CHAPTER IV

DEVELOPMENT AND VALIDATION OF PROGRAMMES

A. Development and Validation of Linear Programme
   Preparation
   Writing the Programme
   Tryout and Revision

B. Development and Validation of Branching Programme
   Preparation
   Writing the Programme
   Tryout and Revision

References
The present study seeks to investigate the interaction between some personality and mental ability variables and achievement through three instructional treatment modes namely, linear and branching styles of programming and expository method of teaching. A linear and a branching programme on 'measures of central tendencies' - a topic of high school statistics were constructed for this purpose. The development of these programmes is presented in the following pages.

Development and validation of a programme, linear or branching, is a fairly complex exercise. It consists of the following major steps:

(A) PREPARATION - It includes selection of the topic, writing of the content outline, describing the task in explicit terms, analysing the task and constructing of the tests of entry level and terminal behaviours.

(B) WRITING THE PROGRAMME - The writing of the programme includes presenting the material in frames active responding, providing for confirmation or correction of responses, using prompts to guide student response and careful sequencing of the frames.

(C) TRYOUT AND REVISION - The tryout and revision consists of writing the original draft, editing the draft and tryout and revision of the edited draft.
(A) PREPARATION:

(i) Selection of the Topic:

The topic for programming should be selected with great care. The topic should not only be amenable to programming, but the programmer himself should be thoroughly convergent with the subject matter. In view of these criteria it was decided that 'Measures of Central Tendacies', a topic from mathematics course (Statistics) for high school students of the Board of High School and Intermediate Education, Allahabad, was selected. The present investigator is a graduate in mathematics and post-graduate in physics and as such is thoroughly convergent with the topic. The topic itself consists of well designed and fairly sequenced steps which can be easily programmed. Leedham and Unwin (1971) also points out, "The subject (Mathematics) lends itself readily to a programming approach... At secondary level conventional teaching in mathematical topics already bears a superficial resemblance to programming".

(ii) Content Outline:

The content outline should cover all the material planned to teach (Claws, 1961). Once the topic has been selected, the next step is to carefully prepare the content outline covering the materials that are to be taught. The outline of the present topic was prepared after a thorough study of a number of text books of high school level and
other reference books. Some secondary school teachers with sufficiently long experience of teaching statistics to high school classes were also consulted. The academic background of the present investigator was also of great help in writing the content outline. Since the programme was to be constructed in Hindi, the content outline was also prepared in Hindi. The outline has been presented in Appendix A.

This outline was also employed as text for expository method of teaching. The following topics have been covered in the outline.
(iii) Objectives in Behavioural Terms:

The objectives in behavioural terms represent the particular responses that can be expected in the student’s repertoire when the programme is completed. Writing specifica-
tions of objectives in behavioural terms is the initial step in the development of a programme. The objectives with their behavioural outcomes provides guidance in the planning of instruction. Mager (1975) while emphasising the importance of objectives in developing programmed learning material also points out, "Objectives are useful in provi-
ding a sound basis for the selection or designing of instruc-
tional content and procedures". He further writes, "... objectives can serve as a spotlight to illuminate the worth of that existing instruction and they can provide a basis for improving it". The writing of objectives in behavioural terms or task description has been presented in the following paragraphs:

Task Description:

A task description involves the explicit and unambiguous description of terminal behaviours, which are to be achieved through the programme. Robert Jager (1962) and Robert Miller (1962) after working independently have proposed two more or less similar procedures of task des-
cription. According to Jager's procedure the task description requires identification of the terminal performance which
the instruction attempts to produce, specification of the conditions under which the behaviour is expected to occur and the criteria of acceptance of students' performance. Miller's procedure of task description is somewhat more difficult to describe. According to Miller, an unambiguous and clear task description must have indication of the cue which calls for the response, activation or the response to be made and feedback, or the indication of how adequate the response has been. The difference between the two procedures of task description chiefly one of terminology (Becccecco, 1970). Both the procedures of task description involves specifically the description of stimulus conditions under which the student must perform, indication of response he is to make in behavioural terms and provision for feedback or for assessment of student performance. In the present programme Miller's criteria of task description as briefly described above have been adopted for the present study as they are objective, practicable and have a high degree of precision.

In the present programme development, the following task descriptions were made:

1. The learner must be able to define and discriminate the following measures of central tendencies:
   (a) Mean
   (b) Median
   (c) Mode
2. Given the ungrouped data, the learner must be able to calculate the mean.

3. Given the grouped data in score form, the learner must be able to calculate the mean.

4. Given the grouped data in class interval, the learner must be able to calculate the mean by long method.

5. Given the grouped data in class interval. The learner must be able to calculate the mean by short method.

6. Given the ungrouped data with odd number of cases, the learner must be able to calculate the median.

7. Given the ungrouped data with even number of cases, the learner must be able to calculate median.

8. Given the grouped data in score form, the learner must be able to calculate median.

9. Given the grouped data in class interval, the learner must be able to calculate median.

10. Given the ungrouped data, the learner must be able to calculate the mode.

11. Given the grouped data in score form, the learner must be able to calculate mode.

12. Given the grouped data in score form with more than one score having same highest frequencies, the learner must be able to calculate mode.

13. Given the grouped data in class interval, the learner must be able to calculate mode.
(iv) Task Analysis:

The programmer must not only describe but also analyse the tasks he expects the student to perform. While the task description is the description of terminal behaviours which the programme proposes to achieve, the task analysis examines the component behaviour the learner must acquire in the process of reaching the terminal behaviour. In a proper task analysis, the teacher would correctly classify the behaviour involved in each objective and establish the best learning condition for each. A task analysis may also identify the subtasks which must be learned in the process of learning the task proper. Peter Sipe (1966) suggests that task analysis involves building a pyramid of objectives. In the top of the pyramid is the instructional objectives. This objective is analysed into subobjectives which are needed for achieving the above mentioned instructional objective. These statements of subobjectives will form the next lower level of pyramid. The third level of the pyramid constitutes the component behaviours which are needed for the achievement of the subobjective. This analysis continues downwards till the level of entering behaviours are reached. Fig. 6 presents the pyramid of objectives for the general objective of 'definition and calculation of various measures of central tendencies'.

