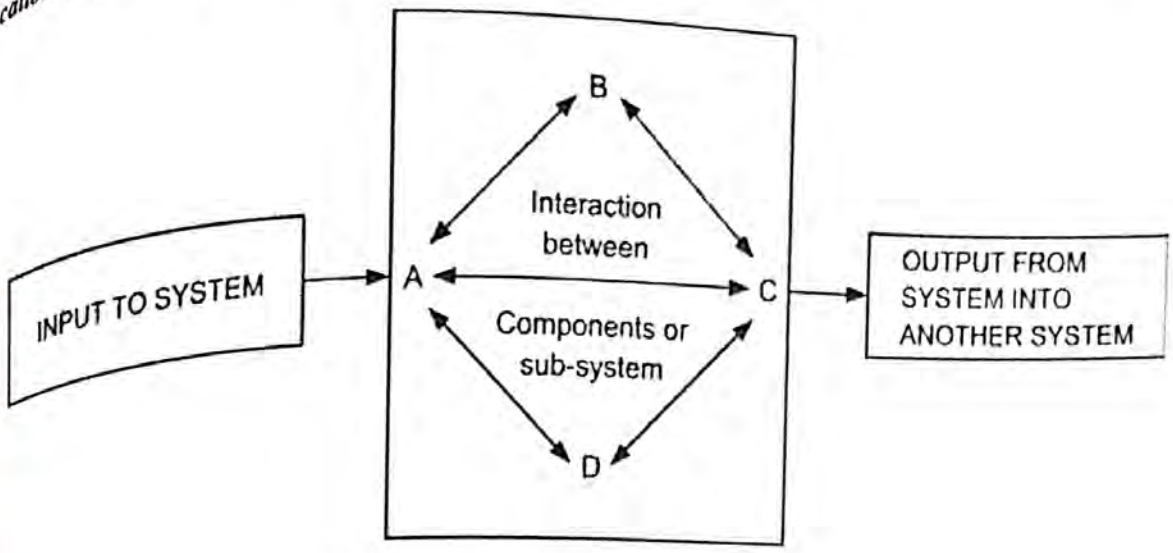


Fig. 15.1: A typical system.

Systems Approach in Education

Education is a dynamic system, its efficiency being determined by the inputs and the outputs. It is a dynamic organization of mutually related components organized in a meaningful pattern. Any change in one component may affect the overall performance of the system, either beneficially or adversely.

Systems approach, as applied to education, is a rational problem solving method of analysing the educational process taken as a whole, incorporating all of its parts and aspects, including the students and teachers, the curriculum content, the instructional materials, the instructional strategy, the physical environment and the evaluation of instructional objectives (Cyrs, I and Lowenthal, R A., *Model for a Systems Approach to Curriculum Design (1970).*

Vandana Mehra in an article in *University News* of June 24, 1991 gave the systems model of the process of education as given in Fig. 15.2. As is evident from the figure, input to an educational system consists of people, resources and information and the output consists of people whose performance has improved in some desired way The output is improved through increasing the efficiency of the educational process for enabling optimum assimilation of knowledge and skills to occur during the educational process and hence maximize the quality of the output.

Components of an instructional system are:

(i) Stating instructional objectives, which help a system designer to decide what to teach,

(ii) Pupils,

(iii) Teachers,

(iv) Content.

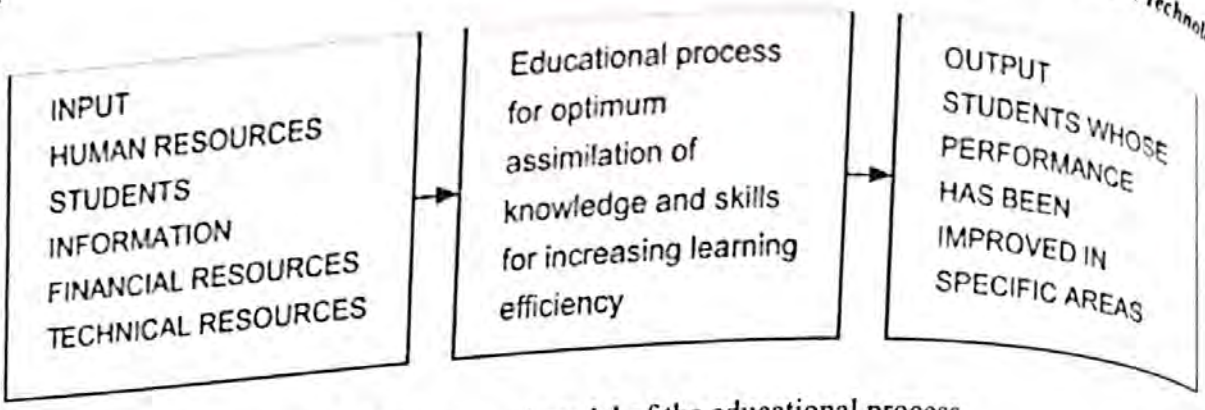


Fig. 15.2: The 'system' model of the educational process.

(v) Determining optimum learning conditions to attain instructional objectives, i.e., task analysis, keeping in mind the entry behaviour of learners,

(vi) Deciding upon the instructional strategy and media, and

(vii) Conducting evaluation (formative and summative), and feedback.

Figures 15.3, 15.4 and 15.5 explain the various aspects of instructional system.

Processes involved in systems approach. Following processes are involved in the Systems Approach:

1. Identifying objectives.
2. Designing learning experiences.
3. Evaluating effectiveness in achieving the objectives.
4. Improving learning experiences in the light of evaluation to achieve better attainment of objectives.

Steps in Systems Approach

I. *Identifying Objectives.* This step includes:

1. Determining the broad aims of the course.
2. Deciding what kind of people you are helping your students to become.
3. Finding out the range of backgrounds, interests, attitudes, aptitudes, skills and understandings of the students.
4. Deciding learning experiences that the learners should process.
5. Deciding about the test you will use as a criterion for evaluation when checking the extent to which objectives have been achieved.
6. Deciding about the various techniques you would use, i.e., paper-pencil test, interviews, observation, questionnaire etc.

