CHAPTER IV

DEVELOPMENT OF TOOLS AND LEARNING MATERIAL
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For the purpose of the present study, following tools and learning material were developed by the investigator himself for local use:

(i) Programmed Text in Branching Style.
(ii) Criterion Test.
(iii) Learning Package.

DEVELOPMENT OF PROGRAMMED TEXT IN BRANCHING STYLE

The Intrinsic Programmed Text was developed by the investigator himself for the local use. The various steps for the development of the programmed text in branching style taken by the investigator are given below:

4.1 SELECTION OF THE CONTENT:

Lysaught and William (1963) suggested that the selection of the content to develop a programme should be made, keeping in
mind the field of specialization of the programmer, the size, ease, depressed level of learning, logical order of the material and the specific needs of the learner. Keeping the abovementioned suggestions in view, the following two units of IX class Mathematics Course A syllabus prescribed by Central Board of Secondary Education, New Delhi (India) were selected:

2. Trigonometry.

4.2 ASSUMPTIONS ABOUT THE LEARNER:

The programme to be devised will serve the population of IX class students of age group 14+ years. The learner will consist of male and female students from urban area falling under the municipal limits of Jammu City, Jammu and Kashmir (India). The learner are from the different social status and cultural backgrounds. It was also kept in mind that the learner is having some previous knowledge of the content material and understands the content matter written in English language. The skill, interest and intellectual level of the learner was also kept in mind. To ensure their knowledge in the subject of Mathematics they were given a test.

4.3 OBJECTIVES IN BEHAVIOURAL TERMS:

Tyler (1932) stressed that the initial behaviour of the learner is very important and must be kept in mind. The same was supported by Bloom's Taxonomy of Educational Objectives and
task specifications. These objectives helped us to decide as to where from to start the programme and where to end it.

Mager (1962) defined an objective as "The intent communicated by a statement describing a proposed change in a learner - a statement of what the learner is likely to be when he has successfully completed a learning experience. It is a description of a pattern of behavioural performance we want the learner to demonstrate".

Mager (1962) has further distinguished between pre-requisites, course-description and objectives. The investigator has kept in mind the recommendations of Mager (1962). Accepting these recommendations as guidelines for writing the behavioural objectives in the present study, the unitwise educational objectives in the behavioural terms of the programme are given as below:

Educational Objectives in Behavioural Terms:

Unit I (Sets and Mapping):

After going through the programmed material provided, the learner will be able to:

1. Write the definition of set, empty set, singleton set and universal set correctly through the process of recall without consulting the book.
2. State the rule to write a set.
3. Identify the members of a set.
4. Translate set builder form into roster form of a set and vice-versa.
5. Distinguish between examples and non-examples of empty set.
6. Give in writing the examples of equal sets.
7. Write the subsets of a set correctly without consulting the book.
8. Solve sums involving union and intersection of two sets correctly.
9. Discriminate between two sets.
10. Sketch the Venn diagram of a set, subset of a set, union of sets, intersection of sets, complement of a set and difference of two sets.
11. Quote orally and in writing the examples of empty set.
12. Label Venn diagrams correctly.
13. By applying Venn diagrams, solve some problems.
14. Write the cross product of two sets correctly.
15. Write a function correctly.
16. Write down the domain and range of a function without the help of text-book.
17. Write the solution for calculating the value of a function.

Unit II (Trigonometry)

After going through the programmed material provided, the learner will be able to -
1. Write the definition of Sine, Cosine, tangent, cosecant, secant and cotangent correctly without consulting the book.

2. Give the solution of the values of trigonometric ratios in writing correctly.

3. Prove fundamental identity by writing a correct proof without consulting the text-book.

4. Write the proof of various identities.

5. Tabulate the values of various trigonometrical ratios for 0°, 30°, 45°, 60° and 90°.

6. Give the solution of the expressions bearing trigonometric expression of angles of 0°, 30°, 45°, 60° and 90° correctly in writing without consulting the book.

7. Give geometrical proof in writing to find the values of trigonometric ratios of 0°, 30°, 45°, 60° and 90°.

8. Consult and write the value of a trigonometric ratio from trigonometrical tables correctly.

9. Write the value of trigonometric expression by using trigonometric tables correctly.

10. Write the correct solution of problems of height and distance.

The abovementioned behavioural objectives are further tested by a test called Criterion Test which is mentioned in the Section 4.10 of this Chapter.