In the pyramid presented in Fig. 6, programme
objectives were further analysed into component behaviours which are involved in the achievement of the objective concerned. Panel-I presents the component behaviours for the programme objective. Given the grouped data in class interval, the learner must be able to calculate the mean by long method. Such component behaviours for every objectives were prepared because they formed the basis for writing the frames.

(v) Test of Entry Level Behaviour:

For every programme of instruction some pre-requisite behaviours are essential. These pre-requisite behaviours form the basis in a programme. They are recalled in the beginning frames for building up the subsequent frames. If the students do not possess these pre-requisites or entry level behaviours, they would not be able to understand the subsequent frames and would also fail on the criterion test. It is, therefore, imperative that the student should be tested for their entry level behaviours before the administration of programme and only those students should be allowed to learn through it who possess the necessary entry level behaviours. A test of entry level behaviour was, therefore, prepared for the present programme. The procedures adopted thereof have been described in the next chapter.
(vi) Test of Terminal Behaviour:

After task analysis, the programmer sets about writing the frames. A criterion frame is constructed for each item of task analysis. A series of teaching frames are also constructed for each of the criterion frames. In this way the whole programme is prepared. Usually two criterion test items are also constructed pertaining to each criterion frame. These criterion test items are also called post-test items or test of terminal behaviours. In the present investigation only one set of criterion test items was prepared. It was considered that, since the criterion test consisted of numerical examples only, there was hardly any need to have duplicate item for every objective. Further, the interval between the pre and post test administration was sufficiently large so that there was hardly any scope for carry over from one situation to another. The test of terminal behaviour was administered both before and after the administration of the programmes. The construction of this test has been described in next chapter.

(E) WRITING THE PROGRAMME:

(i) Frame Writing:

In a linear programme the material is presented through small units called 'frames'. Each frame constitutes a small segment of subject matter which calls forth
particular student response (Taber, et al., 1965). The segment of subject matter is based on knowledge already possessed by the student and a very small increment of knowledge, moving the student steadily towards the terminal behaviour. The size of subject matter to be learned in a frame may vary in different parts of the programme. But in the linear programme, the frames are kept as small as possible to provide good learning. Hancock and Sheffield (1961) concluded that (i) short steps are more effective than large steps for initial learning and (ii) the progressive lengthening of steps lead to best performance on the test of terminal behaviour. While writing the frames for the programme, it should be kept in mind that frames should be as simple as possible, should avoid ambiguous material, should be written keeping in view the mental level of the learner and should try to incorporate the various psychological principles of efficient learning. Leedham and Minchin (1971) suggest a number of guidelines which may assist in frame writing. They point out that while writing the frame, one should be unambiguous, be brief, be simple and be aware of reading ability of students for which programme is intended. Keeping in view all the above criteria of good frame writing, the frames for the present programme were written.

A frame consists of four parts (a) stimulus or
stimulus context (a) enrichment material (c) response
(d) prompts. Frame number 8 of the programme constructed
for the present study has been presented below as an example:
Frame No.8:— The score which appears maximum number of
times in a group is called the mode of that group. In the
scores 15, 18, 20, 22, 25, 27, 27, 30, 32 of the frame
no.4, the score .......... appears maximum number of times.

Hence mode = ..........

(a) Stimulus or Stimulus Context — Each frame consists of
some stimulus or stimulus context. The stimulus or stimulus
context acts for evoking the desired response. These are
the words which precede and follow the blank. In the frame
No.8 presented above, the material 'In the scores 15, 18,
20, 22, 25, 27, 27, 30 and 32 of the frame no.4, the score
which appears maximum number of times' and 'mode' are the
stimulus and stimulus context to evoke the desired response.

(b) Enrichment Material — The fourth ingredient of a frame,
the enrichment material, is optional. The enrichment
material makes the frame more readable or interesting or
recalls previously learned material to facilitate student
response. In many instances interest in a programme is
heightened by inserting the facts which are relevant to the
material being covered but not part of course or programme
objectives. Such material is called enrichment material.
In the frame No.8 given above, the material 'The score which appears maximum number of times in a group is called the mode of that group', is enrichment material which recalls previously learned material to facilitate student response and makes the frame more readable and interesting.

(c) Response - Each frame requires the students to make response or responses. For this purpose each frame either poses a question or leaves a space blank in which the required response is written. The response may be overt or covert. A covert response is not considered satisfactory because it does not control mathematic behaviors of children. An overt response is easily learnt because the student is using most of his senses and his mathematic behaviors are also controlled. In the present programme, overt responding has been employed. While writing the programme frames, care was taken to see that the student reads and understands all the parts of the frame before giving the response. *Vergulues (1964)* has shown that the learner tries to remember only those parts of the frame which he is required to respond to. The frames also required only critical informations to be responded to. Unimportant and trivial informations do not add to the knowledge of the learner. *Holland (1960)* has shown that frames requiring trivial informations to be given, yield a very low error rate in programme performance but the post test error rates
are very high, showing thereby that sufficient learning has not taken place through the frames. *Contrariwise*, the frames requiring critical informations to be responded to yield comparatively higher programme error rate i.e. they are comparatively more difficult but the post test scores are fairly high showing a comparatively better learning through such frames. Keeping in view this discussion it was considered that the frames in the present programme should require only critical informations as responses. The response blank were kept, as far as possible, near the close end of the frame. Horn (1963) argues that the blank space should appear as close to the end of the frame as possible because this position spares the student the awareness of flipping his eye back and forth, skidding around inside frame after frame looking for the relevant material. In the above example, the blank space is provided near the end of the frame and requires the 'mode' to be filled in. The correct responses of each frame are given on the back page and as to avoid knowledge of response before writing or filling up the blanks.