II. *Designing Learning Experiences.* This includes:

1. Visualising conditions necessary to achieve these objectives.
2. Identifying learning sequences.

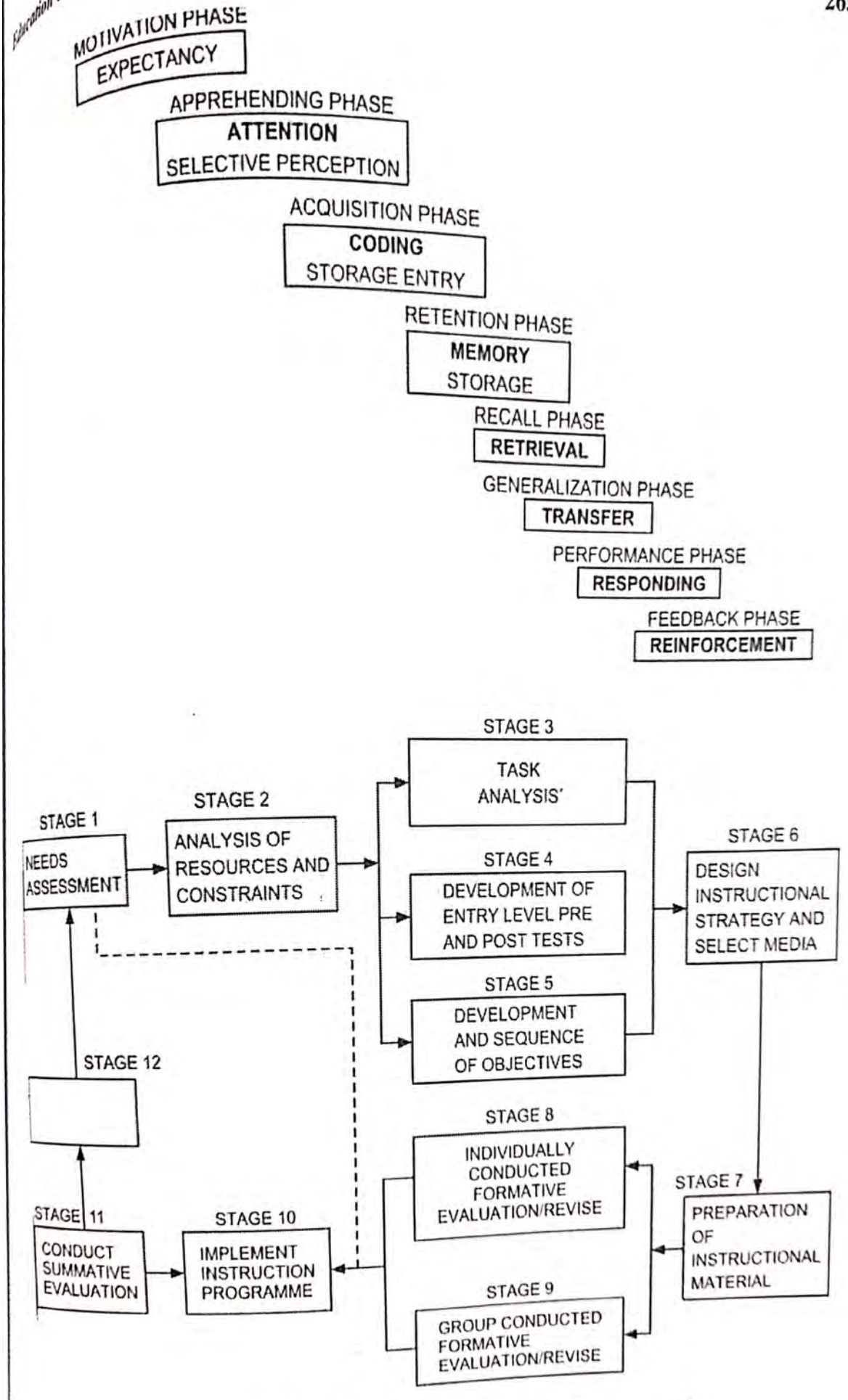


Fig. 15.3: Model of the instructional system

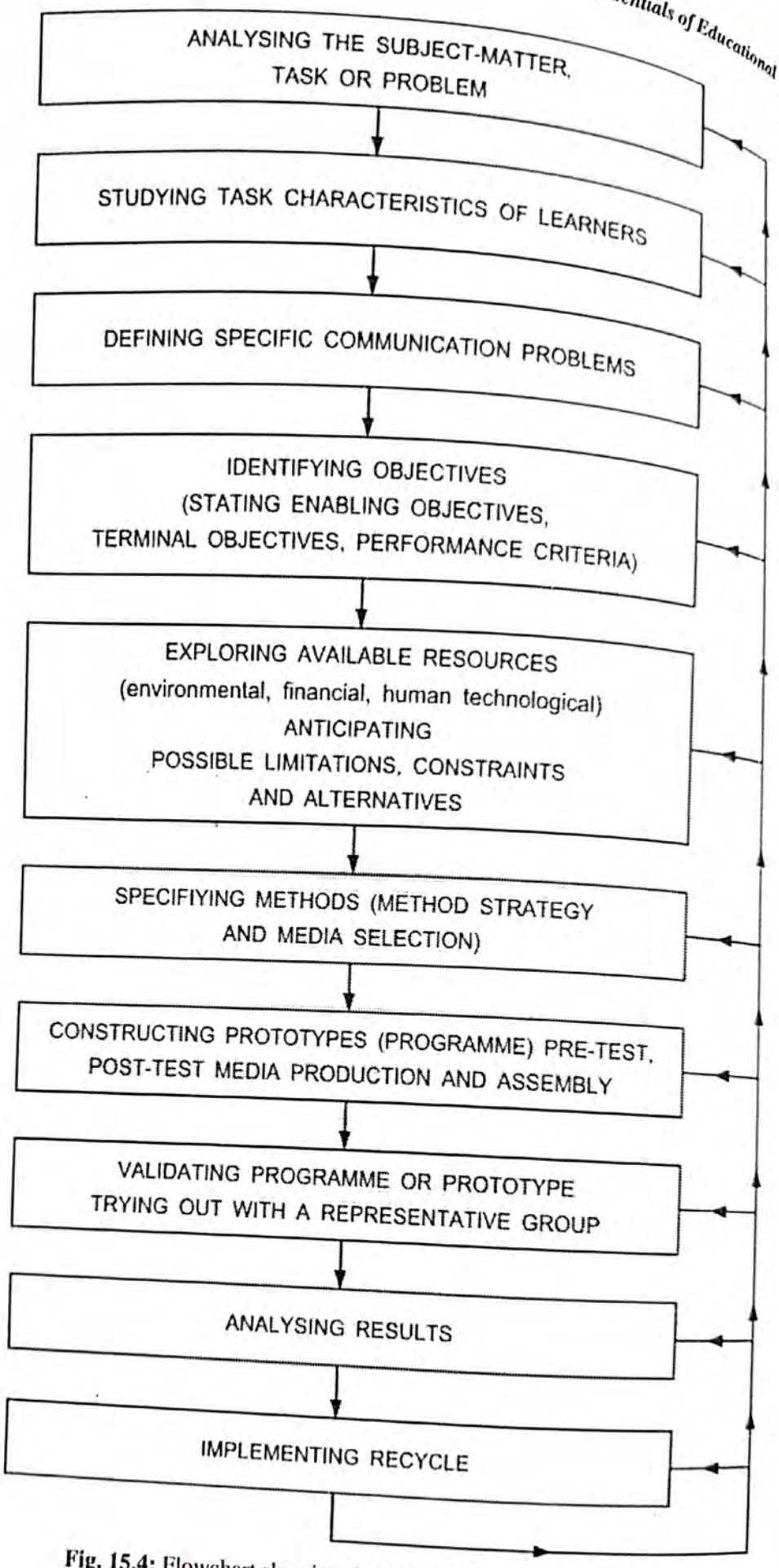


Fig. 15.4: Flowchart showing the detail of the path followed at macro-level—instructional level in designing a system.

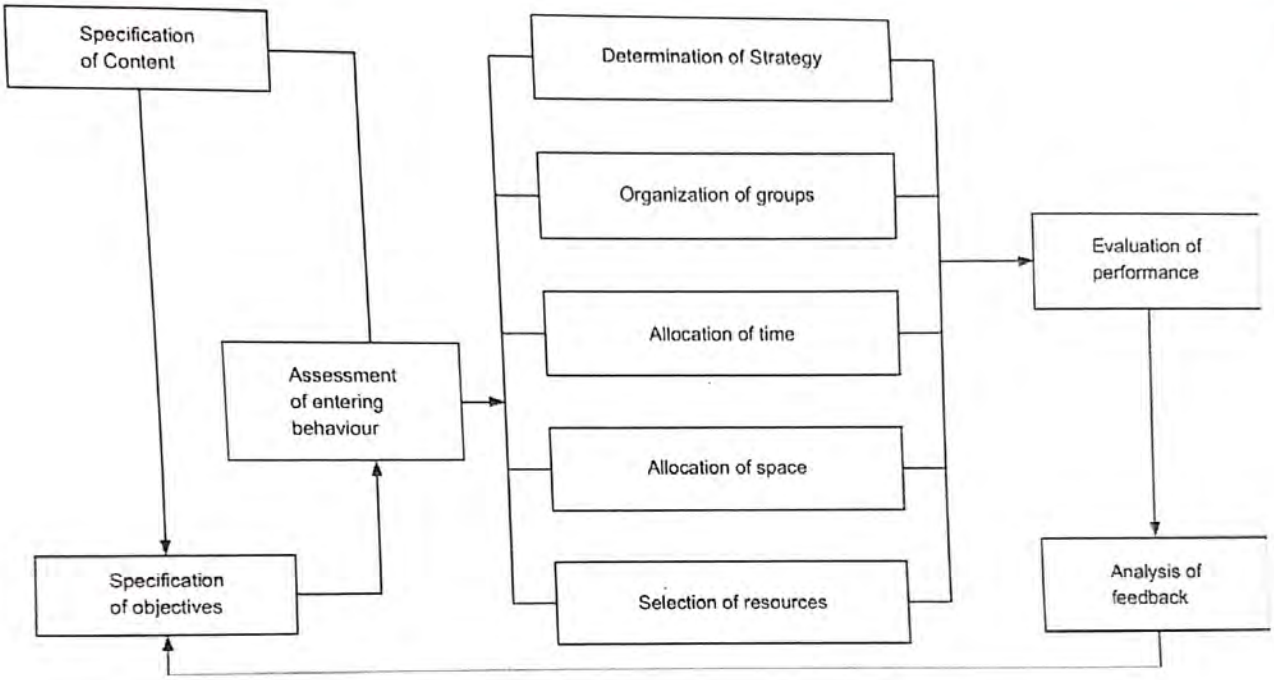


Fig 15.5: Systematic approach to instruction
(As developed by Vernon S. Gerlach and Donald P Ely in *Teaching and Media: A Systematic Approach*)

3. Deciding teaching strategy for reaching the goal.
4. Selection media of teaching-learning, i.e., lecturing, discussion, field trips, role play, textbook, models, programmed learning, multi-media, etc.
5. Preparing recordings of experiences including film-based or digital recordings.

III. ***Evaluating Effectiveness in Achieving the Objectives.*** This implies:

1. Engaging students in the learning experiences you have designed.
2. Applying criterion tests to determine how students have changed as a result.
3. Determining which objectives have been most widely attained, which remain unattained and by which set of students.
4. Determining whether any unplanned objectives have been attained.

IV. ***Improving Learning Experiences.*** This means:

1. Determining the strengths and weaknesses of the course.
2. Identifying remedial weaknesses.
3. Trying out the revised learning experiences and evaluating again.
4. Updating the course.
5. Restarting the course.

Advantages of Systems Approach

1. Systems approach provides a framework on which the plans for implementing changes in education can be built.
2. It assists in identifying the suitability or otherwise of the resource material to achieve the specific goal.
3. It helps in assessing the resource needs, their sources and facilities in relation to quantities, time and other factors.
4. It assists in making use of technological advance to provide integration of machines, media and people for attaining the defined goals.
5. It permits an orderly introduction of components required to be demonstrated for systems' success in terms of student learning.
6. It avoids rigidity in plan of action as continuous evaluation affords desired changes to be made.

Role of the Teacher in the Systems Approach

It is a fact that the best teachers have always adopted something resembling a systems approach. It has, therefore, been stated by Michael Eraut and Geoffrey Squires that a systems approach is a 'response different in degree rather than kind from the other good method'.