4.4 DEVELOPMENT OF SPECIFIC OUTLINES OF CONTENT MATERIAL TO BE PROGRAMMED:

The programmer passed through the following phases for
development of specific outlines of the content material to be included in the present branching programme:

**Observation Phase:** The content matter was observed in actual classroom situation by the investigator by teaching himself in IX class. The hardnuts in the curriculum were noted down for a special attention to be paid while writing a program. The logical order, need of the learner and his ability level was observed.

**Curriculum Phase:** Implementing the findings of the observation phase, the programmer chalked out a brief outline of the content matter to be programmed.

**Subject-Matter Expert Interview Phase:** The programmer held an interview with other subject-matter experts and discussed the blueprint of his content material to be written as a branching programme. The suggestions of these subject experts were implemented and accordingly many additions, deletions, modifications and corrections were made in language of the content and the content itself.

**Teaching Point Outline:** A brief summary of teaching points was prepared by the programmer.

**Logical Order:** The content matter was arranged in a logical order.

**Development Order:** The programmer planned to prepare or write his programme to follow the order of simple to complex learning.
Keeping in view the above six phases, the programmer decided to include the content-material in his programme, which is as given below:

**Content of Unit I (Sets and Mapping)**

- Definition of Set.
- Notation of a Set.
- Member or element of a set.
- Tabular and set builder forms of a set.
- Subset of a set.
- Superset of a set.
- Power set of a set.
- Union of sets.
- Intersection of sets.
- Universal set.
- Complement of a set.
- Venn Diagram and its Applications.
- Cartesian Product of two sets.
- Relation and Function.
- One-to-one function.
- To find the value of a function.

**Content of Unit II (Trigonometry)**

- Introduction of Trigonometry.
- Definition of Trigonometric ratios.
- Fundamental Identity.
- Proofs of other Identities.
- Behaviour of Trigonometric ratios as \( \theta \) varies from 0° to 90°.
- Use of Trigonometric Tables.
- Simple Problems of height and distance.

4.5 **WRITING A PROGRAMME:**

In an intrinsic programme, Sections or Parts of information are comparatively large. At the end of each section of information, the student responds by indicating his answer to a multiple choice question. In this type of programming, the learner is not to construct a response but to choose a correct answer from the given alternatives. Choice of a correct answer leads him to the next section of information and choice of wrong answer leads him to remedial material especially designed to clear his particular error. There are many types of intrinsic programme but here we are using the simplest one. In this type, the student will return directly from the remedial material to the original question but this time better equipped to answer it. The major function of a multiple-choice question is to test whether the postulated learning took place or not.

Crowderian Programme was developed for two units. Each unit was further divided into a number of sections. Each section taught the learner a particular concept or rule. At the end of each section, a fill in the blank type question was put to the learner. It was followed by some alternative answers to it. These sections or paragraphs were arranged in a logical order.
Each paragraph or section is technically called a frame. A frame is defined as a statement of information which is presented to a learner at a time.

Design of a Frame:

A frame consists of the following steps:

**Stimulus:** It is the matter which is presented to the learner. The learner is stimulated after going through a particular frame.

**Response:** It is the answer expected from a learner. Sometimes the learners have to construct a response and sometimes they have to select a correct response out of a number of responses. In Crowderian program, multiple responses are given and the learner has to select the correct response.

**Reinforcement:** The learner compares his answer with the answer given by the programmer. If he is right, he gets confirmation and goes to the next frame otherwise returns to the same frame but better equipped this time. Thus the principle of reinforcement is fully met.

In the construction of frames of this programme, an attention was given to the following characteristics:

- Its language should be simple and correct.
- It must motivate the learner.
- It should be unambiguous.
- It should be success oriented.

The following four types of frames were included in the present programme:

**Introductory Frame:** These frames introduce the topic to learner.

**Teaching Frames:** The content is taught to learner through these frames. These frames are about seventy-five percent in this programme.

**Practice Frames:** These frames provide a scope to practise the content material.

**Testing Frames:** Content matter is tested in these frames.

Prompts and priming have been used very cautiously in this programme. Prompts have been defined as a device to increase the probability that out of a particular set of alternatives, a particular response will come out to be emitted. Priming is pouring the information into the mind of the learner to enable him to respond correctly to a frame.