(d) *Prompts or Cues* — Prompts or cues are provided in the frame to guide the student to the correct response without over controlling his behaviour and to prevent the student from making unnecessary errors. *Eyer* (1966) defines prompt, "any technique employed to make emission of the correct answer more likely". They are supplementary stimuli
in that they are added to a frame to make the frame easier but are not sufficient in themselves to produce the response (Markle, 1964). It has been shown by quite a few researchers that prompts or cues help in better learning. Alimble and Jepsen Sulff (1953) found that students in the prompted group scores higher on practice items, transfer items and the most difficult items. The students showed the greatest superiority on those items for which prompts had been provided. Oliver Cooke and his associate (1960) also argued that instructional procedures which furnish the student sufficient guidance to avoid mistakes is superior to procedures which only correct errors after they are made. A variety of prompts may be employed in the frames. The prompts may be formal or thematic. Formal prompts are those which give an idea of the form of correct response while the thematic prompt is one which gives an idea of the theme or the subject matter of the correct response.

The formal prompt may be partial response prompt, rhyming prompt, literal prompt and frame structure prompt. These various formal prompts have frequently been used in different parts of the present programme. In frame no. 26 of the panel no. 1, the method of calculation of midvalue has been explained and that for the first class interval has been calculated, which serves as a prompt for calculating the remaining values. Thus the partial provision of the
correct response in this frame has served as a prompt. This prompt is, therefore, called a partial response prompt. Since it gives an idea of the 'form' of the correct response, it is a formal prompt. The frame no. 30 of the panel-1 utilizes frame structure formal prompt. In this frame the first two items have been partially prompted and for remaining items of the frame, the stimulus material is arranged in such a way as to prompt the correct response.

The thematic prompts may be of picture prompt, context setting prompt, synonyms and antonyms prompt, analogies prompt, rules prompt and inductive prompt. In the present programme, these various thematic prompts have been utilized. In frame no. 29 of panel-1 synonyms 'or' is used to prompt the correct response. In frame no. 28 of the same panel, rule that 'mean is obtained by dividing the total score of students by the total number of students' serves as a prompt to evoke the correct response.

(ii) Criterion and Teaching Frames:

The criterion or terminal frame is one which tests pupil's knowledge without auxiliary clues or prompts whereas teaching frames is one which is needed inorder to proceed for criterion frame. The teaching frame teaches various interim objectives or objectives of the programme whereas the criterion frame tests the criterion objective.
(C) TRYOUT AND REVISION:

The tryout and revision of programme involves two types of teaching:

(I) Developmental Testing

(II) Validation Testing

(I) Developmental Testing:

The developmental testing aims at revising the draft programme by the help of students till it is felt that it will be able to achieve the objectives. It is completed in the following two stages:

(i) The individual testing stage

(ii) The group testing stage

(i) The Individual Testing Stage:

This is the most important stage for improving the programme. This stage takes the help of the student themselves in improving the programme. In fact the consumer (here the student) should be the best judge for a teaching programme. Thomas Gilbert (1960) suggests,

> Take your first crude effort to the student. Remember, he is going to teach you. The student can not fail. If he does not get where you want him to go, you have failed. Try something else. In the absence of anything better, let him be your guide. If you come to a dead end, vary your approach until you have gotten him to where you want him to go.

At this stage the original draft of the programme is
improved with the help of student one at a time. This individual tryout is repeated till finally the students do not make any mistake and programme seems to achieve the objective for which it has been constructed. The individual tryout works on the principle of 'diminishing return'.

The frames originally prepared were first written on cards (size approximately 4" X 3") with one frame on one side of the card and its correct response on the reverse side. These cards were employed for individual tryout. Six students cooperated in the individual tryout. In accordance with the suggestions of Leedham and Unwin (1971), these students were selected from the lower end of the intelligence spectrum of the students for whom the programme was intended. The individual tryout required a perfect rapport between the student and the programmer. This was achieved by a very affectionate treatment towards these students and by making his feel that his cooperation was essential for improving the programme and that the programme does not intend to identify the students mistake. After the selection of students, these cards were presented one by one to individual students and the students were required to write down their responses on a separate response sheet. After writing down the response, the student were required to flip the card over to see the correct
response. The programmer also noted the time taken by the student to complete a frame, his response, reaction and editing comments on the following proforma:

**TABLE-II**

SAMPLE PROFORMA OF INDIVIDUAL TRYOUT FOR LINEAR PROGRAMME

<table>
<thead>
<tr>
<th>Frame No.</th>
<th>Time Taken</th>
<th>Student's Response</th>
<th>Student's Reaction</th>
<th>Editing Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>2 m</td>
<td>Modifi-</td>
<td></td>
<td>CRAB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>3 m</td>
<td>Need for</td>
<td></td>
<td>RATIO+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Midvalue</td>
<td></td>
<td>MALE</td>
</tr>
<tr>
<td>27</td>
<td>3½ m</td>
<td>One more</td>
<td></td>
<td>PROMPT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>example</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>2 m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>2 m</td>
<td></td>
<td></td>
<td>OVER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VIEW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>82</td>
<td>8 m</td>
<td>Requires</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clarification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>83</td>
<td>9 m</td>
<td>- do -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>84</td>
<td>6 m</td>
<td>- do -</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As pointed out earlier the time taken to complete a frame and student's reaction to it were noted on the
proforma. A perusal of the sample proforma presented above would show that frame nos. 82, 83 and 84 have taken too much time to complete and the student's reaction is also of tiredness or blocking. Such frames were modified. The frame no. 82 was originally as follows:

Frame-82:

"Analysis table" of frame-81 will be filled up as follows:

(i) The highest frequencies in the column-1 of grouping table are 18. These are of scores......and........