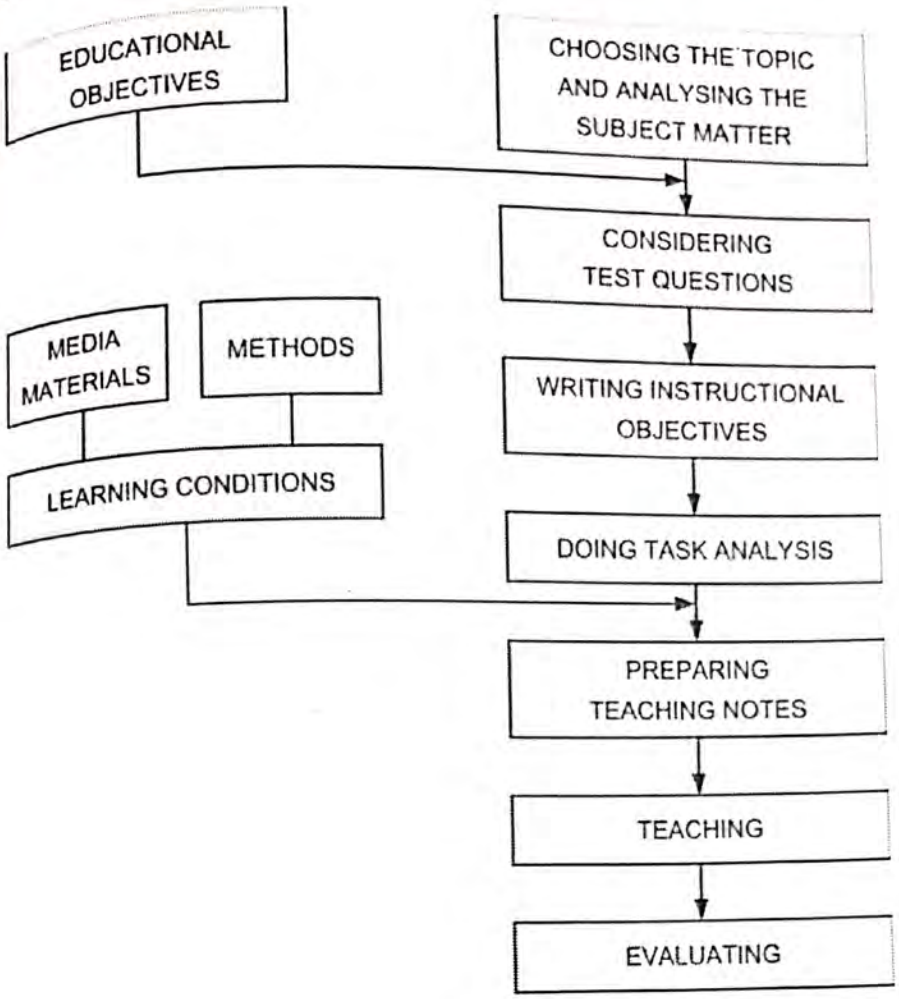


Fig. 15.6: Flowchart showing the detailed path followed by a teacher in an instructional system

A system oriented teacher does the following:

1. Thoroughly assesses the inputs of his system.
2. Gathers as much data as possible about his subject matter.
3. Thinks of alternative processes for achieving his objectives.
4. Analyses his objectives and splits them up into well-defined learning tasks.
5. Ensures discussions regarding processes and components based on the best means of furthering the purposes.
6. Activates the system by putting the plan into action.
7. Gathers feedback data resolutely and systematically.
8. Modifies the system's components and processes based on the feedback.
9. Assesses the effectiveness of the system by comparing the outputs with the inputs.
10. Modifies the system based on feedback from all resources.

Task Analysis

Meaning of task analysis. Task analysis here involves a careful examination of the tasks and/or objectives in an effort to determine such things as how the subject of the task analysis will be taught, to whom and when. The task analysis breaks down the task into its constituent parts, which involves detailed listing of component behavioural elements of a job or task. Analysis of a task is indeed an inventory in which knowledge, skills and attitudes are defined and isolated with a view to ultimately synthesizing them into a hierarchical organization relevant to the writing of the learning prescription.

As the name implies, task analysis is a way of describing how a task is performed. First of all, the skill to be imbibed at the end of the unit of instruction is described, and then analyzed into a repertoire of behaviour structures that must be sequentially built up to arrive at the terminal performance. The task analysis specifies the conditions of learning. Thus, task analysis takes the 'macro' performance and breaks it down into 'micro' behavioural components which are the building blocks of instruction.

Objectives and purposes of task analysis. According to Alexander Yelon, "A major objective of the task analysis is the isolation and identification of the different elements in the task to be learnt so that the designer can decide what types of learning are involved and how to go about teaching the various concepts, principles and perceptual motor skills embedded in a task."

Task analysis enables us to bring principles derived from learning theory to bear on the sequencing of instruction. Gagne has observed, "In this task analysis we identify classes of behaviour which differ in respect of the conditions necessary for learning." The task analysis assists the teacher to determine the specific task the student has failed to perform. It can also be said that the task analysis describes the task which the student has to perform, i.e., the learning goal. Task analysis also isolates the required behaviour and identifies the conditions under which the behaviour occurs.

In task analysis, the knowledge to be taught must be systematically organized so that salient points are identified and critical bias and pieces of information are not omitted.

Types of Task Analysis

Task analysis takes a variety of forms depending on the nature of the task, the level and aspiration of the learner, the objective of teaching and several other factors. Broadly speaking, there are three types of task analysis:

1. Information-Processing Analysis.
2. Task Classification.
3. Learning Task Analysis.

The information-processing analysis and task classification maybe carried out in any order or simultaneously. Learning task analysis depends upon information yielded either by information-processing analysis or information-processing analysis and task classification together.

According to Gagne, from these analyses, one may expect to discover and delineate:

(1) The competent 'steps' involved in the performances which have been identified as target objectives.

(2) The kind of learning represented by the target objectives, which will indicate required conditions for learning.

(3) The pre-requisites of the target objectives which, since they must be previously learned, imply a sequence of institution.

Action Tasks. Every description of action tasks includes the following four different aspects of the task:

1. The different actions being taken to reach a goal.
2. Each action is preceded by cues that help to decide the action which is to be taken.
3. Each action is followed by a feedback.
4. Every description of action task contains information about the person or object acted upon.

Techniques of Task Analysis

The three most important and frequently used techniques are:

1. Interviews: individual and group.
2. Direct observation.
3. Technical manuals.

Constraints and special conditions in task analysis. Following are the three kinds of special conditions that should be considered:

1. The environmental conditions.
2. The operative conditions.
3. Social conditions.

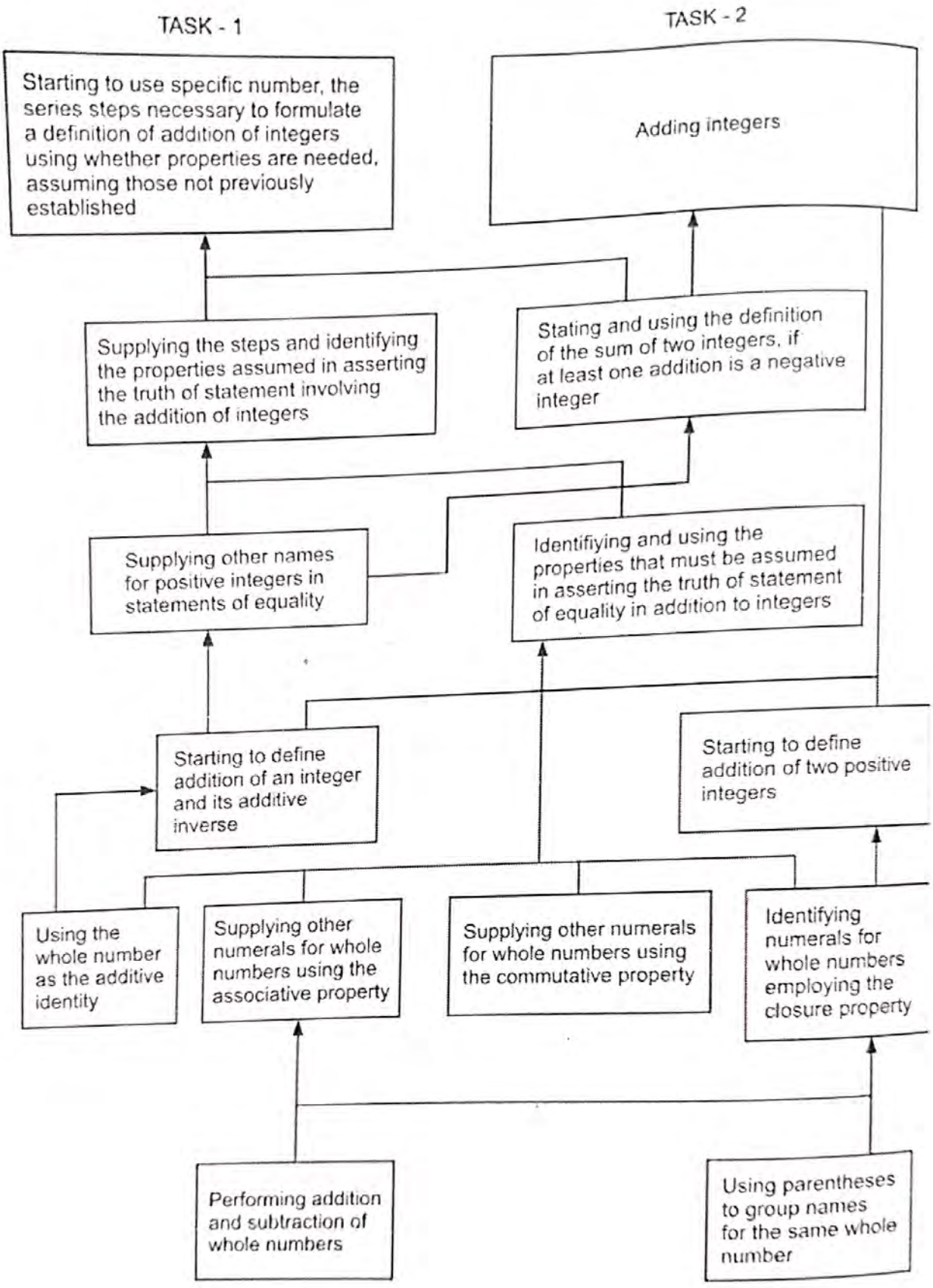


Fig. 31.1: Task analysis of two objectives in mathematics.

