is a mastery test and the standards of attaining the objectives lie in the close proximity of 100% or (90/90 standard). On the other hand the achievement test is mainly a discriminating test and its main emphasis is upon discriminating one student from the other. Therefore, the standards of the attainment of objectives are
not set as high in an achievement test as in a criterion test.

At the planning stage of the construction of test, advance decisions about the content and its analysis into different units were taken. The investigator clearly defined the instructional objectives for each unit in behavioural terms and decided the weightage to be given to objectives falling on each unit. The decisions regarding the content were taken after thorough discussions with the subject matter experts of the subject concerned.

The test items of the initial draft of the criterion test were written taking into account the objectives and the content needed to achieve these objectives while writing the test items, following points, were kept in view:

- the item was related to at least one of the desired objectives;

- the item was clear and unambiguous as for as possible;

- the item was related to the ability level of the students for whom it was meant.

The subject matter experts in biology and the teachers who were teaching this subject at secondary and Pre-University level, were frequently consulted before and after writing the test items, to ensure technical accuracy, adequacy and suitability of the content.
Initially 110 items were written but finally 100 items were selected to be administered to the students for tryout. The test was administered to those students who had read the topic previously. Items were suitably arranged in the form of a test. The directions were simple and written in clear language. Items of one kind were clustered in one unit, for ease of scoring. The scoring key was prepared in advance. Before the administration of the test the normal testing conditions were ensured. No time limit was imposed on students.

The initial draft of the criterion test was administered on a representative sample of 72 students with boys and girls equal in number approximately. The programmer personally supervised the subjects and helped them to remove their doubts pertaining to the language and misprints, if any, in the draft of the test.

**TABLE -1**

**DETAILS OF THE SAMPLE OF THE FIRST DRAFT OF THE CRITERION TEST.**

<table>
<thead>
<tr>
<th>Class</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Medical</td>
<td>38</td>
<td>34</td>
<td>72</td>
</tr>
</tbody>
</table>
Table-1, shows the structure of the sample used for the first draft of criterion test. The students selected belonged to Pre-Medical class of randomly selected colleges located at Chandigarh and Ambala. Among 72 students, the number of boys was 38 and that of girls was 34.

**Table -2**

**SPECIFICATION OF ITEMS IN THE FIRST DRAFT OF THE CRITERION TEST**

<table>
<thead>
<tr>
<th>Section</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>items</td>
</tr>
<tr>
<td>Types of items</td>
<td>Multiple choice</td>
<td>Completion type</td>
<td>Short answer</td>
<td>Matching type</td>
<td>No. of items</td>
</tr>
</tbody>
</table>

Table-2, shows that there were four sections, namely I, II, III, IV of the criterion test. Section I included multiple choice items, section II completion type, section III short answer type and section IV included matching type items.

For scoring the criterion test, one mark was assigned to each correct item and for incorrect response zero mark was given. For guessing, no correction formula was applied because the number of multiple choice items omitted by the students was
negligible.

After scoring the criterion test, the scores were tabulated and classified.

Each item was analysed for its discriminating power (D.P.) and difficulty value (D.V.). The D.P. and D.V. for each item was calculated on the scores of the students on two criterion groups (upper and lower) with 27 per cent cases in each group as recommended by Kelley (1939).

The index of discriminating power (D.P.) and index of difficulty value (D.V.) were calculated by the following formulae, given by Garrett (1959).

\[
D.V. = \frac{R_U + R_L}{N} 
\]

\[
D.P. = \frac{R_U - R_L}{0.5N} 
\]

\( R_U \) = Stands for number of correct responses in the upper group.

\( R_L \) = Stands for number of correct responses in the lower group.

\( N \) = Stands for total number of students in both the groups.

The D.P. and D.V. corresponding to each item have been given in the Appendix B. The D.V. of the test items ranged from .15 to 1 while D.P. ranged from 0 to .85.
Ebel's (1966) criteria for evaluating the item discrimination indices, which are given below were duly considered in this connection:

<table>
<thead>
<tr>
<th>Index of discrimination</th>
<th>Item evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>.40 and above</td>
<td>Very good items</td>
</tr>
<tr>
<td>.30 to .39</td>
<td>Reasonably good</td>
</tr>
<tr>
<td>.20 to .29</td>
<td>Subject to improvement</td>
</tr>
<tr>
<td>Below .19</td>
<td>Poor items to be rejected</td>
</tr>
</tbody>
</table>

Garrett (1966), however, contends that items with discriminating indices of .20, as a general rule are satisfactory. Ebel's criteria for retaining, modifying and rejecting the items were applied as shown in Table-3. For bringing out the second draft of the criterion test.

### Table-3

**THE DISTRIBUTION OF DISCRIMINATING POWER OF THE ITEMS OF THE FIRST DRAFT OF THE CRITERION TEST**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Discriminating power</th>
<th>Frequency</th>
<th>Item No.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>.40 and above</td>
<td>48</td>
<td>4, 6, 7, 17, 31, 35</td>
<td>Accept as such</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>42, 43, 47, 48, 50,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>52, 53, 54, 58, 59</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>60, 61, 64, 66, 67,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>68, 69, 72, 73, 75,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>76, 77, 78, 79, 80,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>81, 82, 83, 84, 85,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>86, 87, 88, 89, 90,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>91, 92, 93, 94, 95,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>96, 98</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>.30 to .39</td>
<td>11</td>
<td>23, 24, 29, 49, 51,</td>
<td>Accept as such</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>62, 65, 74, 97, 99,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Table-3 (contd...)
### Table-3 (Contd.)

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Discriminating power</th>
<th>Frequency</th>
<th>Item No.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.</td>
<td>.20 to .29</td>
<td>30</td>
<td>1,3,5,9,11,12, 13,15,18,19,20, 21,22,25,26,27, 28,30,32,33,34, 37,39,41,45,46, 55,56,57,71.</td>
<td>Accepted and revised</td>
</tr>
<tr>
<td>4.</td>
<td>Below .19</td>
<td>11</td>
<td>2,8,10,14,16,36, 38,40,44,63,70.</td>
<td>Rejected</td>
</tr>
</tbody>
</table>

Table-3, reveals that the items with discriminating power of .40 and above were accepted as such and items having discriminating power between .30 and .39 were also accepted as such, being classified as reasonably good items. Items having discriminating power from .20 to .29 were revised and modified. Items having discriminating power below .19 were rejected. In the first draft of criterion test, on the basis of D.P., out of the total number of 100 items, 59 items were accepted as such, 30 items were revised and modified and 11 items were rejected.

A careful examination of the test in respect of its items showed that even though some items were rejected, the coverage of the content was not disturbed.
In the selection of multiple choice items DeCesco's (1970) rule was followed. The items which were answered by 50 per cent of the students correctly were accepted as such and others were revised and modified on the basis of language and distractors. For selection of distractor criterion of at least 10 per cent answers to a particular distractor was followed.

