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THE PRESENT INVESTIGATION - PLAN AND PROCEDURE

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THE PRESENT INVESTIGATION - PLAN AND PROCEDURE

On the basis of the survey of literature comparing different forms of programmes, the investigator made certain important observations. Most of the studies involved short programmes and no information was available as to the characteristics and methods of preparation of the programme forms compared. Many studies failed to involve control over learning situations, experimental and or statistical control of variables. In certain studies, even the sample was not clearly defined or described.

There are certain specific observations pertaining to programme forms. One striking observation is that relatively few studies are there with branching forms, probably due to the fact that linear forms are familiar and popular, easy to prepare due to the small steps, sufficient knowledge of edit coding, error analysis and so on. Secondly, even in linear forms the comparison of overt and covert response modes outnumbers other studies, for example, prompting and confirmation.

The availability of very few studies free from technical or design deficiencies, and lack of studies probing into the efficacy of hybrid forms, and skip programme forms and theoretical speculations favouring certain programme

forms, made the investigator to undertake a study comparing linear forms (overt and covert), response prompt forms (overt and covert), mixed forms (Hybrid form and skip programme form) and branching form. The main interest of the investigator, of course, is to compare them both in terms of immediate gains employing the immediate posttest scores and long term gains in terms of the retention scores. As the programmed materials allow the student to work at his own individual speed, it was also decided to consider the time factor as another index of comparison among the treatment groups. Efforts were also taken to minimize the technical or design deficiencies and to make the treatment groups comparable in terms of the initial and intervening variables by randomization. And finally, efforts were taken to make the different programme forms as perfect as possible and as much comparable as possible; and the results were analysed and interpreted using the highly sophisticated statistics which allow for the initial variations and class-to-class variations, applying the special techniques of covariance.

The problem

The statement of the problem reads

> "An Investigation into the Relative Effectiveness of Different Forms of Programmed Learning Material."

Terms Defined

For the purposes of the present inquiry the following definitions were used.

1 Programme Form: Variations in programmes in terms of response mode (overt and covert), route traversed by the student (linear or branching), or method of responding (construct or response prompt). These different forms require the same pre-requisites, and terminal behaviours, The performance is evaluated by the same criterion test.

2 Linear Overt Form: The Skinnerian form with small steps requiring either construct responses or selection of one of the two or more alternatives.

3 Linear Covert Form: It is a linear programme as above, but the response is internalized which the student presumably makes(thinking) but which is neither recorded nor otherwise available to an observer.

4 Response Prompt Overt Form: The linear form in which the response blanks are already filled; the student has to copy down the response word.

5 Response Prompt Covert Form: The linear form in which the response blanks are already filled; the response is internalized which the student presumably makes (reading) but which is neither recorded nor otherwise available to an observer.

6 Skip Programme Form: It is a form that contains small steps; the sequence starts with a terminal frame and student who makes a correct response here would skip certain frames dealing with further elaboration of the sub-concept. If the student makes an error, he goes through further elaboration of the point. Here, the student has to write down the response.

7 Branching Form: The usual Crowderian form with remedial materials. The student has to write down the response.

8 Hybrid Form: It is a form containing the mainstream frames of the branching form and the remedial material is given in the linear style. The student has to write down the response.

9 Effectiveness: The effectiveness of a programme form would be considered in view of the following three criteria:

i) Performance on the criterion test immediately given after the programme.

ii) Percentage of retention using the retention test given after six weeks.

iii) Time taken to finish the programme.

Scope of the Study

Due to the reasons mentioned earlier, the investigator undertook the responsibility of preparing seven different forms of programmed learning materials on the lesson "Thermometers".

The seven forms are:

A. Linear Overt Form

B. Linear Covert Form

C. Response Prompt Overt Form (Copying)

D. Response Prompt Covert Form (Reading)

E. Skip programme form

F. Branching Form

G. Hybrid Form (Branching Linear Form)

The forms differ in certain aspects like step size, mode of response, utility and manipulation of errors, etc. But all of them are based on the same entering requirements, as measured/identified by the same entering behaviour test which was prepared for the validation of the programme; both the content and sequence are based on the same terminal objectives, as measured by the same criterion test; all of them have the same criterion frames at the terminating point of each objective; and finally they are administered simultaneously to the students distributed randomly into the seven treatment groups, thus making the sample comparable.

The seven programme forms were described in detail in the first chapter. In general the following points can be mentioned here:

i) Forms A, B, C, D, E and G consist of frames of small steps (G has the remedial frames).

ii) Forms A, C, E, F and G require overt response i.e., writing down the answer, while B and D require covert response, i.e., just thinking or reading the frames.

iii) Forms E, F and G consist of branches according to the response made while the remaining forms are used in a linear style.

Hypotheses

It has been hypothesized that -

a) there is no true difference in the achievement of the seven treatment groups on the immediate posttest;

b) there is no true difference in the achievement of the seven treatment groups on the percentage of retention;

c) there is no true difference in the time taken by the seven treatment groups to finish the programme.

Some limitations of the present study

One must exercise restraint in generalizing the findings in view of the following observations:

a) The experiment was restricted to the eighth grades only.

b) The subjects were taken from the English medium schools.

c) The sample was drawn from the schools of the City of Baroda. No urban school was included.

d) Seven forms of only one programme were prepared on 'Thermometers'. The findings, therefore, may hold for a subject like physics.

Preparation of Programme Forms

As has already been mentioned, the programme forms differed in certain technical aspects, like mode of response, size of steps, and the manipulation of errors while they all shared the following things in common:

i) Topic
ii) Task Analysis
iii) Pre-requisite Behaviours
iv) Entering Behaviour Test
v) Terminal Behaviours
vi) Criterion Test
vii) Terminal Frames

In the present investigation the following two types of materials were used:

a) Programmed materials consisting of the seven programme forms; and

b) Programme evaluative materials, consisting of the entering behaviour test and the criterion test.