(Source: R M Gagne Learning and Proficiency in Mathematics, Mathematics teacher, 1963)

Role of the Teacher in Task Analysis

1. He should administer diagnostic pre-task before beginning instruction. This enables the teacher to understand the position of the learner.
2. The teacher should meet the individual differences of the learners.
3. The teacher must give clues to the learner which he needs.
4. The teacher should provide maximum guidance to the learner.
5. The most sophisticated teaching–learning is problem solving.

Example of task analysis. The two desired objectives, as shown in Fig. 31.1, have been broken into subordinate behaviours. Each element is thought to support the learning of each succeeding topic in the hierarchy as indicated by arrows.

Programmed Learning or Instruction

CHAPTER OUTLINE

- Introduction
- What is Programmed Learning?
- Characteristics
- Fundamental Principles
- Styles of Programming
- Development of the Programmed Instructional Material
- Advantages and Applications of Programmed Learning
- Self-Learning Programmed Module
- Summary
- Review Questions
- References and Suggested Readings

Introduction

Programmed learning or programmed instruction represents one of the effective innovations in the teaching-learning process. As a highly individualized and systematic instructional strategy, it has been found quite useful for classroom instruction as well as self-learning or auto-instruction. In our country, also there have been attempts for the use of programmed instructions especially in providing material to the students of correspondence courses. Suitable self-instructional programmed materials for different subjects and grades have been prepared and it is being used for instructional or self-instructional purposes. Programmed learning occupies a unique place in the teaching and learning of the all the school subjects especially those requiring logical and systematic study coupled with independent practice and drillwork.

Let us now have the desired knowledge and understanding of the skill of programmed learning.

What is Programmed Learning?

Generally, the learning performed or instruction provided by a teaching machine or programmed textbook is referred to as programmed learning or instruction. Let us seek some help from the definitions put forward by various scholars regarding the meaning of the term programmed learning.

- **Smith and Moore (1962):** Programmed instruction is the process of arranging the material to be learned into a series of sequential steps, usually it moves the students from a familiar background into a complex and new set of concepts, principles and understanding.

Jacobs and others (1966): Self-instructional programmes are educational materials from which the students learn. These programmes can be used with many types of students and subject matter, either by themselves, hence the name "self-instruction" or in combination with other instructional techniques.

- **Espich and Williams (1967):** Programmed instruction is a planned sequence of experiences, leading to proficiency in terms of stimulus responses relationship, that have proven to be effective.

Leith (1966): Programme is a sequence of small steps of instructional material (called frames), most of which require a response to be made by completing a blank space in a sentence. To ensure that expected responses are given, a system of cueing is applied, and each response is verified by the provision of immediate knowledge of result. Such a sequence is intended to be worked at the learners' own pace as individualized self-instruction.

Susan Markle (1969): It is a method of designing a reproducible sequence of instrumental events to produce a measurable and consistent effect on the behaviour of each and every acceptable student.

- **Gulati and Gulati (1976):** Programmed learning, as popularly understood, is a method of giving individualized instruction, in which the student is active and proceeds at his own pace and is provided with immediate knowledge of results. The teacher is not physically present. The programmer, while developing programmed material, has to follow the laws of behaviour and validate his strategy in terms of student learning.

N.S. Mavi (1984): Programmed instruction is a technique of converting the live instrumental process into self-learning or auto-instructional readable material in the form of micro-sequences (the segments of subject matter) which the learners are required to read, make some right or wrong response, correct wrong responses or confirm the right response and attain complete mastery of the concepts explained in the micro-sequences.

In conclusion, the above definitions may reveal the things given ahead regarding the meaning, nature and characteristics of programmed learning.

Characteristics

1. Programmed learning is a method or technique of giving or receiving individualized instruction from a variety of sources such as programmed textbook, teaching machine, and computers with or without the help of a teacher.
2. In this technique, the instructional material is logically sequenced and broken into suitable small steps or segments of the subject matter, called frames.
3. For sequencing a particular unit of the instructional material, the programmer has to pay consideration for the initial or entry behaviour of the learner with which it begins and the terminal behaviour or the competence which the student is required to achieve.
4. In actual operation, a frame (a small but meaningful segment of subject matter) is presented to the learner. The learner is required to read or listen and then respond actively.
5. This learning system has an adequate provision for immediate feedback that is based on the theory of reinforcement. For instance, while responding to the first frame of the programmed material, the learner is informed about the correctness of his response. If he is correct, his responses are reinforced and if he is wrong, he may correct himself by receiving the correct answer.
6. It is the interaction between the learner and the learning material or programme that is emphasized in the programmed learning. Here the student is actively motivated to learn and respond.
7. It provides self-pacing; thus learning may occur at individual rate rather than general, depending upon the nature of the learner, learning material and the learning situations.
8. It calls for the overt responses of the learner that can readily be observed, measured and effectively controlled.
9. It has the provision for continuous evaluation that may help in improving the student's performance and the quality of programmed material.

On the basis of these features, we may define programmed learning in the following way:

Programmed learning is a systematically planned, empirically established and effectively controlled self-instructional technique for providing individualized instruction to the learner through logically sequenced small segments of the subject matter by using the principles of operant conditioning and schedules of reinforcement.

Fundamental Principles

The studies and researches in the field of programmed learning have led to the establishment of some fundamental principles associated with a good programmed learning strategy. These are summarized below:

1. ***Principle of small steps:*** This principle is based on the basic assumption that a person learns better if the content matter is presented to him in suitable small steps. Therefore, a

programmer while preparing a programme should try to arrange the subject matter into a properly sequenced and meaningful segment of information, called frames. These segments should be presented one at a time before the learner for responding.

2. ***Principle of active responding:*** This principle rests on the assumption that a learner learns better by being active. In programmed learning, the learner may remain active if he responds actively to every frame presented to him. Therefore, a good programme should actively involve the learner in the learning process. It should be so formed that the learner may not feel much difficulty in moving from one frame to another and to remain meaningfully, busy and active by responding to the frames thus, acquiring the knowledge step-by-step.

3. ***Principle of immediate reinforcement:*** The psychological phenomenon of reinforcement is the basis of this principle. One person learns better when he is motivated to learn by receiving information of the result just immediately after responding. Therefore, in a good programme, appropriate consideration is always made for the provision of immediate reinforcement by informing him about the correctness of his response.

4. ***Principle of self-pacing:*** Programmed learning is a technique of individualized instruction. It is based on the basic assumption that learning can take place better if an individual is allowed to learn at his own pace. So, a good programme should always take care of the principle of self-pacing. The programming of the material should be done in view of the principle of individual difference and the learner should be able to respond and move from one frame to another according to his own speed of learning.

5. ***Principle of student-testing:*** For better learning, it is always good to seek continuous evaluation of the learning process. The principle of student testing meets this requirement. In the programmed learning, the learner has to leave the record of his response because he is required to write a response for each frame on a response sheet. This detailed record helps in revising the programme. It may also prove a good source for studying and improving the complex phenomenon of human learning.

Styles of Programming

In programmed learning, the presentation of instructional material or subject matter to the learner in a suitable form is termed as programming. Various types of programming have emerged on account of researchers and experimental studies in the field of programmed instruction. The following list gives some of the mentionable ones:

1. Linear or extrinsic programming
2. Branching or intrinsic programming
3. Mathetics programming
4. Ruleg system of programming
5. Computer-assisted instruction
6. Learner controlled instruction.

1. Linear Programming

B F Skinner is the originator of linear programming. It is also called a single track programme. According to Skinner, a creature, a bird or a human being can be led to a desired behaviour by means of a carefully constructed programme consisting of small steps leading logically through the subject matter from topic to topic, provided each step is reinforced by some kind of favourable experience or reward. The increments in information which the learner is expected to absorb are small. The favourable experience or response increases the probability of the same response occurring again in the future. The process of rewarding the correct response to a stimulus increases the general tendency to give a response.

The process may be graphically illustrated as in Fig. 9.2.