4.6 **PROGRAMMING TECHNIQUE EDIT** :

Programme was edited with reference to continuity, accuracy, relevance of content-material, style and vocabulary. Gaps left were filled. Irrelevant material was removed and some new relevant material was added, to increase the clarity of certain ambiguous sections.
4.7 **COMPOSITION EDIT:**

The intrinsic programme was checked for language - grammar, spelling, the ability to communicate and punctuations. It was got corrected for language from the language experts and their corrections and suggestions were accepted and the programme was revised.

4.8 **INDIVIDUAL TRY OUT (ONE-TO-ONE TESTING):**

This is a face to face interaction between a student and the programmer. The programme is tested on one student at a time. First of all, a personal rapport is established with him. The programmer told him that the programme is tested and not the student rather the student is helping in writing a better programme. The student is asked the difficulties faced by him regarding language, content-material, logical order, its way of presentation or any other kind of reaction. The difficulties and suggestions of the student were noted down by the programmer. The above process of individual try out was replicated on nine students. On the basis of feedback received from the students, the programme was revised to be tried out at the small group testing.

4.9 **VALIDATION OF PROGRAMME:**

Having drafted and edited the programme, the next step was its testing, for the strength of a programmed material resides not only in the product but in the empirical testing procedures employed in its production. The empirical testing
of a programme on a student population is known as validation testing of a programme. Developmental testing procedures were followed at the developmental stage of the programme. The validation testing procedure was intended to be employed to study as to how the draft programme was successful in teaching the specified population. Espich and William (1967) maintained that "The device or whatever it is, fails to live upto the purpose, for which it was designed if the student does not walk away from it possessing these terminal behaviours that the programme was intended to impart". The success of a programme is measured from the performance of the student on that programme.

The validation of a programme can be done for the following criteria:

- Error rate Analysis.
- Sequence Progression.
- Density Ratio.
- 80/80 or any other standard analysis on the basis of criterion test scores.

**Error Rate Analysis:** Error rate analysis criterion was not used for the validation of the intrinsic programme because the founder of this style was of the opinion that low or high error could not decide the effectiveness of a programme. Moreover, in branching style if a learner goes wrong, he is supplied with
the remedial material which explains why he was wrong and some more material is provided to help the learner to find the correct response.

**Sequence Progression:** Sequence Progression criterion was not used because this helps in linear programme, consisting of a large number of small steps, and in that it may happen that the sequence of presenting the didules may affect the efficiency of a programme. In branching style the didules are only small in number. Each didule or section teaches a full concept or subconcept. Therefore, there arises no need for validation of branching programme against sequence progression criterion.

**Density Ratio Test:** The density function is an indirect measure of the rate at which stimuli are introduced in a programme (Green, 1962). Actually programme density is the measure of the difficulty of a programme without dependence upon the student-population upon which the programme is to be administered. The measure for calculating the difficulty of the programme without depending on item-analysis technique is called type/token ratio (Green, 1962).

For calculating the type/token ratio (TTR) of a programme, the number of different respules are counted. This means that if a particular respule occurs twice or thrice in a programme, it will be counted as one as we wish to know only non-repetitive respules. The total number of respules in the programme is also ascertained. Now, the TTR is calculated as follows:
If every respule is different from other respule, the programme density is 1.00. This is the case when every didule contains a new concept. In the present study each frame contains a new concept in it. Hence total number of respules will be equal to number of different respules in each unit which will give token/type 1.00 always. Thus, the density ratio test cannot be applied in the branching programme considered by this programmer in the present study.

Validation of the Programme against Criterion Test: The programme was validated against the "80/80 standard". The analysis was made to ascertain whether the terminal objectives of the programme have been attained or not. The 80/80 standard emplies that the class mean should be eighty percent or more and every objective should be achieved by 80 percent of the population. The analysis was carried out at small group testing stage and field testing stage.