In preparing the programme forms the following steps were involved:

a) Selection of subject area programmed and integration of this into the learning process as a whole (vide page 98 A)

b) Preparation of a general statement of objectives and programme specification.

c) Construction of terminal test based on programme objectives.

d) Decision regarding teaching point outline, the order of presenting the instructional matter.

e) Detailed breakdown of objectives into rules.

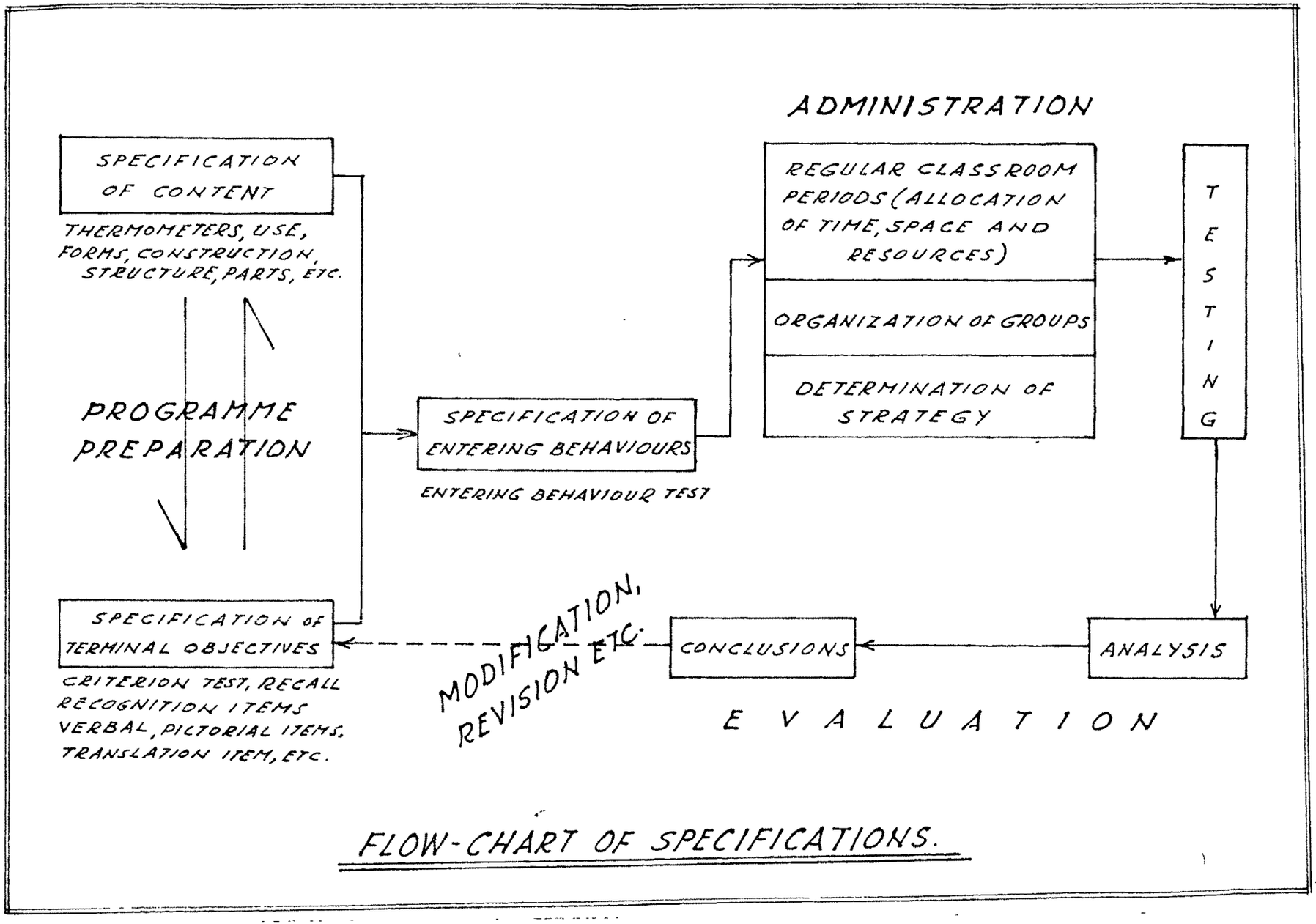
f) Construction of test frames.

g) Development of content, including frame writing.

Specification of Content

The topic selected for programming was from the unit of science curriculum - Thermometers. The following concepts were included - What is a thermometer, its shape and parts, How it is made, types of temperature scales, special types of thermometers, and how they work.

Students generally feel it difficult to comprehend because they are not allowed to observe carefully and



FLOW-CHART OF SPECIFICATIONS.

98A

leisurely the real thermometer or a figure of it. Also, the coordination between pictorial representation and verbal description becomes poor because of the fewer occasions provided for the student to see the figure and associate the parts with functions. Thus, the details do not get established and just terms like 'Centigrade', 'Fahrenheit', 'steel index' etc., exist in their vocabulary without much analytical or practical values.

As the terminal behaviours did not require any manipulation or handling of real thermometers, maximum number of relevant figures were used instead of real thermometers, and it was expected that the students could benefit to the maximum possible extent out of the minimum available resources.

Entering Behaviours

The programmed learning material was built upon what the student already knew, and dealt with things unknown to the student. The detailed statement of the initial and terminal behaviours provided the guide lines for constructing the programme. The pre-requisite knowledge specified the required basic knowledge, understanding and skills and abilities that a student should possess in order to take the programme.