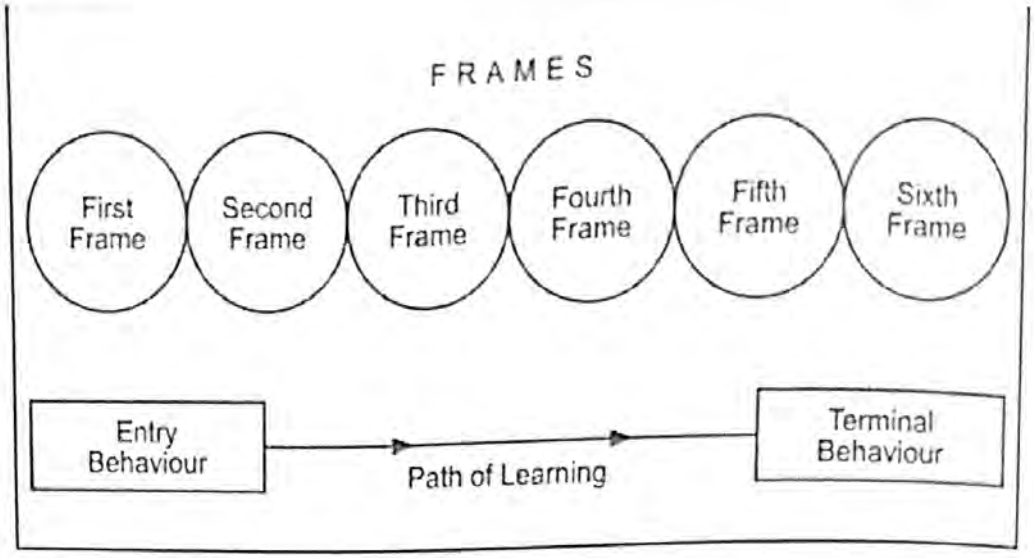


Fig. 9.2: Arrangement of frames in linear programming.

As shown in the figure, the sequence of frames and path of learning in the programmed learning is systematic and linear. That is why this type of programming is referred to as linear programming. Hence all the learners have to proceed through the same frames and in the same order.

In a linear programme, a learner's responses are controlled externally by the programmer sitting at a distant place. Hence linear programming is also termed as extrinsic programming. In branching programming, the learner's response is controlled internally by the learner himself, which is why it is called intrinsic programming.

Principles of Linear Programming

(i) Principle of small steps.

(ii) Principle of active responding.

(iii) Principle of minimum errors.

(iv) Principle of knowledge of results.

Chief Characteristics of Linear Programming

(i) A linear programme is a single track or a straight line programme.

(ii) In this programme, learning material is presented in a series of small steps (frames).

(iii) Every learner follows the same path in a linear programme.

(iv) In linear programming, the content is broken up into small units that may range from a one-word passage to one of as many as 40 or 50 words in length.

(v) In a linear programme, the learner is given a small programme with a small amount of information.

(vi) The sequence of steps remains unchanged.

(vii) The learner is expected to compose his own answer to each question.

(viii) The learner is expected to respond actively to each step or frame.

(ix) The responses of the learner get immediate reinforcement.

(x) Linear Programming provides for self pacing, i.e., one can learn according to one's own speed.

(xi) Linear programming moves slowly but steadily in leading a learner from initial to terminal behaviour.

(xii) Each of the units constitutes a frame.

(xiii) In a linear programme, the programmer controls the response of the learner.

(xiv) In a linear programme, the learner learns by avoiding errors.

Merits of Linear Programming

(i) Immediate knowledge of results acts as a great motivator and releases anxiety and tension.

(ii) The smallness of the frames brings the sub-goals within the reach of the learner and thereby facilitates secondary reinforcement.

(iii) Repetition strengthens the responses and ensures learning.

(iv) Easy nature of the programme provides 'success experience' to the learner.

Limitations of Linear Programming

(i) In linear programming, the learning process becomes somewhat dull on account of the following reasons (a) Subject matter is broken into very small pieces, (b) Responding is quite mechanical and restrictive, and (c) The learning process is quite slow.

(ii) The use of linear programmer is limited to some subjects and topics.

(iii) Linear programming cramps the imagination of the learner and initiative for creative, integrative and judgement learning.

(iv) Linear programming encourages guessing.

(v) Linear programming does not develop the discriminating power of the students.

2. Branching, or Intrinsic, Programming

Branching or Intrinsic Programming was developed by Norman A Crowder (1954), an American technician. According to Crowder, branching or intrinsic programme is one which adapts to the needs of the learners without the medium of any extrinsic device such as a computer. It is not controlled extrinsically by the programmer.

Norman A Crowder was a technician working in the United States Air Force. He was faced with the problem of efficiency of vocational training. His programme is based on

intuition. His approach at the most is practical. This type of programme employs multiple choice response patterns. The learner is required to select one right answer out of several responses presented to him.

Characteristics of a Branching Programme

(i) A frame may contain two or three related ideas or related sequences.

(ii) Each frame is of relatively bigger size as compared with the linear type.

(iii) With a view to answering the question, the learner has to arrive at an answer by setting the relationship between one idea and the other and by filling up the gaps not fully covered in the frame. Only then can he select the correct alternative from the multiple choices given.

(iv) The learner moves forward if his responses are correct but is diverted or branched to one or more remedial frames if he does not give the correct response.

(v) Frames explain the matter afresh when response is not correct. The frames ask the learner questions to elicit the right answer and reveal his previous mistakes. The learner then returns to the original frame.

(vi) The cycle goes on till the learner passes through the whole instructional material at his own pace.

(vii) Branching programme contains multiple choices of items where the learner selects a response, whereas in linear programmes or Skinnerian style the responses are constructed rather than selected.

(viii) In a branching programme, all learners do not follow the frame route. Rather, the route depends on the response made by the learner. Thus, learners branch according to their responses.

Assumptions of Branching

(i) Learning takes place better if the subject matter is presented in its totality.

(ii) Learning takes place better if the subject matter is presented in the form of meaningful components or units.

(iii) Wrong answers do not necessarily hinder the learning of a correct answer.

(iv) Multiple choice items help more in the learning process.

(v) It is based on the possibility of detecting and correcting errors.

(vi) Basic learning takes place during the learner's exposure to the new material.

(vii) Learning takes place better if the learner is allowed sufficient freedom to take decisions for adopting the instruction to his needs.

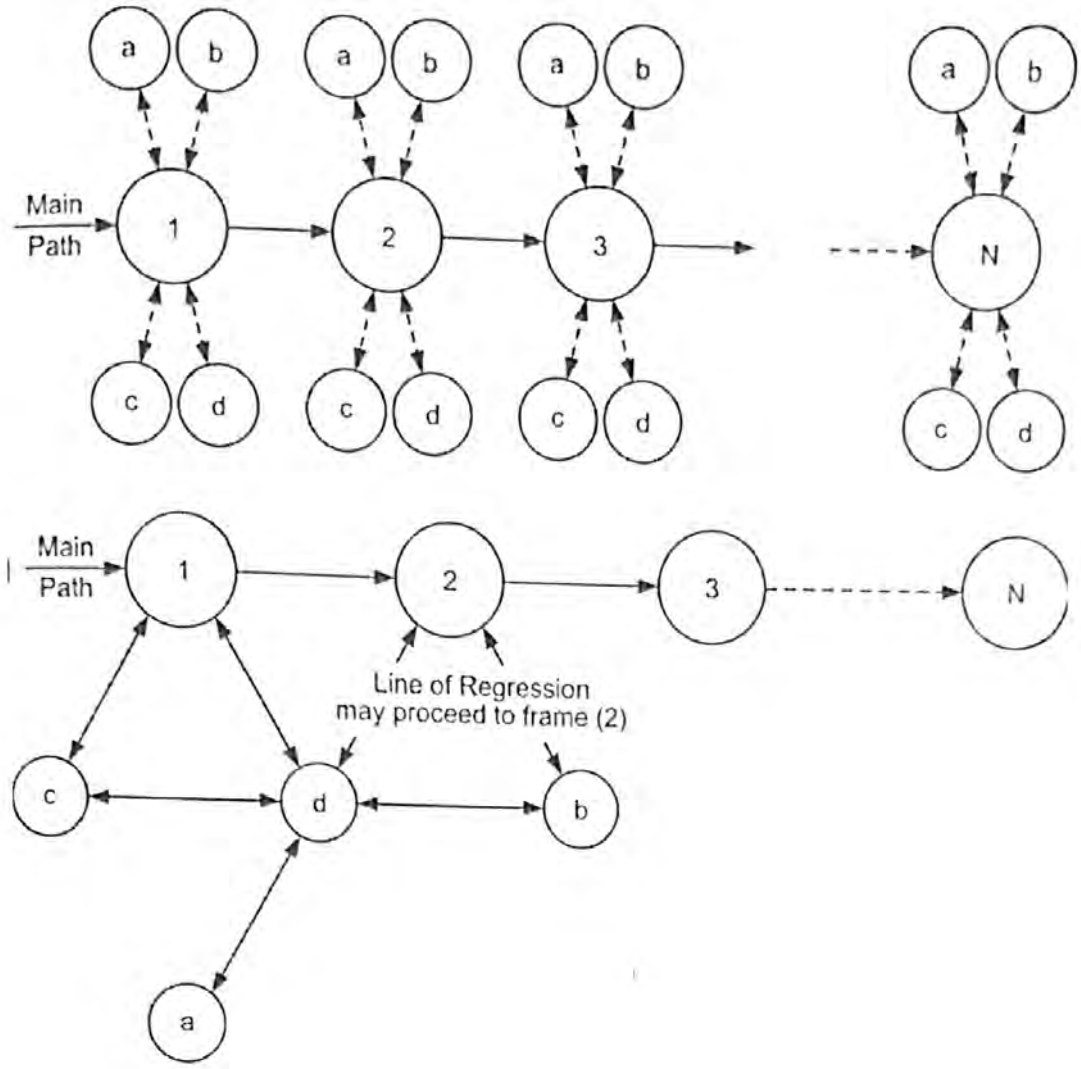


Fig. 9.3 : Main path and branching in branching programme.