"80/80 Standard" at Small Group Testing Stage: The criterion test response-sheet of the students of small group which had already been exposed to the intrinsic programmed material were analysed. Table 4.1 gives the analysis of responses against "80/80 Standard".
TABLE 4.1
"80/80 Standard" Analysis of the Criterion Test at Small Group Testing Stage of Intrinsic Programme

<table>
<thead>
<tr>
<th>Unit</th>
<th>No. of Students</th>
<th>80% of Students</th>
<th>No. of Items</th>
<th>80% of Items in Criterion Test</th>
<th>Item Mean</th>
<th>Group Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>12</td>
<td>10</td>
<td>15</td>
<td>12.0</td>
<td>9.33</td>
<td>11.67</td>
</tr>
<tr>
<td>II</td>
<td>12</td>
<td>10</td>
<td>12</td>
<td>9.6</td>
<td>10.25</td>
<td>10.25</td>
</tr>
</tbody>
</table>

From the above table, it was seen that item mean for Unit I of criterion test at small group testing stage was 9.33 in respect of Unit I. The value 9.33 was less than 10 (80% of 12 students). It did not satisfy the first condition of "80/80 Standard" that the item mean should be 80 percent or more. The group mean of 11.67 was also less than 12 (80 percent of the items). It also did not satisfy "80/80 Standard". So Unit I was revised and modified.

The item mean 10.25 of Unit II was found to be more than 10 (80% of the students). It satisfied "80/80 Standard". The group mean 10.25 is also more than 9.60 (80 percent of the items) which also satisfied "80/80 Standard". Therefore, unit II was retained as such.

After revision and modification of Unit I of the intrinsic programme, the criterion test was administered to another sample of 180 students who formed the population for the field testing stage.
The analysis of criterion test scores at field testing stage is given in the Table 4.2.

**TABLE 4.2**

Analysis of Criterion Test Scores at Field Testing Stage

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>No. of Students</th>
<th>80% of Students</th>
<th>No. of Items in Criterion Test</th>
<th>80% of Items</th>
<th>Item Mean</th>
<th>Group Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>180</td>
<td>144</td>
<td>15</td>
<td>12.0</td>
<td>156.80</td>
<td>13.07</td>
</tr>
<tr>
<td>II</td>
<td>180</td>
<td>144</td>
<td>12</td>
<td>9.6</td>
<td>152.08</td>
<td>10.14</td>
</tr>
</tbody>
</table>

From the above table, it can be seen that the item means of criterion test at field tryout stage are 156.80 and 152.08 in respect of Unit I and Unit II respectively which are more than 144 (80% of 180 students) in each case. Therefore, the first condition of "80/80 Standard" is satisfied.

As 180 students took the test for each Unit, so the maximum score of each item could be 180 and 80% of 180 was 144. Thus we see that every item of the criterion test is scored right by at least 144 students (vide Table 4.2). In other words, every terminal behaviour of each unit of the programme is attained by at least 80 percent of the students.

The group means as seen from Table 4.2 are 13.07 and 10.14 in respect of Unit I and Unit II respectively. 13.07 is
more than 12 (80 percent of the items) and 10.14 is more than 9.60 (80 percent of the items in Unit II). Thus, the group mean of all the units at the field testing stage are more than 80 percent of the item scores in each unit. This satisfies the second condition of "80/80 Standard" set for the programme validation against an external criterion measure. The flow-chart of the final draft of each unit of the intrinsic programme is given on the next page. The Intrinsic Programme thus validated has been given in Appendix-V and was used as one of the treatments in the present study.

DEVELOPMENT OF CRITERION TEST

A criterion test measures the terminal behaviour of performance of the learner whose behaviour the programmer wants to shape through the programme. It is different from the achievement test. The achievement test measures the gain scores of student whereas the criterion test measures the behavioural change. It measures the effectiveness of the programme. Its main objective is to see the percentage of items attempted correctly by the percentage of students. It suggests the acceptance, rejection or modification of an item of the programme. Very difficult or very easy items are to be rejected. The language expert must be consulted for accuracy, comprehension etc.

A programme on the above two units namely (i) Sets and Mapping; and (ii) Trigonometry was written. The subject experts
Fig. 4.1 FLOW CHART OF INTRINSIC PROGRAMME ON UNIT I
sets and mapping
Fig. 4.2 FLOW CHART OF INTRINSIC PROGRAMME ON
UNIT II (Trigonometry)
and language experts were consulted for accuracy of material, grammatical correctness, language comprehension, logical orderliness etc. Only three types of taxonomic objectives namely, knowledge, comprehension and application were included in the present programme. The unitwise split-up of the items on knowledge, comprehension and application of the criterion test is given in the Table 4.3.