Entering behaviour statements incorporated the same principles as those of terminal behaviour statement, viz., they were, stated in observable behavioural terms, they were

objectively testable, they specified the student action, and they specified the conditions and minimum acceptable level of performance.

Entering behavioural Statement

Example - Given a list of seven things, the student should be able to classify them into solids, liquids and gases by making not more than one error.

Entering Behaviour Test

Before giving the actual programming, the entering behaviour test was given to make sure that the student possessed the pre-requisite skills on the basis of which the concepts were further developed, but were not quite efficient with the concepts developed in the programme.

Entering Behaviour Statement	Entering Behaviour Test Item
Given a list of seven things, the student shall be able to write whether they are Solids, Liquids or Gases, by making not more than one error.	Write whether the following are Solids, Liquids or Gases: a) Cotton . . . . . b) Stone . . . . . c) Milk . . . . . d) Air . . . . . 5) Water . . . . . 6) Hydrogen . . . . . . 7) Mercury . . . . .

Terminal Behaviour

Mager (1962) defines the terminal behaviours as "...that which refers to the behaviour you would like your learner to be able to demonstrate at the time of your influence over him (the learner) ends".

The terminal behaviour statement included the following important aspects:

i) They were stated in behavioural or performance terms describing what the learner would actually Do.

ii) They described the conditions under which the learner would be required to perform his actions.

iii) They specified the minimum level of performance expected from the learner.

Example - Behavioural objective and its components:

Behavioural Objective	Its components
Given the temperature in words,	The condition under which the student would perform
like 'Minus twenty seven degrees Centigrade'	
the student shall be able to WRITE it in symbolic forms	what the learner should actually do ..
like "-27°C " with accuracy of the signs, digits, symbol of degree and C or F in the respective order and position.	the minimum level of performance

Criterion Test - a test on Terminal Behaviours

The test on the terminal behaviour, known as criterion test, is a devise to know whether the student, after completing the programme, has reached the acceptable standard of performance or not. The items on the criterion test were derived from the frame work of task analysis.

The criterion test items were put in the programme at the end of each sub-concept, as criterion frames called 'exercises', providing the information regarding the workability or otherwise of the sub-concept, thus suggesting the interim performance and progress of the learner.

The items on criterion test were based on the following aspects:

a) The stated terminal behaviours were translated into appropriate criterion item.

b) Criterion test items were objective based.

c) Criterion test item included appropriate instructions regarding the mode of response etc.

d) Criterion test items were devoid of prompts and cues.

Example Illustration of a Behavioural Objective and the related Criterion Test Item

Behavioural Objective	Criterion Test Item
Given the temperature in words like 'minus twenty seven degrees Centigrade', the student shall be able to WRITE it in symbolic forms like '-27°C' with accuracy of the signs, digits, symbol of degree and C or F in respective order and position.	i) Minus twenty-one degrees Fahrenheit is written as . . . . . , ii) Hundred degrees Fahrenheit is written as . . . . . , iii) Minus twelve degrees Centigrade is written as . . . . .

In the following page is given a table indicating the different concepts included in the criterion test and the number of questions under each concept. It can be seen that the test items include different aspects, and thus can be said to have what may be called the content validity, in the language of test construction.

Contentwise Analysis of Criterion Test — TABLE NO. 3.1

S.No.	Concept	Question No.	Total
I	GENERAL		
	a) Definitions	1, 2	2
	b) Symbolic representation of temperatures	3, 4, 5	3
	c) Abbreviations	6, 7, 8, 9	4
II	TYPES OF THERMOMETERS		
	a) Common Thermometers		
	i) Shape/Structure	29	1
	ii) Working	16, 22, 27	3
	iii) Reasons for using mercury	19, 20	2
	iv) L.F.P. & U.F.P.	21, 30, 31, 32, 33, 34	6
	b) Clinical Thermometers		
	i) Structure/Shape	10	1
	ii) Use	14	1
	iii) Parts & functions	11, 12, 13, 24, 28	5
	c) Maximum-Minimum Thermometers		
	i) Structure/Shape	35	1
	ii) Special Parts	17, 18, 23, 25	4
	iii) Liquids used	36, 37	2
	iv) Recording the temperature	26, 38, 39, 40	4
	d) Six's Thermometer	15	1

Task Analysis

The next step of programming was the selection of the concepts and their analysis into S - R chains and multiple descriminations. The concepts and sub-concepts were listed in the order in which they were proposed to be taught keeping in view the relations among the concepts.

The task analysis was represented in a flow chart of words as well as terminal behaviours in the most suitable order in which they could be sequenced in the programme (vide page 105A) The flow chart was made flexible enough in order to make any changes later according to the evidences of tryout.

The frames were constructed on the basis of the suggestions and guidelines given by programmers like Patricia Callender (1969).