**Table 4**

**The Distribution—Percentage of the Correct Responses and the Distractors in the First Draft of Criterion Test.**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Form of Response</th>
<th>Item No.</th>
<th>Frequency</th>
<th>Remarks</th>
<th>Remarks and response reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Correct response</td>
<td>4, 28, 37, 40</td>
<td>4</td>
<td>Revised &amp; modified</td>
<td></td>
</tr>
<tr>
<td></td>
<td>with less than 50% distribution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Distractors completing with the correct answer</td>
<td>NIL</td>
<td>NIL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Distractors with less than 10% distribution</td>
<td>1, 9, 11, 22, 27</td>
<td>5</td>
<td>Revised &amp; modified</td>
<td></td>
</tr>
</tbody>
</table>

Table 4 shows that items 4, 28, 37 and 40 were revised for correct response as these four items had less than 50% distribution and items 1, 9, 11, 12 and 27 were revised for their distractors.
which attracted less than 10 per cent responses. The revision of these items were made both with regard to the stem and the responses. The items were revised for clarity of language and the formulation of problem. The responses were modified to make the correct response significantly prominent. The details of response analysis of multiple choice items is given in Appendix-B2.

2.5.1

RELIABILITY AND VALIDITY OF FIRST DRAFT OF CRITERION TEST.

For the evaluation of the criterion test, its reliability and validity were determined by statistical techniques as applicable to achievement tests. For computing reliability coefficient of the test, Kuder-Richardson formula as given by H.G. Macintosh and R.B. Morrison (1969) in their book "Objective Testing" was used. It is quick method which can be used with the 27 per cent grouping employed in finding the discrimination index. This provides reliability coefficient as a whole. The higher this coefficient is, the more reliable it is likely to be. The formula is as follows:

\[
r = \frac{K}{k-1} \left[ 1 - \frac{2n \sum (N_H + N_L) - \sum (N_H + N_L)^2}{0.667 \left[ \sum (N_H - N_L) \right]^2} \right]
\]

\( r = \) Reliability co-efficient.
\( n = \) Number of students in one group.
\( N_H \) = Scores of the students in upper group.

\( N_L \) = Scores of the students in lower group.

\( K \) = Number of items in the test.

Table-5 gives the details of the computation of reliability co-efficient of the first draft of the criterion test.

**TABLE-5**

**COMPUTATION OF RELIABILITY COEFFICIENT OF THE FIRST DRAFT OF CRITERION TEST**

\[
\begin{align*}
\Sigma ( N_H + N_L ) & = 3026 \\
\Sigma ( N_H + N_L )^2 & = 77894 \\
\Sigma ( N_H - N_L ) & = 699 \\
\left[ \Sigma ( N_H - N_L ) \right]^2 & = 488601 \\
K & = 100 \\
n & = 20 \\
\rho & = \frac{100}{99} \left[ 1 - \frac{2 \times 20 \times 3026 - 77894}{0.667 \times 488601} \right] \\
\rho & = 0.877
\end{align*}
\]

It may be observed from the above calculations that the reliability co-efficient of the first draft of the criterion test computed by Kuder Richardson formula was obtained to be 0.877.
2.5.2

THE SECOND DRAFT OF THE CRITERION TEST

The items after having been revised, modified and rejected on the basis of discriminating power and difficulty value and the multiple-choice items having been revised and modified with regard to their distractors and responses, the second draft of the criterion test was prepared. The second draft consisted of 89 test items.

The second draft of the criterion test was administered on a representative sample of 72 students of Pre-Medical class of randomly selected colleges of Chandigarh and Ambala. Boys and girls were represented in almost equal proportion of the sample.

TABLE -6

DETAILS OF THE SAMPLE OF THE SECOND DRAFT OF THE CRITERION TEST

<table>
<thead>
<tr>
<th>Class</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Medical</td>
<td>37</td>
<td>35</td>
<td>72</td>
</tr>
</tbody>
</table>

Table-6 shows the structure of the sample used for the second draft of the criterion test. Among 72 students, the number of boys was 37 and that of girls was 35.
It may be observed from the table-7 that the number of items in the second draft of the criterion test was 35, 19, 28 and 7 in respect of multiple choice, completion type, short answer and matching type items respectively.

The difficulty value and discriminating power of the test items were calculated. As mentioned earlier, the top 27 per cent and below 27 per cent students were taken as the criterion sample for item analysis. The difficulty value and discriminating power were tabulated (Appendix-8). The items accepted, rejected or modified by using Albe's (1966) criteria are given in table-8.
TABLE- 8

THE DISTRIBUTION OF DISCRIMINATING POWER (D.P)
IN THE SECOND DRAFT OF THE CRITERION TEST.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Discriminating power</th>
<th>Frequency</th>
<th>Item Nos.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>.40 and above</td>
<td>40</td>
<td>3,6,12,18,27,33, 40,43,44,45,47, 48,49,51,52,54, 57,58,59,61,62, 63,66,67,68,69, 70,71,72,73,74, 75,78,79,80,81, 83,84,85,86,</td>
<td>Accepted as such</td>
</tr>
<tr>
<td>2.</td>
<td>.30 to .39</td>
<td>19</td>
<td>8,19,20,21,24, 32,34,38,39,41, 42,46,50,56,60, 76,77,82,88</td>
<td>Accepted as such</td>
</tr>
<tr>
<td>3.</td>
<td>.20 to .29</td>
<td>30</td>
<td>1,2,4,5,7,9,10, 11,13,14,15,16,17, 22,23,25,26,28,29, 30,31,35,36,37,53, 55,64,65,87,89</td>
<td>Revised and modified ed.</td>
</tr>
<tr>
<td>4.</td>
<td>Below .19</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
</tr>
</tbody>
</table>

It may be observed from the table-8 that there were 89 items in the second draft, out of these 40 items were with discriminating power of .40 and above. These items were accepted as such. 19 items had discriminating power between .30 to .39.
thus, also accepted as such. While 30 items had D.P. between .20 and .29, these were modified and revised.

In the second draft there was no item which could be rejected because of low discriminating power. The comparison of first and second modified draft of the criterion test revealed a significant improvement in the second draft. It may also be pointed out that all the items in the second draft had difficulty value ranging from .38 to .90.

The response analysis of the multiple choice items of the second draft was also done (Appendix-8). In the selection of multiple choice items DeCecco's (1970) rule was followed. The items which were answered by 50 per cent of the students correctly were accepted as such. For distractors, the minimum standard of 10 per cent responses was arbitrarily decided. It is, therefore, clear from the table-8 that the criteria set forth by the investigator are met with. No further modification of any item is, therefore, needed.

2.5.3

RELIABILITY

The reliability of the second draft of the criterion test was also computed by Kuder Richardson formula (as explained previously) as given by H.G. Macintosh and R.B. Morrison (1969) in their book "Objective Testing" on page-71.
The justification for adopting this formula has been given in the previous pages.