Thus these scores have been written in front of column-1 below the scores...... and ........

(ii) Similarly, in the column-2 of the grouping table, the highest frequency 29 is of scores........and........

These scores have been written in the analysis table of frame-81 at appropriate places.

(iii) The highest frequency of column-3 of grouping table is of scores........ and ........ Write down these scores in appropriate places in the table.
Analysis Table:

<table>
<thead>
<tr>
<th>Column</th>
<th>Scores with highest frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

frequency

Apparently the blocking is due to lack of understanding and ambiguous language. It may also be due to the following factors: (a) Dissimilar alignment columns and rows of grouping and analysis table, (b) writing the scores in place of their tally marks and consequent confusion in calculating frequencies, (c) requiring a calculation of large number of frequencies. The frame was therefore, modified as follows:

(i) The allignment of groups and columns was made similar to the grouping table given in frame 80.
Analysis Table:

<table>
<thead>
<tr>
<th>Score Column</th>
<th>Tally marks of Scores with highest frequency</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1  2  3  4  5  6  7</td>
</tr>
</tbody>
</table>

∞
4
6
7
8
9
10
11
12
13
14

This eliminated the confusion regarding the columns and the obtained scores.

(ii) The frame was divided into 3 frames each requiring a small bit of information. The first frame of this series i.e. frame no. 61 of modified programme was a prompted frame requiring students to put tally marks against the score/scores having highest frequency in column 1. Tally marks were preferred to the usual practice of writing the score as such because in the later case there was some confusion in arriving at the total frequency. There was no such
confusion when the tallies were used. In each of the following frames, i.e. frame nos. 81, 82 and 83 frequencies of one column at a time were required to be filled in by the students. In this way single frame was divided into three frames rendering the sequence comparatively more easy. An individual tryout of this sequence did not show any sign of blockade. The modified frames were:

Frame-81:

For calculating the mode by grouping method, the analysis table was framed after completion of grouping table. In the analysis table tally marks are put in front of scores having the highest frequency of each column. From the grouping table L.H.C., it can be seen that the highest frequency is.... which is of scores..... and ..... Thus in the analysis table the tally marks will be put in front of scores 9 and 11 below column 1.

Frame-82:

In the same way, the highest frequency in the column 2 of frame-80's grouping table is....... of this frequency is the sum of frequencies..... and ....... of score 9 and 10. Thus tally marks must be put in front of scores 9 and 10 under column 2. Please put the tally marks in the analysis table in column 2 at an appropriate place.
Frame-83:

The highest frequency in the column-3 of frame-80's grouping table is..... This frequency is the sum of frequencies.......and.....of scores.......and.....

Please put the tally marks in the analysis table at an appropriate place.

### Analysis Table

<table>
<thead>
<tr>
<th>Scores Column</th>
<th>Tally marks of scores with highest frequency</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1 1 1</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Frame no.83 and 84 (of the draft programme) also elucited a feeling of tiredness on the part of the student. These frames were also modified.
In this way all the frames were scrutinized for the time taken and for evoking a feeling of tiredness or blocking. Some frames were found to possess some minor defects e.g. in some frames the correct response was implied, the frame lacked illustrations or the frames were obviously give away ones. The appropriate editing remarks were noted and the frames were revised accordingly.

Editing and Revision of Frames:

This was done on the basis of editing notes taken during the individual tryout. Some examples would clarify the steps undertaken by the programmer/investigator. Original frame no. 26 was as follows:

The formula for midvalue

\[ x = \frac{\text{........}+\text{........}}{2} \]

The editing remark for this frame was 'RATIONAL' which indicates that the frame sequence being reinforced fails to provide the student with an adequate picture of the reasons for learning the material covered by the sequence. Thus rationale are needed. The revised frame was as follows:

In this way when scores are given in class intervals then the representative score of that interval is........

....The formula for calculating midvalue,

\[ x = \frac{\text{........}+\text{........}}{2} \]
Similarly, frame no. 27 was originally as follows:

Find out the midvalues of the class intervals given in the following table:

<table>
<thead>
<tr>
<th>Class Interval</th>
<th>Frequency</th>
<th>Midvalue</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>5-10</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>10-15</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>15-20</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>20-25</td>
<td>3</td>
<td>-</td>
</tr>
</tbody>
</table>

The editing remark for this frame was 'PROMPT' which indicates that the frame does not provide any clue to evoke correct response. So the prompts are needed. The above frame was revised as follows:

Calculate the midvalues of class intervals given in the following table:

<table>
<thead>
<tr>
<th>Class Interval</th>
<th>Frequency</th>
<th>Midvalue</th>
</tr>
</thead>
<tbody>
<tr>
<td>(C.I.) 0-5</td>
<td>4</td>
<td>2.5</td>
</tr>
<tr>
<td>5-10</td>
<td>5</td>
<td>...</td>
</tr>
<tr>
<td>10-15</td>
<td>1</td>
<td>...</td>
</tr>
<tr>
<td>15-20</td>
<td>5</td>
<td>...</td>
</tr>
<tr>
<td>20-25</td>
<td>3</td>
<td>...</td>
</tr>
</tbody>
</table>

The midvalue \( x \) of class interval 0-5 = \( \frac{0+5}{2} = 2.5 \)

Similarly calculate the midvalues of other class intervals.
In the frame no.21, the editing remark was C R A B which indicate that the correct response was missing the frame. If the correct response is missing the student is unable to check his response, this creates frustration. The missing of correct response also results in wastage of students' valuable time because he has to reread the portion of the programme in order to check his response. So the correct response was added to the frame.