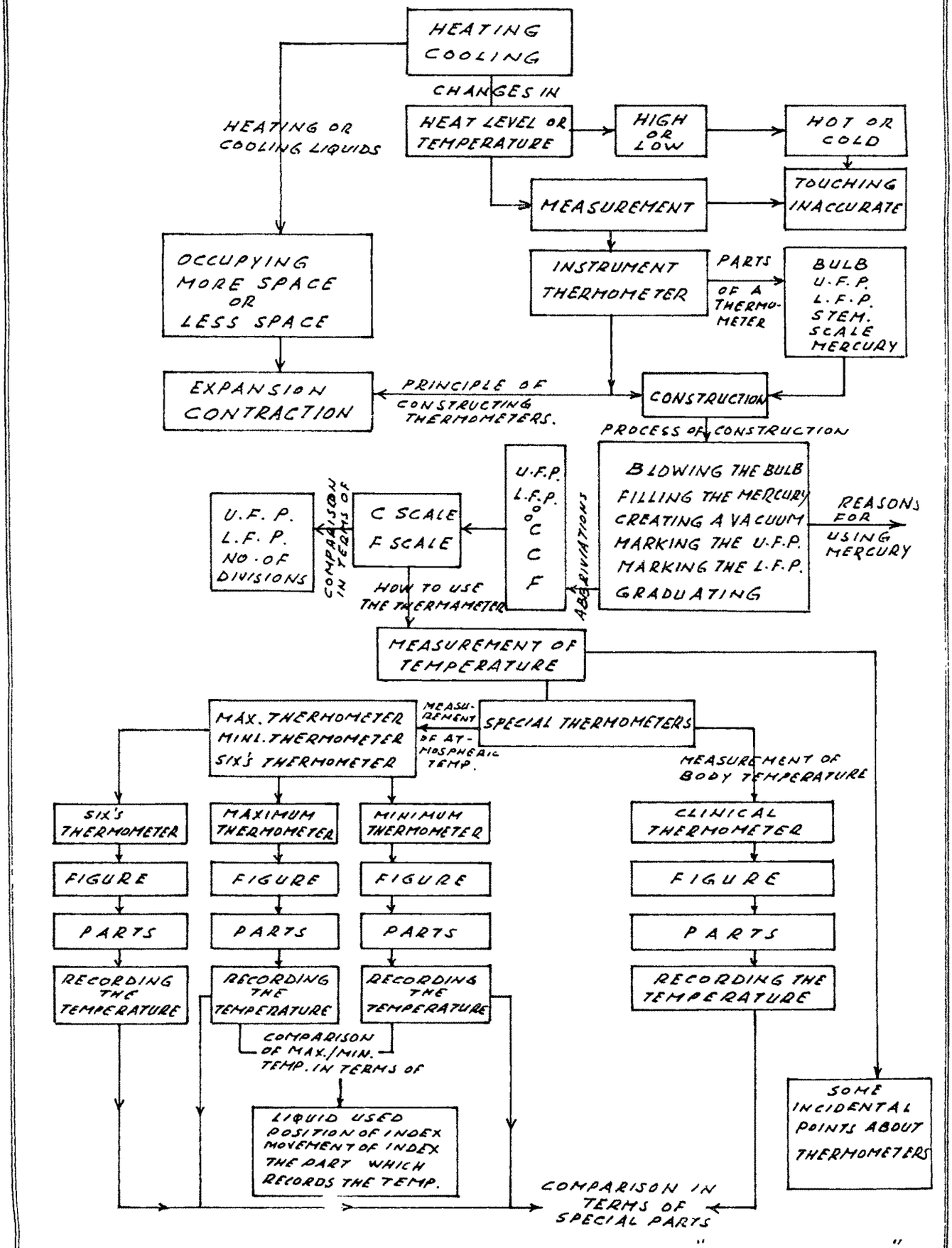
a) The wording was made as unambiguous as possible;

b) The response required of the learner was made relevant. Trivial or irrelevant responses were avoided;

c) The frames were made as challenging and stimulating as possible. Too easy material was avoided;

d) In a branching programme, the answer frames were prepared with a view to sorting out any fundamental misconceptions on the part of the learner;

e) The frames were so structured that there was maximum probability of success on the part of the learner.



FLOW-CHART OF THE CONTENT ANALYSIS OF "THERMOMETERS"

Types of Frames

The frames contained in the present programme (both linear and branching) can be broadly classified into three categories:

i) Teaching frames

ii) Practice frames

iii) Test frames (also called 'exercises').

i) Teaching Frames

A teaching frame was meant for presenting new information in logical sequence. The teaching frames were written on the basis of the rules compiled on the subject matter. Prompts were included in order to ensure maximum possibility of success.

ii) Practice Frames

After teaching a point, adequate opportunities were provided to reinforce the desired behaviour. Practice frames were given for each new teaching point, and prompts were gradually faded leading the learner to an unprompted response. Practice frames, hence, were not just copying frames or repetitive frames. The table given in the following page shows the various types of frames used in different forms.

TABLE 3.2

Types of Frames used in the Seven Programme Forms

Types of frames	Programme forms	No. of Frames
1) Linear frames	The two linear forms	209
	Skip-programme forms	
	Hybrid form - (as remedial material)	20 sets
2) Reading frames	The two response prompt forms	209
3) Exercises	All forms	19
4) Frames with answers for exercises	Branching and Hybrid	19
5) Small step, branching frames	Skip-programme form	23
6) Frames with directions & answers for the type 5 frames	Skip-programme form	23
7) Main stream frames	Branching & Hybrid- (including 19 exercises, 1 panel and 9 frames without questions)	48
8) Remedial I - small paragraph and backward directing, for each main stream frame.	Branching form - (excluding 3 frames of remedial III type, mentioned below)	20 sets
9) Remedial II - linear small step and forward directing, for each main stream frame	Hybrid from - (excluding 3 frames of remedial III type, mentioned below)	20 sets
10) Remedial III - Panel like and common for two or three main stream frames	Branching and Hybrid	3
11) Frames without questions	Branching and Hybrid	9
12) Panel on history of thermometers	All forms	1

iii) Test Frames or 'Exercises'

At the end of each teaching point, there were terminal frames called exercises, to test the learner. The terminal frames were not prompted. In a skip programme, this terminal point was given at the beginning of the series, and used to direct the student either to the next teaching point or to further explanation of the same concept. Thus, in skip programme, the terminal frames were given first followed by detailed explanations.

The exercises were made common to all the seven forms. In general, the exercises dealing with the terminal objectives were usually direct questions, with or without a figure, and they included a command like 'write', 'list', 'record', 'name', 'complete', and so on.