**TABLE 4.3**

Weightage to Content Units Within Various Objective Areas in the First Draft of the Criterion Test

<table>
<thead>
<tr>
<th>Content</th>
<th>Knowledge</th>
<th>Comprehension</th>
<th>Application</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit I</td>
<td>13</td>
<td>5</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>Unit II</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>11</td>
<td>19</td>
<td>50</td>
</tr>
</tbody>
</table>

The first draft of the criterion test consists of 50 items in all. Knowledge, comprehension and application have 20, 11 and 19 items respectively. This programme was prepared neatly and carefully. A representative sample of 40 students was selected and this programme was given to them. The criterion test was administered on this representative sample when they have been through the programme.
The acceptance, modification or rejection of an item is based on Kelley's (1939) formula of 27 percent cases in the upper group and lower group respectively. For calculating difficulty value (D.V.) and discriminating power (D.P.), the formulae used were:

\[
D.P. = \frac{R_U - R_L}{.5N}
\]

and

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

Where

- \( R_U \) stands for number of correct responses in the upper group on each item.
- \( R_L \) stands for number of correct responses in the lower group on each item.
- \( N \) stands for number of students in both groups.

Kelley (1939) criterion was followed for selecting items on the basis of D.V. Those items whose D.V. was either below .25 or above .75 were rejected. and those items whose D.V. ranged between .25 and .75 were selected.

Ebel (1966) criterion was followed for selecting items on the basis of D.P. Those items whose D.P. was .40 or above, were retained as such. Those items whose D.P. ranged between .20 and .40 were retained for revision and modification. The items whose D.P. was less than .20 were rejected. The table showing calculations of D.V. and D.P. is given in the Appendix VI. D.Vs
of the first draft of the criterion test are summarised in the Table 4.4 given below:

**TABLE 4.4**
Table Showing the D.Vs of Items of First Draft of Criterion Test

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>D.V.</th>
<th>Frequency</th>
<th>Item Number</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Below .25</td>
<td>2</td>
<td>37, 45</td>
<td>Rejected</td>
</tr>
<tr>
<td>2.</td>
<td>Between .25 &amp; .75</td>
<td>47</td>
<td>From Sr.No. 1 to 50 except item Nos. 9, 37, 45</td>
<td>Accepted</td>
</tr>
<tr>
<td>3.</td>
<td>Above .75</td>
<td>1</td>
<td>9</td>
<td>Rejected</td>
</tr>
</tbody>
</table>

The item numbers 37 and 45 have their D.Vs less than .25 and hence by Kelley (1939), these were rejected. The item numbers 1 to 50 except 9, 37, and 45 have their D.Vs between .25 and .75 and were accepted as such according to Kelley (1939). The item number 9 has its D.V. more than .75 and was also rejected according to Kelley (1939).

The D.Ps of first draft of criterion test are summarised in the Table 4.5 given below:
According Ebel (1966) criterion, 13 items namely 4, 5, 11, 15, 25, 30, 35, 36, 43, 44, 46, 47 and 48 were rejected as their D.Ps were found to be less than .20 (Table 4.5).

The D.Ps of the items having Sr. Nos. 1, 2, 3, 6, 7, 8, 10, 12, 13, 14, 16, 23, 26, 31, 32, 33, 42, 49 and 50 were found to be ranging between .20 to .39. Hence these 19 items were retained for revision and modification.

The D.Ps of 15 items namely 17, 18, 19, 20, 21, 22, 24, 27, 28, 29, 34, 38, 39, 40 and 41 were found to be .40 and above. Hence these items were retained as such.

In the selection of multiple choice items DeCecco's (1970) rule was applied. Those items which were answered correctly by 50 percent students were accepted as such whereas others were revised and modified. For the distractors, the criterion of at least 10 percent answers to a particular distractor was followed.
The distribution percentage of correct responses and the distractors in the multiple choice items are given in the Table 4.6.

**TABLE 4.6**

The Distribution-Percentage of the Correct Response and the Distractors in the First Draft of the Criterion Test

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Responses and Distractors</th>
<th>Frequency</th>
<th>Item Number and Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Correct responses with less than 50 percent distribution</td>
<td>9</td>
<td>1, 2, 3, 4, 5, 7, 8, 17, 31, Revised &amp; Modified</td>
</tr>
<tr>
<td>2.</td>
<td>Distractors competing with the correct response</td>
<td>1</td>
<td>18, Revised &amp; Modified</td>
</tr>
<tr>
<td>3.</td>
<td>Distractors with less than 10 percent distraction</td>
<td>3</td>
<td>3(b), 5(c), 31(d), Rejected</td>
</tr>
<tr>
<td>4.</td>
<td>Correct responses with 50 percent or more distribution</td>
<td>10</td>
<td>6, 9, 10, 11, 12, 13, 14, 15, 18, Retained as such 19, 32</td>
</tr>
</tbody>
</table>

Thus, after rejecting some of the multiple choice items and revising the others on the basis of DV, DP, distribution of correct responses and distraction level of responses, second draft of the criterion test was prepared and was administered to a sample of 185 students. Scoring of the responses sheets was done. Again DVs, and DPs were calculated (shown in Appendix-VI).