**TABLE-9**

**COMPUTATION OF RELIABILITY COEFFICIENT OF THE SECOND DRAFT OF CRITERION TEST.**

\[
\begin{align*}
\sum (N_H + N_L) &= 2305 \\
\sum (N_H + N_L)^2 &= 63971 \\
\sum (N_H - N_L) &= 736 \\
\left[\sum (N_H - N_L)\right]^2 &= 541696
\end{align*}
\]

\[K = 89\]

\[n = 20\]

\[
r = \frac{K}{K-1} \left\{ 1 - \frac{2n \sum (N_H + N_L) - \sum (N_H + N_L)^2}{0.667 \left[\sum (N_H - N_L)\right]^2} \right\}
\]

\[
r = \frac{89}{88} \left\{ 1 - \frac{2 \times 20 \times 2305 - 63971}{0.667 \times 541696} \right\}
\]

\[r = .933\]

It is evident from the calculations in table-9 that the reliability co-efficient of the second draft is higher (.93) than the reliability coefficient of the first draft which was .87. It is in conformity with the standard set by Abel(1966).
VALIDITY OF THE CRITERION TEST

The validity of the criterion test was established by the method of content validity. The content validity is concerned with the adequacy of sampling of a specified universe of content. This was done by comparing the coverage provided by the test items with that of the assumed universe of content, the test was supposed to sample.

According to Thorndike and Hagen (1970) the content validity is found out by relating the tasks to the goals of instructions; if the correspondence between the two is good, the test is valid; if poor, the validity is deemed to be low. Therefore, it was confirmed that no objective was left uncovered in the final draft of the criterion test.

FINAL DRAFT OF THE CRITERION TEST.

After having evaluated the items against the criteria of discriminating power and difficulty value, the final draft of the criterion test was prepared and mimeographed. Sample of criterion test in final form is provided in Appendix A1.

The structure of the final draft of the criterion test was the same as that of the second draft since the refinement of items of the second draft did not affect the distribution of
content in relation to the objectives.

The criterion test, thus prepared, was used as a tool for validating the programme.

2.6

DEVELOPING THE CONTENT OUTLINE. After having specified the terminal goals, the entering behaviour and dimensions of the criterion test, next step in the process is to prepare content outline to cover terminal performances and also the material to be programmed. For writing the content outline a number of books in biology, besides the prescribed text books were consulted. Opinions and suggestions of the subject matter experts were also given due weightage for ensuring clarity and accuracy of the content from technical point of view. In the following pages unit-wise list of the content outline is presented.

UNIT-I

- Definition of the term 'reproduction'
- Definition of the term vegetative reproduction or vegetative propagation,
- Description of the process of vegetative propagation.
- Examples of plants which develop from some vegetative part (root, stem, leaf) of the plant.
- Description of three advantages of vegetative propagation.
NATURAL METHODS OF VEGETATIVE PROPAGATION IN PLANTS.

Vegetative propagation by underground stems.

- Description of the process of vegetative propagation by rhizomes.
- Examples of plants which reproduce by rhizomes.
- Description of the process of vegetative propagation by tubers.
- Examples of plants which reproduce by tubers.
- Description of the process of vegetative propagation by corms.
- Examples of plants which reproduce by corms.
- Description of the process of vegetative propagation by bulbs.
- Examples of plants which reproduce by bulbs.

Vegetative propagation by Aerial Stems.

- Description of the process of vegetative propagation by aerial stems.
- Examples of plants which reproduce by aerial stems.
Vegetative Propagation by Runners

- Description of the process of vegetative propagation by runners.
- Examples of plants which reproduce by runners.

UNIT-III

METHODS OF GRAFTING

- Explanation of the term grafting.
- Definition of stock.
- Description of the function of stock.
- Definition of scion.
- Description of the function of scion.
- Definition of Cambium.
- Description of the function of Cambium
- Description of conditions for successful grafting.
- Description of advantages of grafting.
- Enumeration of three kinds of grafting
- Description of the process of tongue grafting.
- Description of the structure of stock in tongue grafting.
- Description of the structure of scion in tongue grafting.
- Description of the process of wedge grafting.
- Description of the structure of scion i
  wedge grafting.
- Description of the process of crown
  grafting.
- Description of the structure of stock
  in crown grafting.
- Description of the structure of scion
  in crown grafting.

UNIT-IV

ARTIFICIAL METHODS OF VEGETATIVE PROPAGATION.

- Definition of cutting.
- Enumeration of characteristics of
  a good cutting.
- Examples of plants which can grow
  successfully from cuttings.
- Description of the process of
  vegetative propagation by cuttings.
- Description of the process of vegetati
  propagation by layering.
- Definition of layer.
- Examples of plants which propagate
  by the process of layering.
- Description of the process of
  vegetative propagation by budding.
- Description of the structure of scion
  in budding.
2.7

In writing a programme, the programmer has to put his decisions in respect of
terminal behaviour and the content-structure into an effective form. This stage is concerned with the
selection of a suitable programme paradigm and of designing and writing of the frames. Klaus (1964)
feels that "the most difficult step in the procedure is the actual writing of frames". Stones (1979)
has rightly pointed out that the frames form the teaching element in a programme and a good idea of the quality
of a programme can be obtained by the inspection of frames.

2.7.1

The programme paradigm provides the basic conceptual frame work through
which the individual frames (didules) are organized. The programme paradigm selected in the present study
was of linear style and was developed on the lines recommended by Skinner (1954).

The content on biology, specifically, vegetative reproduction in plants is, ideal for linear format. Various methods of vegetative
reproduction include steps, which are systematic, logical, carefully defined and procedural.
Biological content, therefore, provides ample scope for logical development of the subject matter in small bits. Hence, the nature of content itself
demanded the adoption of linear style of programming.

2.7.2

WRITING THE FRAMES

The key thing to look for in programmed instruction is, the way the reader's learning is developed by the instructional discourse in frames.

Each frame should present some information and by skilful discussion build up a teaching theme, the logic of which will enable the learner to answer the questions posed by the programmer. Presentation of relevant stimulus is perhaps the crux of programme writing. If the stimuli are properly presented they can shape the desired terminal behaviour. A frame should have a relevant context, that is the kind of stimuli we hope will be capable of evoking the desired response at some time in future.

Writing of the programme involves three major aspects of the designing of frames:

- Structuring of frames
- Types and distribution of frames
- Sequencing of frames.

2.7.3

STRUCTURING OF FRAMES

A frame is defined as a small segment of subject matter which calls forth particular student responses (Taber, et al., 1965).

Cook (1960) defines a frame as single item or
statement which is exposed to the student at a time.

Margulies (1964) writes that a frame, "presents a small unit of information, requires active response and may be arranged to give immediate reinforcement".