The frame no.53 was originally as follows:
The frequency distribution of 12 students of a class was as follows:

<table>
<thead>
<tr>
<th>x</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

\[ N = 17 \]

In the above distribution score 3 is obtained by 2 students, and score 5 by 8 students. Similarly score 6 is obtained by .......students and score 7 is obtained by .......students.

Score 5 or less than this were obtained by 8+2=10 students. This 10 is called the cumulative frequency of score 5. Core 6 or less than this were obtained by
5+......+......=......students. Thus, the cumulative frequency of score 6 = .........

Similarly, score 7 or less than this were obtained by......+......+......+......So cumulative frequency of score 7 = .........

The editing remark for this was 'OVERVIEW', which indicates that the programme has failed to provide the student with an introductory overall picture of the subject being studied. The following overview of the material to be studied is thus provided before the above frame.

"Upto now we have studied the calculation of median in ungrouped data.

The median of any group = \( \frac{N+1}{2} \) th student's score

For calculating the median in grouped data first we have to calculate the cumulative frequencies. In the next frames we shall explain you the calculation of cumulative frequency and then median with the help of that cumulative frequencies".

In this way all the frames were revised on the basis of individual tryout.

GROUP TRYOUT:

The individual tryout helps in improving the frames and making them suitable even for the dullest student of
the class. This assures that the student would not commit a mistake while learning through the programme. But the individual tryout does not provide any evidence regarding the efficiency with which the representative group for which the programme is constructed would perform. With this objective in view, the programme was administered to a group of twentyfive students. The student comprising the group consisted of weak, average as well as superior students. The group tryout consists of two steps:

(a) Frame Analysis
(b) Post test Analysis

(a) Frame Analysis - This is conducted to find out the error rate of different frames. The number of students responding to a frame and those responding correctly were entered in the following proforma. This helped in calculating the error rate i.e. % of student attempting the frame incorrectly.

**TABLE-III**

**SAMPLE PROFORMA FOR FRAME ANALYSIS OF LINEAR PROGRAMME**

<table>
<thead>
<tr>
<th>Frame No.</th>
<th>Frame</th>
<th>No. of Student Responded</th>
<th>No. of Student Responded Correctly</th>
<th>Error Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Criterion</td>
<td>25</td>
<td>23</td>
<td>8%</td>
</tr>
<tr>
<td>13</td>
<td>Criterion</td>
<td>25</td>
<td>24</td>
<td>4%</td>
</tr>
<tr>
<td>51</td>
<td>Criterion</td>
<td>25</td>
<td>23</td>
<td>8%</td>
</tr>
<tr>
<td>53</td>
<td>Teaching</td>
<td>25</td>
<td>23</td>
<td>8%</td>
</tr>
<tr>
<td>54</td>
<td>Teaching</td>
<td>25</td>
<td>25</td>
<td>0%</td>
</tr>
</tbody>
</table>
The standards are that the frames which had error rate more than 3% (in case of criterion frames) and more than 10% (in case of teaching frames) indicate a need for revision. It was however, considered that these standards are far too rigorous, therefore, the standard needed to be brought down. It was, therefore, decided that if the error rate of criterion frame exceeds 5% and that of teaching frame exceeds 10% then only the frame needed revision. A frame analysis of all the frames were made and it was found that the frames nos. 8 and 51 did not confirm the aforesaid criterion.

An examination of these frames showed that they contained printers error and possibly the boosted error rate may be due to this reason. It was also considered that in view of the every easy frames, as they were, there was hardly any chance of any other reason for the increased error rate. These printing errors were corrected and frames were attempted easily. The error rate also came down to normal. One of the teaching frames revealed abnormal error rates. The frames were very thoroughly scrutinised at the individual tryout stage, therefore, the group tryout did not reveal any abnormality in the teaching frames.

(b) Post Test Analysis - After the administration of programme, a post test was administered to the group who had completed the programme, to estimate the efficiency of
the programme. An analysis of the post test scores was also done to revise and improve the programme. If a student fails at a post test item, it may be due to the defect in the item itself or due to poor frames pertaining to the objective for which the post test item has been constructed. To identify such frames a 'scallogram analysis' was conducted. The post test items were rearranged in the hierarchal order of the objectives and the number of students attempting each items were calculated. The accepted standard in this regard is that in order to accept the item, it should be attempted correctly by 80% of the students. Obviously this would show that post test items as well as the frames pertaining to the objective for which the post test items were written are satisfactory. Again it seems reasonable to argue that this standard is rather too high for situation obtained in India where the educational technology movement is in its infancy. Therefore, even if a post test item was attempted correctly by 60% of the students (standard set up for obtaining the first division) it was deemed to be satisfactory. However, in spite of this watered down standard, some items of the post test were found to be unsatisfactory. The items which were found to be unsatisfactory on the above standard were item nos. 4, 14, 31, 36, 38, 39 and 40. These items were attempted poorly either because of these items themselves
or because of defective frame pertaining to them. The frames were examined thoroughly and it was found that the frames did not possess any defect. Therefore, the defect was possibly in the items themselves. An 'option analysis' of the post test items was done to ascertain the possible cause of the student's poor performance. It was found that item no. 4 contained a printer's mistake, which was corrected. The item no. 14 contained a printer's mistake. A score 20 had been printed in addition to the given scores, which rendered the correct alternative to the item incorrect. These mistakes were corrected by removing the last score 20. The option analysis of item no. 31 revealed that most of the students write midvalues (x) in place of deviations (d), so this mistake of the post test items were corrected by defining the symbol 'd' i.e. deviation. Furthermore, the option analysis of item nos. 38, 39, 40 showed that the students did not prefer any specific distractors. All the distractors were attempted more or less equally by the students was could not answer the item correctly. Evidently the failure on the part of the students to attempt the item correctly was due to the fact that these items required lengthy calculations. The usual practical in such case is to divide the items into small manageable parts. But the nature of these items warranted that it is not divided into smaller items. Therefore, the only alternative felt was to increase the weightage of the item, thereby increasing
its importance.