From Appendix-VI, it was found that DVs of second draft of the criterion test ranged from .33 to .74. The distribution of DVs is shown in the Table 4.7.
TABLE 4.7
The Distribution-Percentage of the DVs of the Items of Second Draft of the Criterion Test

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>DVs</th>
<th>Frequency</th>
<th>Item Nos.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Below .25</td>
<td>0</td>
<td>Nil</td>
<td>Rejected</td>
</tr>
<tr>
<td>2.</td>
<td>Between .25 to .75</td>
<td>27</td>
<td>From Sr. Nos. 1 to 27</td>
<td>Accepted</td>
</tr>
<tr>
<td>3.</td>
<td>Above .75</td>
<td>0</td>
<td>Nil</td>
<td>Rejected</td>
</tr>
</tbody>
</table>

DV of the none of the items was found to be less than .25 or more than .75, so no item was rejected on the basis of DVs. All items from Sr. Nos. 1 to 27 were accepted as such.

From Appendix-VI, it was found that DPs of the second draft of criterion test ranged from .26 to .72. The distribution of DPs is shown below in Table 4.8.

TABLE 4.8
The Distribution-Percentage of the DPs of the Items of the Second Draft of the Criterion Test

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>DPs</th>
<th>Frequency</th>
<th>Item Nos.</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>.40 and above</td>
<td>23</td>
<td>1,3,4,7,8,9,10,11,12,13,14,15,16,17,18,20,21,22,23,24,25,26,27</td>
<td>Accepted as such</td>
</tr>
<tr>
<td>2.</td>
<td>Between .20 to .39</td>
<td>4</td>
<td>2,5,6,19</td>
<td>Revised &amp; Modified</td>
</tr>
<tr>
<td>3.</td>
<td>Below .20</td>
<td>0</td>
<td>Nil</td>
<td>Rejected</td>
</tr>
</tbody>
</table>
DPs of none of the items was less than .20 thereby no item was rejected on the basis of DP.

DPs of the items 2, 5, 6, 19 were found between .20 to .39, so they were revised and modified.

DPs of 23 items (listed above in Table 4.8) were found to be .40 and above. These items were selected as such.

For acceptance or rejection of multiple choice items, DeCecco’s (1970) rule was applied. Those items which were answered correctly by 50 percent of the students were accepted as such whereas others were revised and modified. For the distractors, the criterion of at least 10 percent of the answers to a particular distractor was followed. Response Analysis of Multiple Choice Items of Second Draft of Criterion Test is given in Appendix-VI. The distribution-percentage of the correct responses and the distractors in the multiple choice items are given in the Table 4.9.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Responses and Distractors</th>
<th>Frequency</th>
<th>Item No. and Response Reference</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Correct responses with less than 50% distribution</td>
<td>8</td>
<td>1, 2, 5, 6, 11, 12, 13, 18</td>
<td>Revised &amp; Modified</td>
</tr>
<tr>
<td>2</td>
<td>Distractors competing with the correct answers</td>
<td>0</td>
<td>Nil</td>
<td>Revised &amp; Modified</td>
</tr>
<tr>
<td>3</td>
<td>Distractors with less than 10% distraction</td>
<td>2</td>
<td>7(d), 10(b)</td>
<td>Rejected</td>
</tr>
<tr>
<td>4</td>
<td>Correct responses with 50% or more distribution</td>
<td>6</td>
<td>4, 7, 8, 9, 10, 19</td>
<td>Accepted as such</td>
</tr>
</tbody>
</table>
Then final draft of the criterion test was prepared with due consideration given to modification of items. The structure of the final draft with respect to weightage to the various categories of objectives is given in the Table 4.10.

**TABLE 4.10**

<table>
<thead>
<tr>
<th>Area</th>
<th>Knowledge</th>
<th>Comprehension</th>
<th>Applications</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit I</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Unit II</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>9</td>
<td>11</td>
<td>28</td>
</tr>
</tbody>
</table>

The final draft of the criterion test is given in the Appendix-VI.