Klaus (1961) has given four parts of a frame:

- stimulus and stimulus context
- The cues or prompts necessary to produce the response reliability.
- The response(s) the stimulus evokes; and,
- Enrichment material which makes the frame readable or interesting or which recalls previously learned materials to facilitate student response.

The shaping of learner's terminal behaviour largely depends upon the presentation of the stimuli, that is, the way in which the stimuli are arranged and presented to the learner.

The other important part of the frame is the response it evokes. Frame acts as the stimulus used to guide the students' response. Frames are usually designed to produce responses in a context which is new to the learner. New stimuli are gradually introduced and cueing is slowly vanished.
Feedback is an important element of the frame. It either reinforces the right response given by the learner or corrects his incorrect response.

In the present investigation, while designing the frames, proper care was given to the appropriate stimulus, response and feedback elements. The amount of information presented in each frame was minimum possible for eliciting a particular response. Proper attention was also given to step-size. Step-size denotes the amount of information given to the learner at any one time (Callender Patricia, 1969).

In more specific terms step-size means the ratio at which new concepts are introduced. In the present study the size of the step varied in different parts of the programme. Initial learning frames consisted of small steps followed by large steps as the programme progressed which is in line with a study by MacCoby and Sheffield (1961) that states:

- Short steps are more effective than large steps for initial learning; and
- the progressive lengthening of steps leads to the best performance on the test of terminal behaviour.

Due consideration was also given to the language of the frame to make it simple enough to avoid unnecessary mistakes by the learners.
The small and large steps were mixed up in the programme according to the nature and difficulty of the concepts to be taught.

The linear programme calls for a constructed type of response. In the writing of the programme in present study, frames were constructed in such a manner that the learner was required to construct his own response. Sometimes, 'two option' responses were also given where the student was required to select a response, out of the two given alternatives. At the time of administration of the programme, care was taken to see that the student wrote the response in the blank provided for this purpose rather than putting a check mark(✓) on one of the options.

The overt response was favoured in the present investigation as it has been supported by several studies for example: Anderson (1967), has given two points which have considerable empirical support:

- Overt responses facilitate learning when the responses are relevant to the content of the lesson;
- Overt responses should be required in the learning of unfamiliar and technical terms.

A study by Krumboltz and Kiesler (1965) supported the first, and two studies by Cummings and Goldstein (1962) supported the second conclusion of Anderson.
Feedback, according to DeCecco (1970), "is the condition of establishing the desired behaviour either by confirming the response of the student or by correcting it. When the student finds that his response is correct, he obtains confirmation; when it is incorrect, he receives correction."

In the present study, each frame was provided with correct response. The feedback to the learner was continuous and not intermittent.

Prompts and Cues are provided in the frame to guide the student to give the correct response. Markle (1969) defines prompt as a supplementary stimulus, a hint or bit of assistance, that helps the student to come up with correct response. A prompt is a device that increases the probability that out of a set of alternatives a particular response will come to be emitted (Green, 1962).

DeCecco (1970), has defined two basic purposes of prompts.

- They guide the student to the correct response without over controlling his behaviour; and
- They prevent the student from making unnecessary errors.

In the light of these suggestions due care was taken to avoid both prompting under and over prompting.
Both formal and thematic prompts were used in the teaching sequence whenever and wherever required. **Formal prompts provide the student with information about the structure of the acceptable response but not its meaning.** While **thematic prompt** which is better known as a hint, provides the learner with information about the meaning of the desired response (Skinner 1957).

In the present study the choice of the kind of prompt to be used depended largely upon the nature and purpose of the information given in the frame. In situations where priming was not sufficient to help behaviour emanate: some supplementary stimuli were designed and used in the development of the present programme. The partial and picture prompts were also used in the frames wherever they were essential.

The panels in the form of paradigms, diagrams or any other supplementary information were also used in the development of the programme to enable the students to deal effectively with the frames to follow in a particular unit of the programme. Moreover Panels often save much time and greatly help to clarify the concepts.

The frames were designed taking into account the aforesaid essential elements.

The programme developed for the study consisted of three kinds of frames: introductory, teaching and testing frames.
The introductory frames were mostly copying frames. In these frames stimulus is a written text and the learner usually constructs his response by reproducing a part of the stimulus. Introductory frames were designed to introduce new concepts to the learners.

Teaching frames were constructed to develop the concepts. In these frames the students were given ample practice so that the response gets fixed up. These frames formed the main body of the programme and presented the content structure in terms of specified terminal behaviours.

The testing frames were constructed for testing the attainment of the concept. In these frames, the student was provided with no prompt and was asked to respond at his own.

2.7.4 SEQUENCING OF FRAMES

Sequencing of frames basically depends upon the nature of the content and the description of the instructional objectives the programme intends to teach. For sequencing the frames in the present study, the content was analysed and the order of the presentation of the content was decided on the basis of terminal objectives and the nature of the concept or the procedure. The frames were sequenced as follows.
The introductory frames were used for introduction of concepts. Teaching frames for the development and the fixation of the concepts while the terminal frames were utilized for testing the attainment of the concepts.

The general scheme of building the sequence of frames in the present programme has been that in the beginning the learner was given a considerable amount of stimulus and was required to give a brief response. Then the stimulus was gradually reduced and the response increased. Finally, when the learner reached the terminal frame, he was provided very little stimulus and was required to supply the maximum response.

The difficult concepts in the content were gradually built on simpler concepts keeping in view the criterion behaviours. Not only were the criterion behaviours constantly kept in view but also all basic learning conditions like discrimination, generalization, chaining, practice and reinforcement, required for learning various biological concepts, principles, procedures etc., were properly embodied in the frame sequences. In addition to the above egrule and ruleg sequences were used according to the need and complexity in the subject matter.
2.8

EDITING Espich and Williams (1967) emphasize that a thorough programme edit may uncover many programme inadequacies prior to testing. Editing, eliminates the ambiguities, improves logical sequence, technical accuracy aspect of programme and examines appropriate use of diagrams and illustrations.

For editing the investigator took the cue from suggestions made by Espich and Williams (1969) for three types of editing involved in programming:

- Editing for content
- Editing for composition
- Editing for technique.

2.8.1

EDITING FOR CONTENT The first editing was done by a subject-matter expert (a senior lecturer in botany) to check up the technical accuracy of the content especially the use of technical terms and their definitions, diagrams and various examples given in the programmed material.

2.8.2

EDITING FOR COMPOSITION The second editing was aimed at eliminating various inadequacies and ambiguities related to grammar, language, spellings, ability to communicate and punctuation. The programme was also checked for some technical aspects of the material such as the length of brackets, uniformity of numbering system
of frames and units and placement of illustrations
and diagrams etc.

2.8.3

EDITING FOR TECHNIQUE Editing for the technique was done
on two counts— for the programme on
the whole as well as for the individual
frames. It was concentrated mainly on the following
aspects:

- the continuity of the programme
  from item to item,
- inter-relationship between various
  parts of the programme,
- inter-relationship between sequences.