Merits and Advantages of a Branching Programme

(i) Big size of a frame as well as the branching minimizes unnecessary repetitions and responding, thus reducing the amount of learning time and fatigue.

(ii) The pitfalls and consequences of erroneous logic are usually explained in the remedial frames so that the learner not only gets the correct response but also understands why some other response is not correct.

(iii) Instead of simple response, it provides alternatives in the form of multiple choices.

(iv) Through its broad frames, branching programme provides for more freedom to respond and scope of choosing one's own path of learning according to one's need. Thus it helps in maintaining the interest and initiative of the learner.

(v) Branching programme is helpful in the development of the power of discrimination of the learner.

(vi) Branching programme helps in the development of creativity and problem-solving ability.

(vii) Branching is most useful in the areas beyond facts, definitions and basic skills.

(viii) The frames, being of larger size, contain a good deal of information and this may enable the programmer to enrich his style and expand his ideas.

(ix) The programmed material in branching programme may be employed in the form of programmed text or teaching machines. The material when presented in book form takes the form of a 'scrambled book.'

Limitations and Drawbacks of Branching Programming

(i) The multiple choice questions provided in this programming may lead to guesswork on the part of the learner and he may not understand the subject matter of the frame.

(ii) The setting of appropriate multiple choice questions suiting the entire material of the frames proves a difficult task.

(iii) No branching method can provide infinite branching to take care of all possible needs of every individual student.

(iv) The cost of branching programme is very high when compared with traditional teaching approaches.

(v) The branching programme is not suitable for small children as they are unable to decipher the symbolism.

(vi) The programme needs revision every two years.

(vii) It is difficult to cover the entire subject matter.

(viii) The diagnostic questions framed by the programmer may or may not suit the needs of the individual learner.

(ix) The programme cannot shape the behaviour of the learner.

Programmed Instruction: An Important Innovation

Programmed instruction or programmed learning is one of the important innovations in the teaching-learning process. Programmed instruction is a carefully specified, systematically planned, empirically established, skilfully arranged and effectively controlled self-instructional technique for providing individualized instruction or learning experiences to the learner. The subject matter or learning experience is logically sequenced into small segments. The learning experience is self-corrective. It is an application of the principles of behavioural sciences and technology in the field of education.

The English authors prefer to use the term 'programmed learning'. On the other hand, American writers prefer 'programmed instruction'.

Brief History of Programmed Learning origin of Prog. Learning

It is held by some educators that the 'Gita' is the first example of programmed learning. It is also maintained by them that the text of the 'Gita' has several ingredients of programming: initial behaviour, small steps, active participation, terminal behaviour, immediate feedback and self-evaluation by the learner.

Several educators regard Socrates as one of the earliest programmers, claiming he developed a programme in geometry. This was recorded by Plato in the dialogue MENU. Socrates used to guide his followers to knowledge by conducting them conversationally along a path from fact to fact and insight to insight.

Programmed Learning as 'Technological Revolution' in Education

Programmed learning emerged in the beginning of the 20th century from the efforts of American psychologists. E L Thorndike (1874–1949) was the first psychologist whose findings bear direct relevance to programming. Other important psychologists who have made significant contributions in the field are Sidney L Pressey, Robert M Gagne, Robert Mager and B F Skinner.

Programmed learning is related with the 'Law of Effect' as explained by Thorndike.

Sidney L Pressey, a psychologist of Ohio State University, is credited with developing, in the middle 1920s, practical machines which could teach as well as test. The teaching machines as developed by Pressey present a series of questions to a student and inform him immediately whether his response is right or wrong.

In 1943, Skinner and his two other colleagues started programming by teaching a pigeon to roll a small bowling ball by operant conditioning.

By 1954, Skinner and James G Holland devised the auto-instructional methods which have served the present generation as the basis for present work in programmed instruction. In Skinnerian programmed instruction, whether mechanized or otherwise, the learner is initially asked questions which he can easily answer correctly without any previous study of the particular lesson. The learner is taught by the sequence of questions. He is asked more and more as the lesson proceeds in very small steps.

In 1955, Norman A Crowder developed what he called "automatic tutoring by intrinsic programming" as against "extrinsic programming" developed by Skinner.

Robert Mager (1958) gave a new concept known as "Learner Controlled Instruction", which is a kind of Socratic dialogue in reverse, in which the learner led the instructor. The instructor remained silent until the learner himself stimulated the instructor with questions that suggested the needed illustrations, demonstrations, practice or some other help.

Stoluron, at Illinois, had worked on a process which aimed to provide for greater individualization by measuring needs and developing programmes that require a computer to assist instruction.

In 1962, T F Gilbert gave formalized expression of his technology of education called Mathetics. In 1962, Pennington and Slack expressed further detailed methods of preparing lessons from mathetic principles.

In 1965, E L Rothkopf suggested a term "mathemagenics." Mathemagenic behaviour involves three characteristic activities: (1) The transformation of a nominal stimulus into an effective stimulus (which is to take place within the organism); (2) Some form of elaboration (which, for instance, may take the form of echoic responses); (3) Process exemplified by problem solving and inductive reasoning. These activities must take place before any learning can occur. Rothkopf pointed out that as the learner reads a text, he experiments with and internalizes various kinds of mathemagenic behaviours. The test had questions that a learner encountered, sorted out and extinguished those behaviours which were not effective.

Also in 1965, Lawrence Stolurow (1918–2009) gave the idea of Computer Assisted Instruction (CAI).

Taxonomy of Instructional Objectives

Taxonomy means a classification of an object or an idea. Thus taxonomy of instructional objectives implies classification of instructional objectives. It means an analysis of instructional objectives in terms of the specific and precise teaching outcome or learning appropriate to classroom action.

Taxonomy of objectives has been worked out on the assumption that the teaching–learning process may be conceived as an attempt to change the behaviour of the learners with respect to some learning experience involved in a subject or activity. Behaviour is divided into three domains—cognitive (knowing), affective (feeling) and psychomotor (doing).

Taxonomy of instructional objectives is useful as under:

1. Tools of evaluation can become very objective.
2. It can be helpful in translating into practice the principle of comprehensiveness of evaluation by ensuring proper coverage of various aspects of pupils' growth: cognitive, affective and psychomotor.
3. The evaluation of the evaluation devices in terms of their validity may be facilitated.
4. The evaluation may prove helpful in arriving at a meaningful synthesis of various dimensions of pupils' growth.
5. Identification of areas of inter-relationship among the three domains may be of particular significance in this regard.
6. The logical nature of classification helps in identifying and grading teaching–learning situations which can also be an important source of selecting an appropriate testing situation.
7. Curriculum development and preparation of instructional material can profit from such a scheme of classification in several ways.
8. Preparation and analysis of textbooks based on well defined objectives may prove to be a solid improvement.
9. Classification through its well defined criteria can provide a bridge for further communication among teachers, between teachers and evaluators, curriculum and research workers, psychologists and other behavioural scientists.
10. The taxonomy has also opened up new avenues for research in education.

(A) Bloom's Taxonomy of Educational Objectives

Several attempts have been made by scholars in preparing taxonomy of educational objectives. Prof. Benjamin S Bloom of University of Chicago (USA) is considered to be a pioneer in this field. Bloom was the editor of the first volume of *Taxonomy of Educational Objectives* (1956) produced by an American Committee of College and University Examiners. Bloom presented his taxonomy related to cognitive domain (1956), Krathwohle related to affective domain (1964) and Harrow related to psychomotor domain (1972). See Fig. 6.2.

The hierarchy of taxonomy can be depicted in the following manner:

HIERARCHY

Knowledge (K)	→	Comprehension (C)	→	Application (A)
Analysis (AN)	→	Synthesis (S)	→	Evaluation (E)