In the following pages are given the illustration of an exercise and a table showing various details of the exercises. The table shows the nature of the exercise, its description and the teaching point or the terminal behaviour involved in the exercise.

Illustration of an "Exercise"

EXERCISE NO. 18

Complete the following sentences by selecting the correct words from the list given below:

WORDS: magnet, index, bulb, hair spring, arrow, constriction, vacuum.

(a) Thermometers burst at higher temperatures if there is no _____ above the mercury in the thermometer.

(b) Steel index is prevented from moving by the _____.

(c) The back flow of the mercury is prevented by the _____.

(d) The index is reset using a small _____.

(e) The temperature of the day is recorded by the _____.

(f) To measure the temperature of water, the _____ of the thermometer is immersed in it.

(g) Normal body temperature of 98.4°F is shown in the clinical thermometer by the _____.

Nature of 'Exercises' or Criterion Frames

TABLE NO.3.3

Ex.No.	Description of the exercise or criterion frame	Teaching-point involved (Terminal Objective)
1	A list of words related to expansion and contraction. The student should tkck-mark only those related to contraction	Differences between the nature of expansion and contraction.
2	A figure of a common thermometer. The student should observe the figure carefully and answer certain questions related to the various parts of the thermometer.	The structure and parts of the thermometer.
3	Certain questions related to the nature of mercury. The student should answer them correctly.	The essential characteristics of a suitable thermometric liquid.
4	The statements which describe why mercury is used in the thermometers. The student should tickmark the correct reasons.	The reasons why mercury is used in the thermometers.
5	A figure comparing the Centigrade and Fahrenheit scales with their U.F.P. & L.F.P. marked. The student should observe carefully and answer the questions dealing with the comparison of C and F scales in terms of L.F.P., U.F.P. and the number of divisions on the scale	Differences between C scale and F scale of the thermometer when a comparative figure is given.
6	A list of abbreviations and symbols. The student should translate the abbreviations and symbols into their respective full forms.	Notations related to thermometers.

7	A blank tabular column comparing "Centigrade and Fahrenheit" in terms of L.F.P., U.F.P. and the number of divisions. The student should fill it up correctly.	Recalling the differences between C and F without the help of a figure
8	A figure showing two thermometers without any labels or marks of the fixed points except that figure A contains two marks 'a' and 'b' and figure B contains two marks 'c' and 'd'. With the help of the clue given that figure A contains 100 divisions, the student should be able to complete the sentences like 'value at d is . . . . . .'	Comparison of C and F scales
9	A scrambled list of steps followed in using a thermometer. The student should write the correct order of the procedure.	The method of using a thermometer
10	A labelled diagram of maximum thermometer. The student should observe the diagram carefully and answer certain questions related to the structure and parts of a maximum thermometer.	Structure and parts of a maximum thermometer.
11	A labelled diagram of minimum thermometer. The student should observe the diagram carefully and answer certain questions related to the structure and parts of a minimum thermometer.	Structure and parts of a minimum thermometer.
12	A list of certain parts of thermometers. The student should tickmark the two special parts of the maximum and minimum thermometers not found in common thermometers.	Special parts of the maximum and minimum thermometers

13	A figure showing the positions of the indices of maximum and minimum thermometers. The student should observe the figure carefully and recognize the type of the thermometer and read the temperatures shown by the indices and record the maximum and minimum temperatures correctly.	Differences between the two types of thermometers in terms of thermometric liquid used, position of the index and the method of recording the temperature
14	A blank table comparing the maximum and minimum thermometers. The student should fill the blanks correctly.	Differences between the maximum and minimum thermometers, without the help of a diagram
15	A labelled figure of the Six's thermometer. The student should observe the figure carefully and answer questions dealing with the structure and parts of the Six's thermometer.	Structure and parts of the Six's thermometer without the help of a figure
16	A list of incomplete sentences dealing with the shape, structure, parts and working of the Six's thermometer. The student should fill in the blanks correctly.	Shape, structure, parts and working of the Six'sthermometer without the help of figure
17	A diagram of a clinical thermometer. The student should observe the diagram carefully and answer certain incomplete sentences dealing with the structure and parts of the clinical thermometer.	Structure and parts of the Clinical thermometer with the help of a diagram
18	A list of incomplete sentences related to the special parts and working of various special types of thermometers. The student should select the correct answers from the list of words given.	Parts and functions of various special thermometers
19	An unlabelled diagram of a clinical thermometer. The student should fill the incomplete sentences dealing with the various special parts of the clinical thermometer	Parts of the clinical thermometer with the help of a diagram

Types of Responses in the frame

It was decided to elicit a series of responses from the learner in a variety of different ways. Some of the techniques used were:

a) The Blank Space

The missing word (or words) was supplied by the student on a separate answer sheet. Skinner's constructed response technique frequently employs this type of frames, the material being so structured that the learner has to complete a sentence, supply a missing word, or solve a problem. A blank space was also used for copy items. The open-ended question was provided with a space for the student to complete the item in his own words. This was usually a test item or a criterion frame of exercises.

b) A Straight Question

This was usually associated with criterion frames, but was also given in the teaching sequences when the student had to remember information given in the previous frames, or when the student had to work out an answer on a problem based on the information.

c) Binary Choice

One of the two answers must be selected correctly. The question was presented as: (a) . . . . or (b) , or incorporated in a sentence: (Greater/Smaller), (Hot/Cold), (Expansion/Contraction), (Index/Mercury Level) and so on.

d)A Pseudo Explanation

This technique was frequently employed in the branching programmes where the learner had to select the correct item from a seriesof plausible answers. The pseudo explanations were selected in such a way that the student's ability to comprehend was reflected in his choice.

e)Diagrams

Instead of writing an answer in words, the response sometimes called for use of diagrammatic material and fill up the blank like 'part (A)', 'Part (B)', 'below' etc.