The programme in hand was edited on
all these issues. The continuity of the programme from
item to item was ascertained by the step-size.
The step-size was made neither too long nor too short
for the students. The step size was also considered
on two different levels i.e. the inter-frame and
inter-a-frame step-size. Inter-frame step size was
kept as small as possible so that the students might
not feel the conceptual jumps in moving from one
frame to another.

The inter-relation between various
parts depended on how logically the content was
presented in various parts. It was checked by the
subject matter expert.
The inter-relationship between the sequences of various concepts was also checked and edited. The aim for editing of the individual frames was to find out faults before they affected the performance of the learners on the programme. The relevance of response was checked against its contribution to the terminal behaviour. The frames were also edited in respect of prompts, cues and examples. The redundant material, if any, in the frames was eliminated.

Editing was done, each time the programme was administered on the target population.

2.9

VALIDATION OF THE PROGRAMME Testing of the programme is a kind of trial situation for the frames and frame sequences brought out by the programmer. Programme is an empirically validated product. It is the instructional material that has been prepared and tried out repeatedly until sufficient data have been accumulated for the programmer to be able to say that, given students for whom the programme was written and given appropriate working conditions, the programmer can guarantee a given level of successful learning (Stones, 1979).

The programme was validated in three stages:

- Individual testing
- Small group testing
- Field testing
In each stage of testing the programme was validated against two types of criteria—internal and external. Internal validation was concerned with the frame analysis of the programme, its error-rate and density. The external validation of the programme was against the 90/90 standard.

2.10

INDIVIDUAL TESTING For individual testing the programme was written on specially prepared index cards. It was shown to the experts and colleagues for comments. The programme was modified in the light of the comments and suggestions of the experts. Each frame was written in pencil on a separate card. The correct response was written at the back of the card.

The programme was administered on five students of both the sexes in a very informal situation.

TABLE -10

STRUCTURE OF THE SAMPLE FOR INDIVIDUAL TESTING

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Sex</th>
<th>Age</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Boy</td>
<td>16</td>
<td>XI</td>
</tr>
<tr>
<td>2.</td>
<td>Girl</td>
<td>16</td>
<td>XI</td>
</tr>
<tr>
<td>3.</td>
<td>Boy</td>
<td>15,5</td>
<td>XI</td>
</tr>
<tr>
<td>4.</td>
<td>Boy</td>
<td>15.5</td>
<td>Prep. Medical</td>
</tr>
<tr>
<td>5.</td>
<td>Girl</td>
<td>15.5</td>
<td>Prep. Medical</td>
</tr>
</tbody>
</table>
Table 10 shows the details of the sample in respect of sex, age and class. Five students (three boys and two girls) of average intelligence were randomly selected from colleges and secondary schools of Chandigarh.

2.10.1

PROCEDURE FOR INDIVIDUAL TESTING

At the individual testing stage more reliance was given to close observation or interaction with individual student. The purpose was to obtain feedback from the students from the very beginning. Each frame was carefully tested word for word till the effectiveness of each of the frame was assured.

Individual testing was conducted in a very informal atmosphere. Before individual testing began, effective rapport was established with each student. It was impressed upon the students that they were going to help the programmer in modifying the draft of the programme. It was further emphasized that the questions in the programme were not for testing them but for modifying the programme to suit their needs better.

After each student was put in the proper frame of mind, the draft programme in the form of cards was administered to one individual at a time. Before administering the programme, necessary instructions regarding reading the frames, writing and confirming the responses were given to the student. The student then was asked to read each frame loudly and produce the response orally.
Soon after the response was emitted, the investigator confirmed it orally and the student was allowed to see the correct response.

If the student gave correct response, he was encouraged to proceed. Whenever, the subject produced a wrong response, the investigator obtained the comments of the student to locate the specific difficulty in respect of the stimulus part of the frame. The frame was then modified and given back to the student to read and respond to it again. The exercise was continued till the student emitted the correct response. This whole procedure was continued. Special note was kept of those frames that befuddled the student completely and also of those that required a great deal of explanation.

The whole programme was tailored to the needs of the first student and then it was administered on second, third, fourth and fifth subject in similar fashion.

The drafts as administered to five successive students were not identical since they were modified each time in the light of response given, reactions shown and difficulties expressed in understanding the frame structure by individual subjects. It may be noted that the number of amendments in the initial draft went on decreasing over its successive administration
to students. The plan of successive modification was based on the assumption that if a particular stimulus did not give rise to the desired response, the fault lay with the structure of the frame and not in the learning of the student. It was emphasized that the questions in the programme were not for testing them but for modifying the programme to suit their needs better.

A close analysis of the record of observations made by the investigator during individual testing revealed that incorrect responding to the frames was generally the result of one or more of the following factors:

- Language difficulty
- Magnitude of intra-frame and interframe step-size.
- Sequencing of frames
- Type of response required
- Difficulty in understanding technical terms.

The criterion test was not given at this stage. This may be supported in terms of the suggestion of Espich & Williams who contend that "there is no point in giving the student a test after he has taken the programme on one to one basis, for the discussion of programme and help with difficult frames invalidate any results that might be obtained—-—-—."
2.11

SMALL GROUP TESTING This is the second stage in validating the programme. The programme was revised and modified on the basis of comments and data collected from the individual try-out stage. The modified copy of the programme draft was typed and instructions for going through the programme were prepared.

2.11.1

PROCEDURE FOR SMALL GROUP TESTING The programme at this stage was presented in the typed form. It was administered on a small group of 18 students of both the sexes. The students were selected randomly from the XIth and Prep-Medical classes of schools and colleges of Chandigarh.

TABLE-11

STRUCTURE OF THE SAMPLE FOR SMALL-GROUP TESTING

<table>
<thead>
<tr>
<th>Class</th>
<th>Sex</th>
<th>Mean age</th>
<th>No. of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>XI</td>
<td>Girls</td>
<td>15.5</td>
<td>7</td>
</tr>
<tr>
<td>XI</td>
<td>Boys</td>
<td>15.5</td>
<td>4</td>
</tr>
<tr>
<td>Prep-Medical</td>
<td>Girls</td>
<td>15.5</td>
<td>3</td>
</tr>
<tr>
<td>Prep-Medical</td>
<td>Boys</td>
<td>15.5</td>
<td>4</td>
</tr>
</tbody>
</table>

Total = 18
Table-11 shows the structure of the sample for small group testing. The number of girls is 10 and that of boys is 8 with the mean age of 15.5 years.

The following procedure was adopted for testing at the small group stage. During validation at this stage the students were told in the beginning that they were taking a draft of a programme, which is still in the developmental stage, and that it is the programme that is being tested and not the students concerned. It was also explained that they were acting merely as advisors helping the researcher to modify the programme. However, they were encouraged in every way to give the programme a fair trial and carefully learn the material.