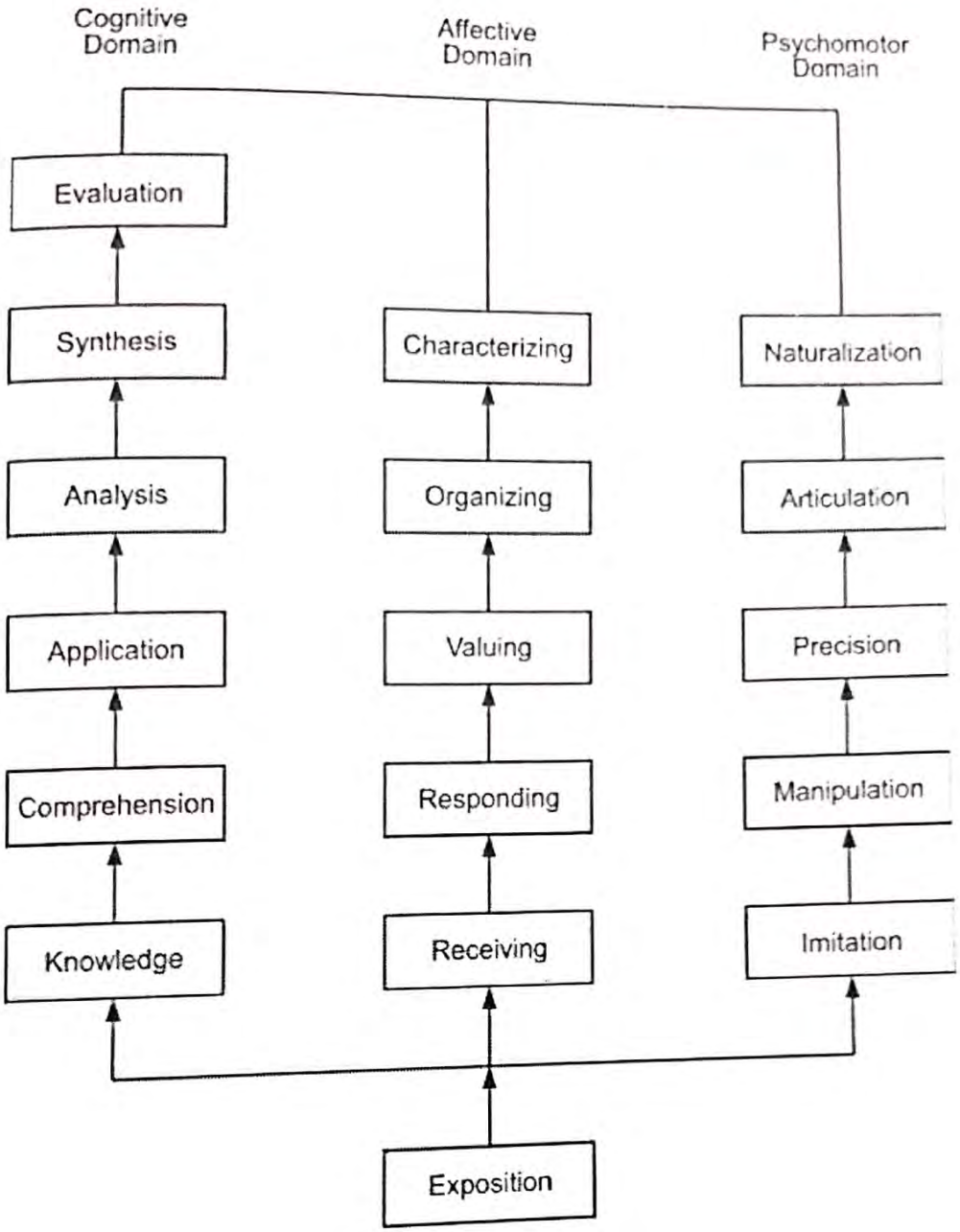


Fig. 6.2: CAP (Cognitive, Affective, Psychomotor) classification of educational objectives.

Taxonomy of Educational Objectives in the Cognitive Domain (Bloom)

1. Knowledge Objective

Knowledge is defined as recall of specifics and universals, recall of methods and processes or the recall of a pattern, structure or setting. This objective stresses the psychological process of remembering.

(a) Knowledge of specifics includes:

(i) Knowledge of terminology,

(ii) Knowledge of specific facts.

(b) Knowledge of ways and means of dealing with specifics includes:

(i) Knowledge of conventions,

(ii) Knowledge of trends and sequence,

(iii) Knowledge of classifications and categories,

(iv) Knowledge of criteria,

(v) Knowledge of methodology.

(c) Knowledge of the universals and abstractions in a field

(i) Knowledge of principles and generalizations,

(ii) Knowledge of theories and structures.

2. Comprehension

(a) Translation,

(b) Interpretation,

(c) Extrapolation.

3. Application

It involves the application of a concept to new or unfamiliar situations.

4. Analysis

It implies the breaking down of a communication into its constituent elements or parts so that relative hierarchy of ideas is made clear.

(a) Analysis of elements,

(b) Analysis of relationships,

(c) Analysis of organizational principles.

5. Synthesis

It refers to putting together of elements and parts to form a whole.

(a) Production of a unique communication,

(b) Production of a plan or a proposed set of operations,

(c) Derivation of a set of abstract relations.

6. Evaluation

It refers to the judgements about the values of materials and methods for given objectives.

(a) Judgement in terms of internal evidence,

(b) Judgement in terms of external criteria.

The above mentioned objectives are clarified as follows:

1. *Knowledge*—It is defined as the remembering of previously learned material. It represents the lowest level of learning outcomes in the cognitive domain.

2. *Comprehension*—It is defined as the ability to grasp the meaning of material. The learning outcomes go one step beyond the simple understanding of material and represent the lowest level of understanding.

3. *Application*—It is the ability to use learned material in new and concrete situations. Learning outcomes in this area require a higher level of understanding than those under comprehension.

4. *Analysis*—It refers to the ability to break down material into its component parts so that its organizational structure may be understood. Learning outcomes here represent a higher intellectual level than comprehension and application because they require an understanding of both the content and the structural form of the material.

5. *Synthesis*—Synthesis refers to the ability to put parts together to form a new whole. Learning outcomes in the area stress creative behaviours, with major emphasis on the formulation of new patterns or structures.

6. *Evaluation*—Evaluation is concerned with the ability to judge the value or material (statement, novel, poem, research report) for a given purpose. Judgements are to be based on definite criteria.

Objective and Mental Process or Ability in Bloom's Taxonomy

Objective	*Mental Process or Ability*
1. Knowledge	1. Recall 2. Recognize
2. Comprehension	1. See relationship 2. Cite example 3. Discriminate 4. Classify 5. Interest 6. Verify 7. Generalize
3. Application	1. Reason 2. Formulate 3. Establish 4. Infer 5. Predict
4. Analysis	Analyze
5. Synthesis	Synthesize
6. Evaluation	Evaluate

Cognitive Objectives and Associated Words

Objective	*Associated action verbs*
1. Knowledge	1. Define, 2. State, 3. List, 4. Name, 5. Write, 6. Recall, 7. Recognize, 8. Label, 9. Underline, 10. Select, 11. Reproduce, 12. Measure.
2. Comprehension	1. Identify, 2. Justify, 3. Select, 4. Indicate, 5. Illustrate, 6. Represent, 7. Name, 8. Formulate, 9. Explain, 10. Judge, 11. Contrast, 12. Classify.
3. Application	1. Predict, 2. Select, 3. Assess, 4. Explain, 5. Choose, 6. Find, 7. Show, 8. Demonstrate, 9. Construct, 10. Compute, 11. Use, 12. Perform.
4. Analysis	1. Analyzse, 2. Identify, 3. Conclude, 4. Differentiate, 5. Select, 6. Separate, 7. Compare, 8. Contrast, 9. Justify, 10. Resolve, 11. Breakdown, 12. Criticise.
5. Synthesis	1. Combine, 2. Restate, 3. Summarize, 4. Precise, 5. Argue, 6. Discuss, 7. Organize, 8. Derive, 9. Select, 10. Relate, 11. Generalize, 12. Conclude.
6. Evaluation	1. Judge, 2. Evaluate, 3. Determine, 4. Recognize, 5. Support, 6. Defend, 7. Attack, 8. Criticise, 9. Identify, 10. Avoid, 11. Select, 12. Choose.

Criticism of Bloom's Classification

Recently there has been strong criticism of the total commitment to behavioural objectives. It has been argued that it is very difficult to frame behavioural objectives relating to feelings and attitudes. All theoretical concepts cannot be translated into behavioural objectives. It is also disputed that the degree of behavioural specification of objectives increases student learning. Objectives, if pushed too far, can become a straitjacket restricting one's individuality. Taxonomy should not become a new orthodoxy to rely on heavily. It should be used judiciously and selectively in the teaching–learning process.

Lewton (1973) and Kelly (1977) have criticised this method of classifying educational objectives as under:

1. Bloom's three-fold classification is somewhat artificial as practice of all the three is closely interrelated.
2. There is not always agreement on the appropriate classification for certain behaviours.
3. In this classification, there is a tendency to overstress 'measurable behaviour' and to disregard the importance of those aspects of pupil's work which are not 'measurable'.
4. Bloom's classification is not applicable to all areas of the curriculum and to all circumstances of learning.

Development of the Programmed Instructional Material Steps Involved

*A **Challenging task.*** The development of a programme is a very challenging, highly dynamic and time-consuming exercise. The programmer must have a scientific temper to study all aspects of behaviour, its various forms and levels. In writing a programme, a programmer has to be very pragmatic and skilful.

Important stages in programming. These are as given below:

I. Preparation.
II. Constructing or writing the plan.
III. Try-out and revision.
IV. Evaluation.

I. Preparation

Peter Pipe suggests the following points before getting down to details:

(i) Be prepared to find that preparation accounts for at least 25 per cent of your total time.

(ii) Do not bother about attaining perfection in one step before you begin the next.

(iii) There is no substitute for hard work. Preparation requires hard work.

(iv) Do not rely on memory to keep track of new ideas.

Steps at the Preparation Stage

These are listed below:

(1) Selection of a topic (unit).

(2) Writing assumptions about learners.

(3) Defining objectives in behavioural terms.

(4) Writing the entry behaviour of the learners.

(5) Developing specific outline of content.

(6) Preparing a criterion test.

(1) Selection of a topic to be programmed. Following points should be taken into consideration:

(i) Is no programme already available on the topic?

(ii) Does it allow one to develop a simple, logical and systematic programme?

(iii) Does it meet the requirements of the curriculum?

(iv) Will it help in reducing the burden of the teacher?

(v) Will the expenses and labour involved in the programme be justifiable in terms of the gains.

(vi) The topic for a programme should be selected from the programmer's own field of study. In the selection of the unit, the following yardsticks must be applied:

(a) Is this something the learner must know?

(b) Is it difficult for him to find a good explanation from other sources?

(vii) The subject matter should be simple.

(viii) The beginner programmer should select short units which he can use, evaluate and revise in a fairly brief period.

(ix) The programmer should select a unit from a field which is usually considered a stumbling block to the learner. Of course, the criteria of ease and length should not be ignored.

(x) Special needs of the students should also be taken into consideration.