**DEVELOPMENT OF LEARNING PACKAGE**

Learning package was developed by the investigator himself for local use. It comprises of the following three programmes:

(i) Computer Programme.
(ii) Summary of Unit I and Unit II; and
(iii) Exercises from the Text Book.
4.10 DEVELOPMENT OF A COMPUTER PROGRAMME:

A computer is basically a calculating machine which is capable of performing the operations of addition, subtraction, multiplication, and division. It can store the data and make use of it latter on. It can perform billions of calculations in a few minutes. It can give intellectual results like human-brain.

A computer is given instructions in Codes which is called computer language. There are many computer languages suitable for different types of computers, namely, BASIC, ALGOL, COBOL etc. In the present study, BASIC (Beginner's All Purpose Symbolic Instruction Code) has been used to develop a programme.

BASIC is a popular time sharing language. It is simple to understand and use. Even a man of no pre-knowledge can write a programme in a short-time. BASIC was developed in 1963-64 at Dartmouth College under the direction of Prof. John Kemeny and Thomas Kurtz. Basic has a grammar and a vocabulary. Grammar refers to rule of syntactical relations of BASIC statements. The vocabulary consists of a set of symbols. A complete set of BASIC definitions that are needed to construct sets of BASIC statements or programmes are shown below:

- Digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.
- Letters A to Z.
- Special Characters: $, *, (), ., +, -, /, , , "' ', £
- Line Numbers: 1 to 9999 can be taken/given.
- Label: Labelling is done in quotation mark like "Computer".
- Constants like +175 or -0.0078.
- Variables like P, Q, R, A5, B7, C(1), D(K+2), D(1,2).
- Operation: addition+, subtraction-, multiplication*, division/, exponential XX or ⁄.
- LET X = Q + (M*0.5)*2
  The expression on the right side of equal to sign will be evaluated and this is assigned to variable name on the left of equal to sign. The previous value of variable if any, is destroyed.
- PRINT (or P.) "Statement" will print the statement on the screen.
- 5000 TO 69 means jumping from line 50 to line 69.
- Statement Number: IF Expression₁ Relation Expression₂ THEN
  Statement Number means if the given relation is satisfied/correct then transfer to statement number. If relation is false then IF statement will have no effect and the next statement in the sequence will be executed automatically.
- 80 STOP means stop the program at line number 80.
  This can be used anywhere in the program when decisions are to made.
- INPUT computer waits until required numbers are typed.
- 9999 END means the program terminates at line number 9999.
The following symbols are used in the programme:

- SQR( ) Square
- SQRT Square root
- NEG Negative
- SIN(radians) Sinθ
- COS Cosθ
- TAN tanθ

The following system commands have also been used in the present programme:

- RUN: Execution of the programme will take place.
- SAVE: Programme will be saved on flopy.
- LIST: Listing will be done.
- HELP: gives explanations.
- NEW: is used to write a new programme.
- OLD: is used to access an old programme.
- SCRATCH: To wipe out the instructions of the programme.

To develop a programme in BASIC, the selection of the following two units from IX class mathematics was done:

I. Sets and Mapping.
II. Trigonometry.

The selection of the above two units was based on the criterion of ease of content matter and its utility for the learner. Another reason of these units to choose was that the investigator had used these two units in Branching Programme. To compare Learning Package with Branching Programme, to neglect the
effect of subject-matter same two units have been considered for a computer programme.

After choice of the units, these units were studied thoroughly in light of devising a programme in BASIC language on BBC Microcomputer. The content matter was discussed with other programmers, computer engineers and experts in the field.

4.11 DRAWING OF FLOW CHARTS FOR COMPUTER PROGRAMMING:

As each of the sections from Sr.Nos. 1 to 26 have three multiple choices in it which implies that the flow charts of all these sections will be same for each section. Flow charts of these sections is given in Fig.4.3.

The combined flow chart of both the Units and all sections from 1 to 26 is given in Fig.4.4.

4.12 WRITING A COMPUTER PROGRAMME:

A computer programme was written in BASIC language. The language expert, other programmers and subject-experts were consulted to revise the first draft of the programme. In the light of the feedback received from various experts, the draft was revised and put to testing.