All the students were given pre-test in order to judge their entering behaviour in the subject before they read the programme. After the pre-test the students were provided thorough instructions regarding the mechanics of the programme in a typed form. The students were encouraged to seek clarification, if any.

The programmer made a careful observation of the students' expressions while they were busy taking the programme. He also recorded the comments of the students. All this information, in addition to students' responses, helped the programmer to revise the programme by pointing out the difficulties faced by them.
After the programme was taken by the students, the post-test was administered and the results were analysed statistically. This analysis pertains to error rate per unit as well as per frame. The draft programme was also evaluated against the 90/90 standard and programme density was calculated.

Students whose error rate was comparatively higher and also those whose pre-test scores were comparatively less, were interviewed by the researchers to discuss the nature of difficulty. Notes were taken of these discussions for the improvement of the draft programme.

2.11.2

ERROR RATE Each wrong response given by the student was treated as an error. "An error is a response not acceptable to the programmer and error rate is the percentage of incorrect responses on a frame, a set of frames, or a whole programme tested on a group of students" points out S. Markle (1969).

Error rate for the individual frames, error rate for the whole programme as also for each unit within the programme was computed by the following formula.
Error rate = \( \frac{\text{Number of errors}}{\text{Number of responses in the unit/programme}} \times 100 \) \( \times \frac{\text{Number of individuals}}{\text{of programme}} \)

**Table -12**

**Error Rate of Units and the Whole Programme at the Small Group Testing Stage**

\( N = 18 \)

<table>
<thead>
<tr>
<th>Unit</th>
<th>Total number of responses</th>
<th>Number of errors</th>
<th>Error rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>121</td>
<td>22</td>
<td>1.01</td>
</tr>
<tr>
<td>II</td>
<td>158</td>
<td>32</td>
<td>1.12</td>
</tr>
<tr>
<td>III</td>
<td>165</td>
<td>34</td>
<td>1.14</td>
</tr>
<tr>
<td>IV</td>
<td>114</td>
<td>24</td>
<td>1.16</td>
</tr>
</tbody>
</table>

| Whole programme | 558 | 112 | 1.11 |

The Table-12 indicates that error rate of the programme after small group testing was 1.11 which is far below ten percent usually accepted norm. The error rate of the different units ranged from 1.01 to 1.16.

**ERROR RATE OF FRAME**

Error rates on all individual frames were also calculated, frames with error rates more than ten percent, were taken up for closer scrutiny and revision.
<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Error Rate</th>
<th>Frame Nos.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>11 to 20%</td>
<td>1, 6, 37, 60, 61, 81, 82</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>21 to 30%</td>
<td>6, 19, 84</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>II.</td>
<td>11 to 20%</td>
<td>116, 131, 141, 148</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>21 to 30%</td>
<td>97, 115, 117, 122, 142, 150, 166</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>III.</td>
<td>11 to 20%</td>
<td>237, 277, 288, 291, 294, 297, 298</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>21 to 30%</td>
<td>206, 208, 224, 232, 262, 308</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>IV</td>
<td>11 to 20%</td>
<td>339, 340, 390</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>21 to 30%</td>
<td>369, 376, 379, 386, 389, 390, 391</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>
It may be observed from the table-13 that ten frames in Unit I needed revision since more than 10% error rate was detected in these frames. Specifically, error rate on seven frames was between 11% to 20% and for three frames between 21 to 30 per cent.

In Unit II, thirteen frames needed revision or modification. Out of these six frames had an error rate between 11% to 20% and seven frames between 21% to 30%.

In Unit III, in all thirteen frames needed revision. Seven frames registered error rate between 11% to 20% and six between 21 to 30 per cent.

In Unit IV, ten frames were revised and modified. Three frames recorded error rate between 11 to 20 per cent and seven frames between 21 to 30 per cent.

Therefore, in all forty six frames needed revision or modification. Table-13, however, does not reveal any cluster of defective frames. The frames with high error rate seemed to be scattered all over the draft programme.

2.11.4

PROGRAMME DENSITY

Programme density is an indirect measure of the difficulty of the programme. Type token ratio(TTR) is the term most frequently used by the programmers for the measurement of
density of a programme. It may be defined as number of different responses per unit divided by total number of responses per unit. Mathematically it can be expressed as:

\[
\text{TTR} = \frac{\text{Number of different responses}}{\text{Total number of responses}}
\]

Using the above formula, the values of TTR as computed have been shown in table-14.

**TABLE-14**

**TYPE TOKEN RATIO OF THE PROGRAMME AFTER SMALL GROUP TESTING**

<table>
<thead>
<tr>
<th>Programme Unit</th>
<th>No. of different responses</th>
<th>Total No. of responses</th>
<th>T.T.R</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>22</td>
<td>121</td>
<td>.18</td>
</tr>
<tr>
<td>II</td>
<td>18</td>
<td>158</td>
<td>.11</td>
</tr>
<tr>
<td>III</td>
<td>21</td>
<td>165</td>
<td>.13</td>
</tr>
<tr>
<td>IV</td>
<td>19</td>
<td>114</td>
<td>.17</td>
</tr>
</tbody>
</table>

Total 80 558 .14

It may be observed from the table-14 that T.T.R of the four units of the programme varies from .11 to .18. Lowest T.T.R had been in Units II and III of the programme. The programme density on the whole was found to be .14.
THE 90/90 STANDARD ANALYSIS

According to Espich and Williams (1967) "90/90 standard" has different meanings to different programmers. They point out that the first ninety represents the class mean, considering all the students, which must be ninety per cent or more. The second ninety denotes that ninety per cent of the students will achieve each and every objective of the programme.

Therefore," 90/90 standard" means that a programme should produce a final criterion test score of 90 per cent or better, by 90 per cent or more of the students in the evaluation group (NSSE, 1967). The "90/90 standard" was tested at two stages of the development of the present programme: small group and the field testing. The following formula was used to test the 90 x 90 standard.

\[
\frac{\text{Mean score of the group}}{\text{Maximum score}} \times 100
\]

A summary of the 90/90 standard analysis, done at the small group stage is given in table-15.
<table>
<thead>
<tr>
<th>No. of students</th>
<th>Scores</th>
<th>Total score</th>
<th>Mean</th>
<th>Total No. of items</th>
<th>1st criterion value of 90/90 standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>87, 88, 85, 83</td>
<td>1436</td>
<td>79.77</td>
<td>89</td>
<td>89.62</td>
</tr>
<tr>
<td></td>
<td>82, 79, 82, 83</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>83, 83, 80, 79</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>80, 75, 75, 75,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>68, 69</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It can be observed from the table-15 that the first criterion value of 90/90 standard in respect of the present programme was 89.62. It is slightly below 90. The draft programmes were also evaluated against the second criterion of the 90/90 standard which required that 90 per cent of the students should attain every objective of the programme. This was ascertained by examining each item of the criterion test (or in certain cases, group of items for an objective) as to whether 90 per cent or more of the students had passed it. It was found that every item was passed by atleast 90 percent of the students. This implies that the second criterion of 90/90 standard was achieved.
2.11.6

SEQUENCE PROGRESSION OF SMALL GROUP TESTING

Sequence progression is another measure of evaluating the efficiency of the programme. Examination of sequence progression in terms of student performance becomes essential because what appears logical to the programmer may or may not be logical to the student.