(II) Validation Testing:

While the aim of developmental testing is to revise and finalise the draft programme until the programmer is satisfied that the programme will be able to do what it was intended to do, the aim of validation testing is to study how far the draft programme is successful in teaching the specified population in the natural conditions of its use. In specific terms, the purpose of validation testing is to find out:

(1) to what extent the programme has succeeded in achieving the objectives for which it was constructed.

(2) what are the reactions of the participating students and teachers.

In order to find out the extent to which the programme is succeeded in achieving the objectives, the pre and post test scores were compared. The average of the pre test scores (excluding the entering level test item scores) was 0 and that of the post test scores was 125. Thus the programme has succeeded in obtaining an average gain of 125 scores.

The validity of the programme was also ascertained by comparing the efficiency of the programme with that of conventional method.
FIG 7 DISTRIBUTION OF ACHIEVEMENT SCORES OF STUDENTS TAUGHT THROUGH CONVENTIONAL METHOD AND LINEAR PROGRAMME
TABLE IV

DISTRIBUTION OF ACHIEVEMENT SCORES OF STUDENTS TAUGHT BY THE CONVENTIONAL AND LINEAR PROGRAMMED METHODS.

<table>
<thead>
<tr>
<th>I.Q.</th>
<th>Percentage of Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conventional</td>
</tr>
<tr>
<td>0-5</td>
<td>0</td>
</tr>
<tr>
<td>5-10</td>
<td>10</td>
</tr>
<tr>
<td>10-15</td>
<td>10</td>
</tr>
<tr>
<td>15-20</td>
<td>20</td>
</tr>
<tr>
<td>20-25</td>
<td>5</td>
</tr>
<tr>
<td>25-30</td>
<td>15</td>
</tr>
<tr>
<td>30-35</td>
<td>15</td>
</tr>
<tr>
<td>35-40</td>
<td>10</td>
</tr>
<tr>
<td>40-45</td>
<td>5</td>
</tr>
<tr>
<td>45-50</td>
<td>10</td>
</tr>
</tbody>
</table>

It would be seen from the Table IV and figure 7 that the achievement scores obtained through different methods possess distinctly separate distribution. While 20% of the students taught by conventional method occupy the lower end of the distribution of scores i.e. scores between zero and 15 whereas none of the students taught by linear programme occupy this part of distribution of scores. The 55% of the students taught by conventional
method occupy the middle part of the distribution of scores i.e. scores between 15 and 35, whereas 60% of the students taught by linear programme occupy this portion of the distribution of scores. The distribution further reveals that the upper end of the distribution of scores (i.e. scores between 35 and 50) is occupied by only 25% of the students taught by conventional method as compared 40% of the students taught by linear programme. This shows that the percentage of students taught by linear programme is higher than that of students taught by conventional method at both, the middle and upper end of the distribution. None of the students taught by linear programme occupy the lower end of the distribution of scores, while 20% students taught by the conventional method fall in this region. This reveals that the present linear programme has resulted in higher achievement as compared to the conventional method.

The efficiency of teaching programme consists not only in the scores obtained by students but also in the time taken to do so. In this respect, the linear programme is also proved to be superior. While the average time taken by the student to learn through conventional method was 4 hours but it was only 3½ hours for learning through the linear programme.
The reactions of the participating students and teachers toward the programme was ascertained by putting questions regarding the frames that are considered either too difficult or too easy and extent to which they like the programme vis a vis the conventional method. None of the frames were considered very difficult or very easy by most of the students and they found the linear programme considerably easier to understand than conventional one.

DEVELOPMENT AND VALIDATION OF BRANCHING PROGRAMME:

Since the branching programme does not utilize any learning theory but depends upon sound techniques of teaching, the strength of the programme lies in its developmental and validation processes. The development of branching programme involves three major stages like that of linear programme:

(a) Preparation
(b) Writing the programme
(c) Tryout and Revision (Developmental and Validation testing) of the programme.

(a) Preparation:

Since the aim of the present study is to develop and validate linear and branching programme both on the same topic (i.e. 'Measures of Central Tendencies'), the steps of preparation i.e. selection of a unit or a topic,
preparation of content outline, defining objectives in
behavioural terms, construction of tests of entering and
terminal level behaviour would be similar to those for
the linear programme. These steps of preparation have
already been presented in the development of linear
programme.

(b) Writing the Programme:

After the preparation stage, the next stage is
actual writing of the programme. In chapter III on design
of the study, the structure of a branching programme has
already been described. Briefly, however, a branching
programme consists of an expository frame which may consist
of two or three paragraphs (Hovtre, 1963). The expository
paragraph is followed by a multiple choice type question
and the student is required to select the one which he
considers correct. If he selects the correct answer, he
proceeds to the next 'main line' frame but if he chooses an
incorrect answer, he is directed to a 'remedial frame'
which points out the causes of his mistake and provides a
further elaboration of facts, concepts, given in the
original 'main line' frame or expository paragraph and is
again directed to the original 'main line' frame. After
the remedial exercise the student is expected to respond
correctly to the multiple choice question given at the end
of expository paragraph or 'main line' frame. Thus the
writing of a branching programme is different from that of linear one.

The writing of branching programme, therefore, requires writing of three parts:

(i) Main line frame
(ii) Alternative responses
(iii) Remedial frames

(i) Main line Frame:- The 'main line' frame constitute a primary part of the branching programme. After passing through various frames learner is able to achieve his target. In a 'main line' frame a small unit of subject matter is thoroughly explained with the help of examples. A inductive–deductive approach and egrule–ruleg procedure was followed. The important aspects of the frame are dark printered or underlined so that greater attention is paid to them.