4.13 PROGRAMME TESTING:

After a programme is written, it should be tested to see if the programme does what it was logically designed to do. The following types of testing were carried out in this programme:
Fig. 4.3 FLOW CHART OF SECTIONS 1 TO 26 OF COMPUTER PROGRAMME
Fig. 4.4 COMBINED FLOW CHART OF COMPUTER PROGRAMME
Desk Check: After writing the programme, it was discussed with many other computer programmers and engineers. Many syntactical errors were detected and corrected. Desk checking for each programme of a section and the whole system was done. Then the programme was tried on the computer.

Parameter Testing: Testing of only one programme is called parameter testing. Each programme was tried separately on the computer. Error removing technique called debugging was employed to remove syntactical as well as logical errors.

System Testing or Assembly Testing: Testing of the system of programmes is called assembly testing. The system of programmes was tried on computer. The errors were diagnosed in it and were removed by debugging the programme. In many programmes the input A = 4, 5, 6, 7 etc. were tried. Computer indicated that no such variable exists which is true because our questions are of multiple choice 3 only. This confirms the assembly testing.

4.14 RELIABILITY OF COMPUTER PROGRAMME:

An error free debugging run merely demonstrated that, for the programme and data supplied and for the environmental conditions at the time, no errors were detected. This established that the programme was reliable.
4.15 EFFICIENCY OF COMPUTER PROGRAMME:

A computer programme is a tool. Hence it will be efficient to the extent that it gets its work done at a minimum "cost". The following are the cost factors:

- The time required to compile the programme.
- The time required to execute the programme.
- The amount of storage space used by the programme.
- The amount of effort required to develop and maintain the programme.

The present programme took a long time in its development. The programmer had to work hard for long time. Some guidance from programming staff and experts was also taken. The time required to compile and execute the programme are not very large. The storage space is a flopy or disket of single side, single density $5\frac{1}{4}$ inches which is a cheap soft-ware material.

Keeping the above factors in mind, the programme developed by the programmer can be said as an efficient programme.

4.16 EFFECTIVENESS OF COMPUTER PROGRAMME:

A programme is effective to the extent that it satisfies the needs of the users of that programme. It depends upon the way the programme is used. So user must know how to use it. To achieve this aim clear instructions have been given before starting
the programme. The user was instructed how to prepare inputs. The output was presented in a way that was useful to him. The present programme is also correct as discussed in the topic "Testing of a Programme". Therefore, the programme developed by the programmer is effective.

4.17 DOCUMENTATION OF COMPUTER PROGRAMME:

The documentation of the programme was done as given below:

Abstract: The present programme consists of Unit I Sets and Mapping and Unit II Trigonometry from IX Class Mathematics book, NCERT, New Delhi (India). There are Nineteen Sections on Unit I and Seven on Unit II, a total of twenty six sections. Each section discusses some content in the syllabus of IX Class and is followed by a multiple choice question.

A Description of Real Problem: The programme intends to teach the above two units of IX Class to the learners.

Information Related to INPUT and OUTPUT: After loading the programme, a paragraph is to be read by the user by go on pressing the RETURN Key. Then a question with multiple choice will be on the screen followed by a question mark? sign on the screen. The user will select one answer say 2 and print it on the screen through the key-board. Press RETURN Key. It will be
followed by OUTPUT of response 2. Then a question "Do you want to go to next section?" will appear on the screen. The user will answer it in "Y" for Yes or "N" for No. No will bring him back to the beginning of Section 1 whereas Yes will carry him to Section 2. The whole of the programme will run like this.

**Flow Charts:** General and detailed flow charts already attached vide flow chart figures 4.3 and 4.4 respectively.

**4.18 SUMMARY OF UNIT-I AND UNIT-II:**

A brief compact summary was written for summarising of the concepts read by the students in computer programme. This summary was discussed with experts in Mathematics and the students. This process was repeated three times. The suggestions of students and experts were fully implemented in this programme. The revisions of the summary were made accordingly. Final draft of the summary on Unit-I (Sets and Mapping) and Unit-II (Trigonometry) is given in the Appendix-VII.

**4.19 EXERCISES FROM THE TEXT BOOK:**

Exercises from the text book were prepared and standardized on Unit-I and Unit-II with the help of other subject experts and teachers. These were given to the students. Their response-sheets were checked and the students were suggested for further study or revision of the programme. The final draft
of exercises is shown in Appendix-VII.

The above discussed three programmes namely computer programme, summary and exercises constitute learning package which has been used in the present study.