For finding out sequence progression a rough measure is to prepare a flow chart. The scores of students on the criterion test were arranged in a rank order. The progression was studied with reference to high and low rankers. Scores of ten students which were non-repétitive, were randomly selected, for preparing scallogram for analysing sequence progression. The scores of the ten students who were thus selected have been given in table-16.

### Table-16

THE CRITERION TEST SCORES OF TEN STUDENTS SELECTED FOR SEQUENCE PROGRESSION

**Total Score = 89**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Scores</th>
<th>S.No.</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>88</td>
<td>6.</td>
<td>80</td>
</tr>
<tr>
<td>2.</td>
<td>87</td>
<td>7.</td>
<td>79</td>
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<tr>
<td>3.</td>
<td>85</td>
<td>8.</td>
<td>75</td>
</tr>
<tr>
<td>4.</td>
<td>83</td>
<td>9.</td>
<td>69</td>
</tr>
<tr>
<td>5.</td>
<td>82</td>
<td>10.</td>
<td>68</td>
</tr>
</tbody>
</table>
It may be observed from the table-16 that the highest score on the criterion test was 88 and the lowest 68. In plotting the scores (✓) was used for a correct response and (✗) for a wrong response. Total scores of the students were entered in a descending order on vertical axis. The test items were arranged in line on horizontal axes. The students' responses were plotted row wise and test items, column wise.

It was observed that the number of correct responses to various concepts decreases in proportion as the programme develops from lower to higher level of learning material. There is a marked trend of increase in errors from high achievers to low achievers.

2.12

PREPARATION OF THE FINAL DRAFT

The individual and small group testing as described in the previous section, provided sufficient grounds for revising and improving the version of the programme. A close scrutiny of all such frames which recorded error rate beyond ten per cent was made for redrafting. All the frames showing higher error rate were thoroughly examined, one by one, for language, content, adequacy of prompts and responses etc. After a careful revision and modification of the programme, final draft was prepared which was now ready for validation at the field testing stage.
Field testing is crucial, it provides evidence as to how well the programme format accomplished its purpose on the population for whom it is developed. Since the purpose of the field testing was to evaluate the programme in its refined form, it actually served as the validation testing.

This section of the chapter presents the findings of the field testing in respect of error rate, programme density and sequence progression as the internal criteria and the students' performance on the criterion tests as the external criterion of the programme.

For validation of the programme at the field testing stage a sample of 60 average students (both boys and girls) of Higher Secondary Schools of Chandigarh and Ambala, was taken. The structure of the sample as regards sex, age and class is given in table-17

<table>
<thead>
<tr>
<th>Structure of the Sample for Field Testing Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Boys</td>
</tr>
<tr>
<td>Girls</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
Table-17 indicates that the sample had almost equal representation of boys and girls. Initially there were a few more cases in the sample but they were dropped as they could not complete the programme or the criterion test owing to absence on certain days of testing. The programme was got cyclostyled. Before administering the programme, due care was taken to create friendly climate and normal classroom conditions. The students were also assured that the programme was being given to them for its improvement and not for their examination.

Pre-test was given to the students before administering the programme. Results on pre-test revealed that entering behaviour of the students was negligible as far as the content of the programme was concerned.

The field testing was completed in four days utilizing two sessions per day. Each session was of two hours duration. The schools were visited in morning and evening sessions depending upon the availability of classes. Therefore, each student worked for two hours per day—either in the morning or in the evening session. At the end of the programme criterion test was given to obtain post-test scores. After the completion of field testing, the scores of the students on the criterion
test were determined and their programmed texts were thoroughly examined, frame by frame for seeking suitable data for computing various measures for programme validation.

2.13.2

ERROR RATE
AT THE FIELD TESTING STAGE

Error rate of different units and of the whole programme was computed by the formula already mentioned in previous section of this chapter.

Error rate values are provided in Table-18.

TABLE-18

ERROR RATE OF DIFFERENT UNITS AND WHOLE PROGRAMME AT THE FIELD TESTING STAGE

<table>
<thead>
<tr>
<th>Programme Unit</th>
<th>Total No. of responses</th>
<th>No. of errors</th>
<th>Error rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>121</td>
<td>12</td>
<td>.16</td>
</tr>
<tr>
<td>II</td>
<td>158</td>
<td>27</td>
<td>.28</td>
</tr>
<tr>
<td>III</td>
<td>165</td>
<td>17</td>
<td>.17</td>
</tr>
<tr>
<td>IV</td>
<td>114</td>
<td>31</td>
<td>.45</td>
</tr>
<tr>
<td>Total</td>
<td>558</td>
<td>87</td>
<td>.25</td>
</tr>
</tbody>
</table>

It is evident from Table-18 that the error rate of the programme as a whole at the field group testing stage is .25. The error rate calculated for different units of the
Fig. 2.2. ERROR RATE UNIT-WISE IN RESPECT OF SMALL GROUP AND FIELD TESTING STAGE OF PROGRAMME VALIDATION.
programme varied from .16 to .45 which is far far below the recognized standard.

The error rate of different units, as set against the corresponding error rate for the small group testing is depicted in fig-2.2. The graph reveals a decreasing trend in error rate over the units for field testing. The error rate of the present programme was found to be less than one per cent. The index of error rate as established here therefore justified the use of programme as a workable instrument for the present study.

Error rate of each frame was also calculated at the field testing stage. Details of the frames that recorded more than 10 per cent error rate is given in table-19.

**TABLE-19**

**FRAMES HAVING MORE THAN 10% ERROR RATE AT FIELD TESTING STAGE**

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Error rate</th>
<th>Frame No.</th>
<th>Total No. of frames</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>11 - 15%</td>
<td>60,82</td>
<td>2</td>
</tr>
<tr>
<td>II</td>
<td>11 - 15%</td>
<td>142,182</td>
<td>2</td>
</tr>
<tr>
<td>III</td>
<td>11 - 15%</td>
<td>297</td>
<td>1</td>
</tr>
<tr>
<td>IV</td>
<td>11 - 15%</td>
<td>312,345,369</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Total</strong> 8</td>
</tr>
</tbody>
</table>
It can be observed from the table-19 that there were only eight frames with error rate more than 10 per cent, the acceptable norm. These eight frames were reviewed and modified accordingly. It may be pointed out that none of the frames had error rate more than 15 per cent.

2.13.3

**PROGRAMME DENSITY AT FIELD TESTING STAGE.**

Type token ratio (T.T.R.) which is considered to be the measure of programme density was calculated by using the formula described earlier in this section. The type token ratio values thus obtained at the field testing stage are recorded in table-20.