(ii) Alternative Responses:- Each frame in a branching programme is followed by a multiple choice questions. Growder (1962) points out that multiple choice question may serve:

(1) to detect a procedural errors and lead to a single corrective frame.
(2) to lead to a correctional sequence
(3) to find a mistake in interpretation of a previous point and return to that point in the programme.
Since the alternatives control the pupil's route through the programme, providing feedback to the learner, selection of these alternatives and their arrangements are among the most important tasks. The alternatives were consisted of the correct response and some distractors. The distractors were constructed on the basis of the most probable errors based either on experience of teaching the material or on the basis of an empirical procedures. The empirical procedure in the present programme consisted in examining the responses given to the different multiple choice items of the achievement test employed during the developmental testing of the linear programme. An ophion analysis of the post test items was made and the errors that were generally committed by students were noted. These errors were employed for constructing the distractors of the multiple choice questions presented at the end of expository or main line frame. For example, after the option analysis of post test items requiring calculation of median the common mistake committed by the student were (i) mean was calculated in stead of median (ii) \( \frac{n+1}{2} \) th term was considered as median in place of scores of \( \frac{n}{2} \) th term.

There is apparently no restriction on the number of alternatives, in the present branching programme three to four alternatives were generally employed to reduce chances of guessing. As a example, frame no. 13 has been presented:
Frame 13:

In an examination, a group have achieved 1, 4, 7 and 9. Find out the median of these scores.

Median is the mid point below and above which 50-50 scores of students lie. If \( N \) is the number of students then

\[
\text{id score} = \frac{N+1}{2} \text{th student's score}
\]

\[\therefore \text{median} = \frac{N+1}{2} \text{th student's score}\]

In the above group

\[
\text{median} = \left(\frac{5+1}{2}\right)\text{th students' score (because } N+5\right)
\]

\[= 3\text{th student's score} = 4\]

Example: In an examination, few students have achieved following scores: 7, 9, 18, 24, 25, 27, 30, find out the median.

Here \( N = 7 \). \[\therefore \text{median} = \left(\frac{N+1}{2}\right)\text{th students' score}\]

\[= \frac{7+1}{2} \text{th student's score} = 4 \]

\[= 24\]

Question: Few students of a class have following scores. Calculate the median:

3, 4, 5, 5, 6, 6, 7, 8, 9
If your answer is -

(a) 5 see frame (63) on page 54
(b) 5.89 " " (64) " " 55
(c) 6 " " (65) " " 56

It would be seen in the above example that the concept of median has been explained thoroughly, than an example has been given and solved in the frame itself. The procedure is thus explained to the students. Following the example, a multiple choice question has been given. The alternatives to the multiple choice question have been selected on the basis of errors generally committed by the students on the achievement test item pertaining to the subject matter of this frame as explained in the foregoing paragraph.

(iii) Remedial or branched frames:— The choice of alternatives in the main frame of the branching programmes takes the learner to the remedial or branched frames. These frames either advises the learner to proceed further in the main line frames or provide remedial excercises by pointing out the errors committed by the students and giving a more exhaustive exposition of the facts of concepts included in the main line frame. As an example, the remedial or branched frames to the main line frame no. 13 presented above have been presented below:
Your answer is wrong.

We know that Median = \( \frac{N+1}{2} \) th student's score.

Here, \( N = 9 \) hence Median = \( \frac{9+1}{2} \) th student's score = 5th " "

You have considered 5 as median in place of 5th student's score. Note that 5th student's score is median.

Now again study the frame no. 13 on page 20 and answer the question:

The student has given value of \( \frac{N+1}{2} \) th i.e. \( \frac{9+1}{2} = 5 \) as median. Obviously the students have failed to find out the 5th student's score. The fact has been further elaborated in the above frame and the correct method of calculation of median of the example presented in the original main line frame has been explained. The student has then been directed to the main line frame.

Frame 64:  

Your answer is wrong.

You have not understood median properly. Median is score below and above which 50-50 cases lie, i.e.

\[
\text{Median} = \frac{N+1}{2} \text{ th student's score}
\]

You have calculated mean instead of median because the mean of question of frame 13 is
\[
\frac{3+4+5+5+6+6+7+8+9}{9} = \frac{53}{9} = 5.9\bar{9}
\]

How study the frame 13 on page 20 again and answer the the question again.

The student's give mean as the response, therefore, this above frame explains the difference between median and mean and further explains the procedure of calculating the median and then directs to the original main line frame.

Page 65

Our answer is correct.

Our have understood the method of calculating median properly because, median = \(\frac{9+1}{2}\) th student's score

\[= 6\]

How study the frame no. 14 on page 21.

He student's response was correct and therefore, the above frame direct to the student to next main line frame.

Tryout and revision:

The tryout and revision of branching programme involves two types of testing:

a. developmental testing
b. validation testing
a. Developmental Testing:

The developmental testing aims at revising the draft program by the help of students till the programmer feels that it will be able to achieve the objectives. It uses the following two stages:

(i) Individual Testing stage
(ii) The Group Testing stage

(i) Individual Testing: The original frames were written on cards with one frame on each card. These cards were presented individually to the students. Four students participated in this individual tryout. The criteria for selecting students for the individual testing of the branching program were similar to those employed for the linear programme. The responses and reactions were noted on the following proforma:

<table>
<thead>
<tr>
<th>Frame No.</th>
<th>Time Taken (Minutes)</th>
<th>Student Response</th>
<th>Student Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>3</td>
<td>Reeds</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>5</td>
<td>Classification</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td></td>
<td>in (\sqrt{2})</td>
</tr>
<tr>
<td>25</td>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The frames were revised on the basis of student responses and reached and consequent remarks. For example, the students were held up in frame no. 18. A perusal of this frame revealed that the students are not able to proceed further because the concept of $\pi/2$ has not been clarified. The frame was revised accordingly, incorporating more examples to explain the concept. Similarly, frame no. 25 was also considered very difficult for the student. It was considered that if a blank table of 'analysis table' was provided, the student response would be considerably easy. His frame was revised accordingly and student gave better response. In this way the whole programme was revised.