Programme Preparation

In writing the programme, the first draft was written on individual cards for the sake of convenience in sequencing them and even to help while doing the individual tryout. First the criterion frame of the sub-concept was written. Then the next preceding frame was written and in this way the frames were written in the reverse order until the frame based on the pre-requisite knowledge was written. Here, Markle's (1969) suggestion, "The fastest way to cover the distance between the two points (entering behaviour and terminal behaviour) is to eliminate anything that student already knows and to take steps as large as they can possibly be taken" was kept in mind. ~~Markle's~~ another suggestion of Markle's, that the frames should be generated as fast as possible, without - being 'mentally blocked' by knowledge of editing was very much helpful in this direction.

The stimulus consisted of verbal matter, action word/ direction as to the responses given by the student, prompts, and at appropriate places figures were also included. For the first draft, the figures were hand drawings, drawn by an artist. The response component consisted of both construct and multiple choice.

Editing the first draft

The first draft was initially edited by subject matter experts in order to check the validity and correctness of the subject matter. Then it was edited by an expert having the knowledge of Edit Code Dictionary developed by Donald Bulluck (1961). Editing was done in order to detect technical faults which could only be identified by an expert but not by tryouts and also to reduce the number of student tryouts. The programme was edited in terms of the macro-structure and micro-structure as described by Krishnamurthy, et al., (1968).

a) In Macro-editing, the whole programme was edited in terms of the sequence, relevance of the elements in terms of the terminal behaviours and relevance of the criterion frames in terms of the terminal behaviours were the focus.

b) In Micro-editing the individual frames were the focus in terms of the technical faults, learning experiences, subsequence, and response control etc. As pointed by Markle (1966) copy frames, irrelevant responses asked for, - irrelevant frames, over-loaded

frames, over-prompting, inadequate strengthening of responses, poor choice of required responses, too easy frames etc., were the technical faults searched for while editing.

Student Testing

After editing the programme, the frames which were changed were written on new cards and the programme was ready for student testing in order to refine it according to the knowledge and needs of the learner. Student testing was done with utmost care because, 'Talking to one student at a time can be a great deal more valuable than compiling errors from large groups. If the student does not understand a particular item, he can often say exactly what words or phrase is giving him difficulty", (Markle, 1969).

A representative student, possessing the pre-requisite knowledge was selected. After having proper rapport and instructions, the student was given the index cards one by one and was asked to read the material carefully and respond accordingly. In the cards, the correct answers were not included for the purpose of student tryout.

During the tryout the programmer involved in the following observations and activities.

i) As soon as the student responded, he was asked how he could arrive at the response. His answer was recorded. If he was wrong, the frame was modified a bit and he was given another chance to respond. He was given a chance to talk, in order to detect any multikeyed items.

ii) The student's overt reactions and behaviour like too much re-reading, going to earlier frames, delay in response, irritation, hurried response, fatigue were noted down.

After the first tryout, the frames were revised accordingly and given individual tryout with four students--two average, one bright and one below average. Each student was given the programme in the same manner, and the criterion test was administered. Then the error rate on each frame was found.

The error rate was found to be about 10% and the students scored more than 70% on the criterion test. The programme was then cyclostyled for group tryout.

Branching Programme

Frame Writing

The present literature could not give any specific procedure about writing the branching programme. The programmer started with dividing the concepts into 'magnageable frames' keeping in mind the warning of Markle (1969) that "... at some point in this division process, you would approach the 'breaking point' where the meaningful chunk becomes fractioned into meaningless small steps". The guiding principle here was that only one idea was presented in a frame, of course, with explanatory sentences or logic of that idea. There were more than one sentence, interwoven into the concept. The sequence ended with a question based on the entire information

of the frame.

First, the prime path or main stream frames i.e. the path that a student answering all the frames correctly would take, were written. In the mainstream frames the information which was assumed to be known to the target population was omitted in order to make the frames as small and as simple as possible. The alternatives selected were such that the wrong choices could indicate the remedial material to be added. The prime path frames contained six parts as indicated by Markle (1969).

a) The answer the student chose in the last frame;

b) The feed back or discussion of why the answer was correct;

c) New information;

d) A question testing his comprehension of the new information;

e) Two or more alternative answers to select from; and

f) Page Number to tell him where to go next for each alternative.

Thus, the preliminary stages for constructing a branching programme were the same as for a linear programme, but frame-writing required a different set of techniques.

Writing the sequence

Sometimes less than 50 per cent of the total frames in a branching programme may be achieving low error rates because they proceed along the main stem of the programme without being routed to remedial frames.

Initially, therefore, the programmer wrote only the main sequence and multiple-choice answers and waited until field testing to decide which parts of the programme caused the greatest amount of difficulty and required remedial subsequences.

This approach has three main advantages, First, there is likely to be a greater continuity in a programme if the main sequence is written first. Secondly, incorrect multiple-choice answers must be plausible to the student. This is the most difficult part of the programme to write. During field testing, more plausible incorrect answers may come from the student themselves and can then be tested on the remainder of the group to see how they react. Finally, the reason why students choose a particular incorrect answer may come from the students themselves and can then be tested on the remainder of the group to see how they react. The reason why students choose a particular incorrect answer can be discussed with them during field testing and may lead to better handling of remedial sequences.

This method has the additional advantage of increasing the likelihood that the programmer will not waste his time

writing remedial subsequences which most learners will never use. The greater the number of subsequences, the more expensive and bulky, will be the programme.

Remedial or Wrong Answer Frames of Branching Programme

While preparing the remedial frames, it was assumed that the student had failed in a genuine attempt to understand the concept, and was entitled to further explanation.