**Table-20**

**TYPE TOKEN RATIO OF UNITS AND THE WHOLE PROGRAMME AT THE FIELD TESTING STAGE**

<table>
<thead>
<tr>
<th>Programme Unit</th>
<th>No. of different responses</th>
<th>Total No. of responses</th>
<th>T.T.R</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>23</td>
<td>121</td>
<td>.19</td>
</tr>
<tr>
<td>II</td>
<td>20</td>
<td>158</td>
<td>.13</td>
</tr>
<tr>
<td>III</td>
<td>21</td>
<td>165</td>
<td>.13</td>
</tr>
<tr>
<td>IV</td>
<td>19</td>
<td>114</td>
<td>.17</td>
</tr>
<tr>
<td></td>
<td>83</td>
<td>558</td>
<td>.14</td>
</tr>
</tbody>
</table>
Fig. 2.4. INDEPENDENT DENSITY UNIT-WISE IN RESPECT OF SMALL GROUP AND FIELD TESTING STAGE.
It may be gleaned from the table-20 that the values of measure of density (T.T.R) of various units range between .13 to 19. The present values of T.T.R clearly indicate that the programme introduces the material gradually, giving a desired repetition.

2.13.4

SEQUENCE PROGRESSION

Sequence progression as already mentioned on previous pages is also an important measure of the efficiency of the programme. There are several ways in which a subject matter can be sequenced and presented to the learner. But the most effective sequence is one which generates an optimum interaction of the learner with the programmed material and this may be construed as a logical internal criterion for establishing the validity of a programme.

Progression of sequence can be determined with the help of flow diagrams. But this is a rough measure. More objective procedure is to arrange the criterion test scores of students, in a rank order and then study the progression with reference to high and low rankers (Pandey, 1970).

In order to present data on sequence progression, the criterion test items were arranged logically in line with the frame sequence for each major concept of the programme. An arrangement of the criterion test items in order of the programme sequence for major concepts is given in Appendix-B2.
After arranging the items of the criterion test in logical order scores of fifteen students which were non-repetitive, were randomly selected from the sample for analyzing sequence progression. The criterion test scores of the students thus selected are provided in Table-21.

**Table-21**

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Scores</th>
<th>S.No.</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>89</td>
<td>9.</td>
<td>79</td>
</tr>
<tr>
<td>2.</td>
<td>88</td>
<td>10.</td>
<td>78</td>
</tr>
<tr>
<td>3.</td>
<td>87</td>
<td>11.</td>
<td>76</td>
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<tr>
<td>4.</td>
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</tr>
<tr>
<td>5.</td>
<td>85</td>
<td>13.</td>
<td>74</td>
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<tr>
<td>6.</td>
<td>84</td>
<td>14.</td>
<td>71</td>
</tr>
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<td>7.</td>
<td>81</td>
<td>15.</td>
<td>72</td>
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<tr>
<td>8.</td>
<td>80</td>
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</tr>
</tbody>
</table>

Table-21 reveals that the highest score amongst the selected students is 89 and lowest, 71.
### Fig. 2:3. SEQUENCE PROGRESSION OF PROGRAMME ON CRITERION TEST ITEMS

**UNIT-I**

<table>
<thead>
<tr>
<th>ITEM No.</th>
<th>SCORE</th>
<th>1</th>
<th>2</th>
<th>55</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>36</th>
<th>37</th>
<th>56</th>
<th>6</th>
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<th>57</th>
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<th>58</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>89</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
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</tbody>
</table>

*Note: The table shows the progression of programme items with symbols indicating the sequence of understanding.*
# Fig. 2-3. SEQUENCE PROGRESSION OF PROGRAMME ON CRITERION TEST ITEMS

## UNIT- II

<table>
<thead>
<tr>
<th>CONCEPT</th>
<th>VEGETATIVE PROPAGATION BY RHIZOMES</th>
<th>VEGETATIVE PROPAGATION BY TUBERS</th>
<th>VEGETATIVE PROPAGATION BY CORMS</th>
<th>VEGETATIVE PROPAGATION BY BULBS</th>
<th>VEGETATIVE PROPAGATION BY AERIAL STEM</th>
<th>VEGETATIVE PROPAGATION BY RUNNERS</th>
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Note: The table represents the progression of the programme on criterion test items. Each item is marked with a '✓' to indicate its status in the sequence.
**Fig. 2.3: SEQUENCE PROGRESSION OF PROGRAMME ON CRITERION TEST ITEMS**

**UNIT III**

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<th>Score</th>
<th>Concept</th>
<th>What is Grafting</th>
<th>Meaning of Stock, Scion and Cambium</th>
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Note: The table indicates the progression of concepts with ✓ indicating progression.
### Fig. 2.3. SEQUENCE PROGRESSION OF PROGRAMME ON CRITERION TEST ITEMS

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Notes:
- V: Correct
- X: Incorrect
**Fig. 2.3. SEQUENCE PROGRESSION OF PROGRAMME ON CRITERION TEST ITEMS.**

**UNIT-IV**

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In order to analyze progression of sequence, scalograms of the four units of the programme for all the major concepts were prepared by following the procedure as explained in the previous section of this chapter. The scalograms thus prepared have been shown in Fig-2.3

The scalograms showed a marked trend of increase in errors from high achievers to low achievers. It can also be observed that the errors tend to cluster towards higher level of learning material in case of low achievers. Again the scalograms disclose no chunks of items where the sequencing may not be in order since the errors tend to concentrate in the diagonal space or towards higher level of learning a concept. The sequencing of frames, in the present form, therefore, seems justified.

2.13.5

EXTERNAL CRITERION FOR VALIDATION 90/90 STANDARD

The programme was also examined in terms of the 90/90 standard which served as the basis for evaluating the workability of the programme. The 90/90 standard as defined and explained in an earlier section means that 90 per cent of the students get 90 percent of the material. It has two criteria: the first 90 represents the class mean while the second, the qualification that 90 per cent of the students will achieve each and every objective of the programme.
In order to determine the first criterion of the 90/90 standard, the mean score value of the performance of the students on the criterion test was calculated. The details are given in table-22.

**TABLE-22**

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<td>89</td>
<td>95.16</td>
</tr>
</tbody>
</table>

It may ascertained from table-22 that the first criterion value of the 90/90 standard of the programme was 95.16 which is beyond the accepted value, and as such was considered satisfactory.

For examining the second criteria of the 90/90 standard, each and every item of the criterion test (or group of items, in case where an objective was tested by more than one item), was analyzed and it was found that more than 90 per cent students had passed every item (or group of items). It indicates that the second criteria of the 90/90 standard was also met by the programme. These results established that the programme had worked
well and is a reliable instrument for the study.

2.14

On the basis of the data obtained at the field testing stage, a few frames that showed more than acceptable error rate were again modified. The programme as finally revised is provided in Appendix-A2.