**Group Tryout.**

After editing the programme on the basis of individual tryout, the programme was administered to a representative sample of 25 students. The students were asked to work carefully and their responses were noted on a separate sheet of paper.

**Frame Analysis.** After administering the branching programme booklet, frame by frame analysis was conducted with the help of following reforms in order to find out the error rate of each frame.


<table>
<thead>
<tr>
<th>Frame No.</th>
<th>Frame</th>
<th>No. of Student Responded</th>
<th>No. of Student Responded Correctly</th>
<th>Error Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Main frame</td>
<td>25</td>
<td>23</td>
<td>8%</td>
</tr>
<tr>
<td>7</td>
<td>Main frame</td>
<td>25</td>
<td>25</td>
<td>0%</td>
</tr>
<tr>
<td>52</td>
<td>Medicinal frame</td>
<td>25</td>
<td>24</td>
<td>4%</td>
</tr>
</tbody>
</table>

The standards of error rate employed in the linear programme were not applicable to a branching programme.

Such standards of error rate of branching programme frames were not available in the previous studies. Therefore, the error rate standard for this purpose were set up on theoretical considerations. The main line frame of branching programme assumes that the concepts, facts or principles included in it should be thoroughly explained with the help of suitable examples employing maxim of efficient text input. Thus in a satisfactory branching programme, main line frame should not yield a high error rate. If an analysis revealed a high error rate for these frames, the frame should be revised or rewritten. However, a low error rate was expected for such frames. A standard of 10% error rate was set up arbitrarily for the revision of main line frames in the present study. If a frame yields a error rate of more than 10%, it was revised. The 10% error rate was considered...
acceptable as it could be taken care of by the remedial or branched frames. However, the remedial frames could not be expected to yield even a very low error rate. Therefore, if a remedial frame yielded an error rate it was rejected and a new frame was prepared in lieu of that. For example, frame no. 52 yielded an error rate of 4. It was a case of revision and therefore, revised. Similarly other frames were revised.

Validation testing of branching programme:

As in linear programme, while the aim of development testing is to revise and finalise the draft programme until the programmer is satisfied that the programme will be able to achieve its objectives, the aim of validation testing is to study how far the programme is successful in teaching the specified population in natural conditions of use. In specific terms, the purpose of validation testing is to find out:

(i) what extent the programme has succeeded in achieving the objectives for which it was constructed.

(ii) what are the reactions of participating teachers and students.

In order to find out the extent to which the programme has succeeded in achieving the objectives, the pre and post test scores were compared. The average of pre
Figure 8: Distribution of achievement of students taught through branching programme and conventional method.
test scores was and that of post test score was 127. Thus the present programme have succeeded in obtaining an average set of 127 scores.

The validity of the programme was also ascertained by comparing the efficiency of the programme with that of conventional method.

**TABLE VII**

<table>
<thead>
<tr>
<th>Class Interval</th>
<th>Frequencies</th>
<th>conventional method</th>
<th>Branching Programme</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>0 )</td>
<td>0 )</td>
<td></td>
</tr>
<tr>
<td>5 - 10</td>
<td>10 ) 20%</td>
<td>0 ) 5%</td>
<td></td>
</tr>
<tr>
<td>10 - 15</td>
<td>10 )</td>
<td>5 )</td>
<td></td>
</tr>
<tr>
<td>15 - 20</td>
<td>20 )</td>
<td>30 )</td>
<td></td>
</tr>
<tr>
<td>20 - 25</td>
<td>5 ) 55</td>
<td>15 ) 70</td>
<td></td>
</tr>
<tr>
<td>25 - 30</td>
<td>15 )</td>
<td>15 )</td>
<td></td>
</tr>
<tr>
<td>30 - 35</td>
<td>15 )</td>
<td>15 )</td>
<td></td>
</tr>
<tr>
<td>35 - 40</td>
<td>10 )</td>
<td>5 )</td>
<td></td>
</tr>
<tr>
<td>40 - 45</td>
<td>5 ) 25%</td>
<td>5 ) 25%</td>
<td></td>
</tr>
<tr>
<td>45 - 50</td>
<td>10 )</td>
<td>15 )</td>
<td></td>
</tr>
</tbody>
</table>

It would be seen from the Table-VII and figure 8 that the achievement scores obtained through two methods possess distinctly separate distributions, while 20% of the students
taught by conventional method occupy the lower end of
distribution of scores i.e. scores between 0 and 15 whereas
5 of students taught by branching occupy this part of
distribution of scores. 55 of the students taught by
conventional method occupy the middle part of the distribu-
tion of scores i.e. scores between 15 and 35 whereas
75 of the students taught by branching programme occupy
this part of the distribution i.e. the distribution further
reveals that the upper end of the distribution of scores
(i.e. scores between 35 and 50) is occupied by only 25 of
the students taught by conventional method as well as
branching programme. His shows that percentage of students
taught by branching programme is higher than that of
conventional method in middle part of the distribution
whereas the percentage of students taught by branching
programme is lower than that of percentage of students
taught by conventional method at the lower end of the
distribution. The percentage of students in the higher part
of distribution is equal for both the methods. His shows
that the present branching programme has resulted in higher
achievement as compared to conventional method.

The efficiency of teaching programme consists not
only in the scores obtained by students but also in the
time taken to do so. In this respect also, the branching
programme is proved to be better. While the average
taken by the students to learn through conventional method was 4 hours, it was only 3 hours and 20 minutes for learning through branching programme.

The reactions of the participating students and teachers toward the programme was ascertained by putting questions regarding the frames that were considered either too difficult or too easy and extent to which they liked the programme, vis-à-vis the conventional method. None of the frames were considered too difficult or too easy by most of the students and they found the branching programme as considerably easier to understand than conventional one.
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