Remedial frames were of the following characteristics -

i) While elaborating the concepts of thermometer new information which would not be seen by the student who would select the correct answer was avoided.

ii) Remedial information was provided for clarification and not meant for giving the correct answer.

iii) The reason why the answer was wrong was carefully explained in order to eliminate the misunderstanding.

For students - one above average, two average, and one - below average - were selected. The frames, written on the separate cards, were presented one by one to the student. The alternatives which were in the mind of the programmer were not given in the frames. The student was asked to read and respond to the frames. The investigator questioned the student to ~~prove as to~~ ascertain how and why he arrived at the answer. The reactions of the student were recorded.

When the response was incorrect, he was given another card containing the remedial instructions and then the prime path frame was repeated. In some cases, the investigator found the students still requiring some more additional information and clarifications. The verbal instructions or clues given were recorded carefully in order to include in later modifications of the remedial or original frames.

In short, the students participated in the entire process of writing, rewriting or modifying the frames, particularly the remedial frames.

After having four trials, the first draft of branching programme was finalised and individual tryout was carried out.

Editing of the Branching frames

The editing of the branching programme was different and the edit codes of linear programme were not applicable. The editing of branching programme was done keeping in mind that a single idea was developed in each frame and unrelated ideas or verbiage were dropped. The remarks made by Peter Pipe regarding the nature of the question at the end of the frame were followed in this editing process. According to Peter Pipe (1966) the question at the end of the information should -

a) require the student to demonstrate his understanding of the idea presented;

b) contain the alternatives which represent reasonable choice;

c) not test a possible misinterpretation;

d) not centre around some trivial point.

The revised first draft was written on paper, in which most of the pages were - divided into two parts A and B and the pages were scrambled within the concepts.

Group Tryout of Branching and Linear Programmes

The initial individual testing was not strictly auto-instructional because of the presence of the programmer to observe, interrogate or prompt the student. So, group testing was done, to provide better sampling, and to keep time records.

In group tryout the following aspects were of primary concern - student response sheet for the Error analysis, taken by each student to finish and criterion test across.

a) Administration of the programmes - Group Tryout

The representative sample of the VIII Std. students was given first the entering behaviour test and then was divided into two groups - one was given linear and the other branching programmes. Then the appropriate instructions were given to each group separately about the nature of work. While the students were through the programme, the programmer helped them whenever they needed it and made a note of any important point.

The starting and final times were noted and when they finished, the criterion test was administered;

b) Analysis of time taken to finish the programme -

The linear programme required 55 minutes to 105 minutes, while the branching programme required 40 minutes to 85 minutes. Of course, considering the time required to turn the pages of a branching programme, or to understand its format etc., it would mean that the branching programme required still less amount of time.

ii) Error rate Analysis

Error rate was considered as an index of the efficiency of linear programme. The accepted error rate, as considered by the investigator, was 10%. Frames with higher error rates were considered for slight modifications.

There were no clusters of errors either on a single frame or in the sequence and whatever errors were there, they were at random and could be attributed to chance.

So it was concluded that the programme, from the point of error analysis was quite satisfactory.

The effectiveness of branching programme was considered rather on the basis of criterion scores, because 'branching programme welcomes errors'.

iii) Criterion Test Analysis

Criterion test was considered as a tool to measure the attainability of the terminal objectives. The following

table shows the frequency distribution of scores, both on linear and branching.

Table No. 3.4

Table showing the Distribution of Scores on the Tryout N=20 for each form

Intervals	Linear	Branching
85 to 89	4	3
80 to 84	4	3
75 to 79	3	4
70 to 74	2	3
65 to 69	1	-
60 to 64	1	2
55 to 59	2	2
50 to 54	-	-
45 to 49	1	2
40 to 44	1	1
35 to 39	1	-

Revision and Final Draft

The last stage of the development of the programme learning material was to revise it on the basis of the validation testing through group tryout data.

The error analysis data rendered certain changes ~~is~~ in some of the frames. The item analysis of the criterion test suggested certain addition of the frames and for better instructions in the test.

Modifications made in the programmes

After error analysis and analysis of criterion scores, the following modifications were made:

i) The frames were made smaller. e.g. marking the U.F.P.

ii) Certain concepts were dropped. e.g. mathematical conversion of F scale into C scale and vice-versa.

iii) Sequences were altered. e.g. the parts of the thermometer were introduced along with a figure of it, before going to the construction of it.

iv) Response modes were changed. (e.g.) the original item was: "Below are given some words. Some of them are related to expansion, and others to contraction. Divide them properly into those two groups".

The modified one reads "Below are given some words related to expansion and contraction. Tick-mark (✓) only those related to contraction.

v) Method of presentation was altered.
e.g. in the tryout form, the maximum thermometer and the minimum thermometer were taught simultaneously. In the modified version they were taken separately.

vi) Illustrations were added. (e.g.) figures showing the working of the Six's thermometer.

vii) Format of questions changed. (e.g.) the original item reads "Group I consists of the parts and Group II consists of functions. Match them properly. The revised item reads "complete the following sentences by selecting the correct words given ~~from~~ in the list".

PREPARATION OF PROGRAMME FORMS

TABLE NO. 3.5

	Forms	Types/Nature of frames	Methods of preparation
A.	Linear Overt Form	Small frames of usual linear style; Terminal frame at the end of the sequence	Extensive tryout, revision and finalisation
B.	Linear Covert Form	Small frames of usual linear as in form A; but the directions given require covert responses	Form A is used with special directions demanding covert response
C.	Response Prompt Overt Form	Small frames, answers already filled; copying the correct response	Form A is taken and the blanks are filled with correct responses.
D.	Response Prompt Covert Form	Small frames filled with answers as in C; reading the frames.	Form A is taken and the blanks are filled with correct responses.
E.	Skip-programme Form	Terminal frames followed by linear frames of form A.	Terminal frame of form A is given at the beginning and then detailed linear frames of A follow; tryout carried out to tailor the sequence if necessary
F.	Branching Form	Main stream frames and remedial frames of usual branching style	Extensive tryout, revision and finalisation
G.	Hybrid Form	Main stream frames of Form F and remedial frames of linear style (Form A)	Main stream frames taken from Form F; linear frames taken from form A.

CLASSIFICATION OF VARIABLES

(a) Independent Variables

The experimental treatments are the forms of the programme on 'Thermometers'. They include -

A. Linear Overt Form

B. Linear Covert Form

C. Response-Prompt Overt Form (Copying)

D. Response-Prompt Covert Form (Reading)

E. Skip-programme Form

F. Branching Form

G. Hybrid Form (Branching-Linear Form)

(b) Intervening Variables

In an experimental study of this type many intervening variables can be considered, like the socio-economic status, grade level, intelligence level, scholastic achievement in science, pre-requisite knowledge about the lesson, etc.

In the present study, grade level was held constant by selecting the sample from the VIII Standard only. Socio-economic status could not be known precisely because the overseas students (mainly from Africa) and students from outside Baroda could not give family backgrounds accurately. As the students were randomly divided into seven treatment groups it was assumed that socio-economic status and age were randomized.

Also, there are studies indicating that the socio-economic status is not to that extent contributing to the achievement. The IEA study in which the comparisons among twelve countries were made, for example, indicates that the curriculum and methods of instruction may be a far more influential factor than socio-economic class. (Kulkarni, 1968).

The same trend is seen in a national survey of mathematics achievement in India for a representative sample of schools taken from all over the country. The investigators of this survey did not find any appreciable relationship between the composite score on the socio-economic scale and mathematics achievement (Kulkarni, Naidu, and Arya, 1969). In a later study by Kulkarni and Naidu (1970) also the results were quite consistent with the earlier tones of 'not much of correlation between socio-economic status and achievement score in mathematics'.

Finally, the investigator considered the following variables:

i) Intelligence

ii) Scholastic Achievement in Science

As intelligence ~~was~~ has been found to correlate significantly with scholastic achievement in Science (Shah, 1964), it was decided to just control the IQ by using the technique of analysis of covariance.

c) Dependent or Criterion Variables

The relative effectiveness of the different forms of the programme was assessed on the following criteria:

i) Immediate posttest score

ii) Percentage of retention

iii) Time taken to finish the programme.

TOOLS

The following tools were used in the present study;

a) Forms A, B, C, D, E, F and G of the programme on "Thermometers"

b) Entering Behaviour Test

c) Criterion Test

d) Shah's Non-Verbal Intelligence Test

SAMPLE

A programme on Thermometers (unit of IX Std.) was prepared and then seven forms were derived from the programme. The programme was given to the students of VIII Std. because it was found that in some schools it was already covered in IX Std. There are about ten English medium schools (Secondary) in the city of Baroda and out of these only nine have VIII Std. The investigator could manage in getting cooperation from eight out of the nine schools eligible for selection.

All the students of the above mentioned schools were included, though, at the end, there was a reduction in

the sample size due to wastage. The sample consisted of 322 students drawn from 11 classes of Std. VIII and there were 46 students in each treatment group.

Table No.326

Table showing the Final Sample used in the Statistical Analysis

Class	n in each treatment	Number of treatments	Total
Baroda H.S. A	4	7	28
Baroda H.S. B	5	7	35
Baroda H.S. C	5	7	35
Baroda ONGC	3	7	21
Convent of Jesus & Mary A	6	7	42
Convent of Jesus & Mary B	5	7	35
Jnan Deep	1	7	7
Rosary	6	7	42
Sanskar	1	7	7
Shreyas	5	7	35
Vidyakunj	5	7	35
Total	46	7	322 (N)

PROCEDURE

First Phase

The experiment was conducted separately in each class of the sample. The class was first randomly divided into seven groups in order to assign one treatment to each group. Care was taken that there were equal number of students in each group. The subjects were instructed to go according to their own speed and it was made clear that they need not race through the work because it was not meant to compare one individual with another. The time taken by each subject was noted in order to get the average time taken by each treatment group. Immediately after finishing the programme, the criterion test was administered, the score on which was taken as an index of effectiveness of the programme.

The oral instructions for the programme and for the criterion test for all the groups were given by the investigator himself. The programme administration included a rest pause in order to minimise fatigue.

Second Phase

The criterion test was readministered after a lapse of six weeks and the score of this was taken. The percentage of retention was calculated as the second index of effectiveness.

EXPERIMENTAL DESIGN

Random replication design was followed in the study. The students of each class were randomly allotted in equal numbers to each of the seven groups. In each class students worked simultaneously in one of the seven groups. The procedure was replicated in all the classes. Scores on immediate posttest and retention test were found for each student.

Statistical Analysis

This is an experimental study and it was felt that the groups might be initially unlike with regard to mean IQs. The investigator calculated the mean IQs of all the seven groups and found them to be obviously different. It was in the light of these obvious differences that it was decided to go for statistical control. ~~So it was decided to go for statistical control~~. So it was decided to analyze the data using the special technique of analysis of covariance called "Analysis of Covariance in Duplicate Experiments in Randomly Selected Schools" (Lindquist, 1970).

The statistical analysis using the analysis of covariance was carried out comparing the different treatments with respect to immediate test scores and retention scores. (Percentage of retention).

Analysis of covariance does not tell us which one treatment is different from the other. Therefore it was decided to carry out the Least Significant Difference (LSD) Test using a pooled error variance (MSW or within group variance) computed in the analysis of variance.

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