2. Writing assumptions about the learners. The programme is meant for the learners.

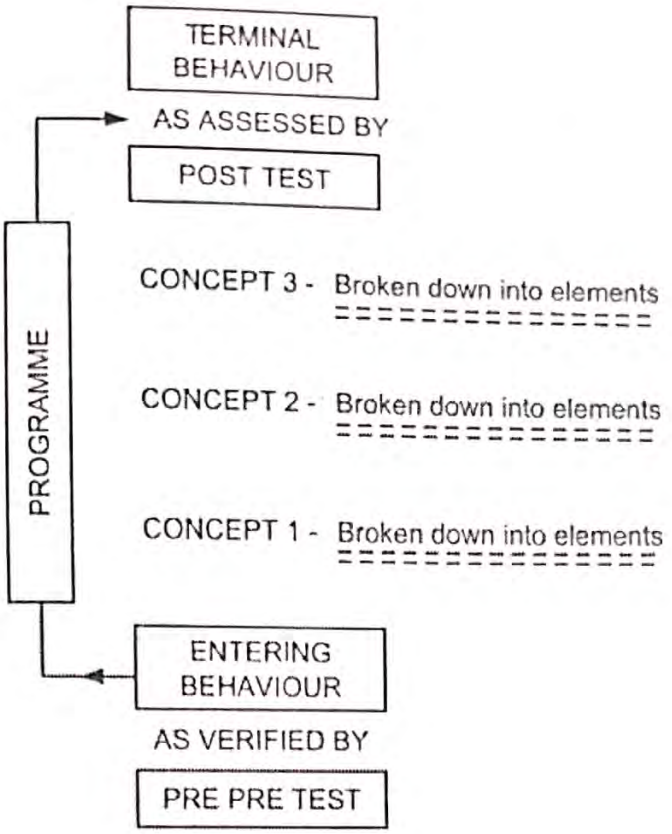


Fig. 9.6 : Flowchart indicating the structure of the programme.

Therefore, a programmer should be fully aware of the characteristics of learners. Following points should be taken note of:

(i) The programmer must list basic assumptions about learners in objective and concrete terms.

(ii) He should describe the age and gender, skills, interests and ambitions of the learners.

(iii) The ability of the learners may be judged from scores obtained on intelligence, aptitude and achievement test, etc.

(iv) The programmer should know the socio-economic status of the learner.

(v) The programmer should know the educational level of the parents of the learner.

(vi) The programmer should be quite frank in writing assumptions about learners.

(vii) The programmer should not be concerned about its length or its literary style.

3. ***Writing objectives in behavioural terms.*** The programmer should state clearly the type and extent of the behavioural changes to be expected from the learners after going through the programme developed by him (Note: This aspect has been discussed in detail separately).

4. ***Writing the entry behaviour of the learners.*** We start with something that the learners already know, i.e., initial information and knowledge possessed by them. The starting point with respect to one's behaviour is called his entry behaviour and the end-point as the terminal behaviour. Hence the programmer has to describe the behaviour of the learners in terms of the base, i.e., pre-requisite knowledge, skills, attitudes and interests, etc.

5. Developing specific outlines of the content. The course contents to be covered through the programme are decided on the basis of assumptions about the learners, their entry behaviour, objectives to be realized in the form of terminal behaviour and the courses of study prescribed by the authorities—school, department of education, board, etc.

The contents should be organized logically as well as psychologically and an ideal balance struck. Every possible effort should be made to go through the relevant literature: textbooks, work books, manuals, etc. Subject matter experts may also be consulted.

6. Preparing a criterion test. The criterion test is designed to ascertain the effectiveness of a programme by measuring the learner's performance on clearly defined educational tasks. Through the criterion test, the terminal behaviour of the learner reached after the completion of the unit of a programme is assessed for ascertaining the extent to which the desired objectives have been realized. A sort of standard to test the programme is set up. In the light of this standard or criterion test, evaluation is made whenever needed.

II. Construction Or Developmental Phase (Writing of the Programme)

The writing of the programme is carried out under the following heads:

1. Writing the draft frames in a sequence, i.e., from simple to complex.
2. Editing the draft frames by a team of experts usually consisting of:

   (i) Subject matter expert, (ii) A skilled writer, and (iii) The programmer.

III. Try-Out and Revision

This step is carried out as under:

1. Giving the programme to a few individual learners, finding out their reactions and making necessary changes in the light of said reactions.
2. Trying out the programme on a group of learners at a few places and making changes on the basis of reactions.
3. Trying out the programme in the field.

IV. Evaluation

Evaluation enables the programmer to judge the success or failure of the programme. It is done on internal as well as external criteria.

Internal evaluation is done in terms of three aspects: (a) Error rate, (b) Programme density, and (c) Sequence progression.

External measures include: (a) Criterion test, (b) Gain ratio, and (c) Learner's attitude.

The programmer or the evaluator applies 90–90 criterion. In other words, the statements or the frames where 10% or less than that number of learners give incorrect responses are considered to be valid. The statements or the frames in which more than 10% learners give wrong responses are deleted.

Specific Skills Needed in the Construction of a Programme

Skills needed for the planning stage. These are:

(a) Skill in writing behavioural objectives.
(b) Skill in defining entry behaviour.
(c) Skill in content analysis.
(d) Skill in preparing a criterion test.

Skills needed at the writing stage. These include:

(a) Skill in differentiating the functional and structural ingredients of frames.
(b) Skill in using primes and prompts.
(c) Skill in ordering and arranging frames in a proper sequence.

Skills needed at revising, editing and testing

(a) Linguistic skill.
(b) Editing skill.
(c) Skill in individual testing which requires establishing a rapport.
(d) Skill in obtaining evidence about the relevance and value of the programme.

Use of Primes, Prompts and Cues in Programming

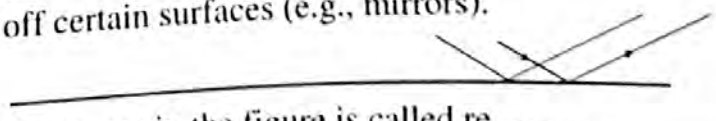
For helping the learner make the correct response and eliminate error, he is assisted in the form of 'primes' and 'prompts' in the introductory frames. Priming is introduced in a frame through a process of copying the response given in the stimulus material. For example:

> All elements are made up of small particles of matter called 'atoms'.
>
> The smallest particle of copper is called.....
>
> Response: atom

A prompt, on the other hand, does not indicate to the learner the correct response in the stimulus itself. A hint or cue is provided to help the learner to choose the correct response. According to Skinner, prompts can be classified into two categories:

(i) Formal prompt, (ii) Thematic prompt.

A formal prompt provides an indication of the form of response. For example:

> One of the optical phenomena which can be studied by using rays of light is reflection. Rays of light bounce off certain surfaces (e.g., mirrors).
>
> 
>
> The phenomenon that you see in the figure is called re.....
>
> Response: reflection

Thematic prompt depends on the general properties of the prompting stimulus. It gives a hint. For example:

> The ray that is incident on a reflecting surface is called 'incident' ray. The ray which is reflected by the mirror is called ..... ray.
>
> Response: reflected

It may be kept in view that the primes and prompts should be provided only in the initial steps and thereafter gradually withdrawn.

Illustrative Programmes in School Subjects

Programme No 1: Civics Class X

Introduction. This is a programme meant for you for the study of salient features of the Constitution of India.

In this programme, you will find paragraphs which are called frames. Study each frame carefully and write down what is required. Answers are given at the end. After stating your answers, check them. If your answer is wrong or you do not understand anything, you can again go back to the frame. It is not a test but instead it is a self-study programme.

Frame 1: The Constituent Assembly of India was set up under the provisions of the Cabinet Mission Plan to frame the Constitution of India which was formally adopted on 26th Nov. 1949 and came into force on 26th January 1950. It took nearly three years to complete the work.

(a) What was the work assigned to the Constituent Assembly?

(b) Under what provision was it formed?

(c) When did our Constitution come into force?

(d) When was it adopted?

(e) How much time did the Constituent Assembly take to complete its work?

[*Ans.* (a) To frame the Constitution of India, (b) Provisions of the Cabinet Mission Plan, (c) 26th January 1950, (d) 26th November 1949, (e) Nearly 3 years]

Frame 2: The Preamble of the Constitution has a great significance but is not a part of the Constitution. The Constitution was framed by the people of India through their representatives. It stresses the fact that the reins of political power ultimately lie in the hands of the people of India.

(a) Is the Preamble a part of the Constitution?

(b) By whom was the Constitution framed?

(c) In whose hands do the reins of political power ultimately lie, in India?

[*Ans.* (a) No, (b) The people of India through their representatives, (c) The people of India]

Frame 3: The Preamble of our Constitution is as under:

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC and to secure to all its citizens:

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity;

and to promote among them all

FRATERNITY assuring the dignity of the individual and the unity and integrity of the Nation;

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.

Note—Three new terms—Socialist, Secular and Integrity—were added to the original text of the Preamble when it was amended in 1976 by the 42nd Amendment.

The Preamble stresses the democratic basis of the Constitution by stating that the People of India gave to themselves this Constitution. It also states objectives like justice, liberty, equality and fraternity.

(a) Who has given us the Constitution of India?

(b) What kind of justice has been ensured by the Preamble?

(c) What type of Republic is to be constituted?

(d) What kind of equality has been given to its citizens?

(e) How many types of liberty can a citizen enjoy?

[*Ans.* (a) The people of India, (b) Social, economic and political, (c) Sovereign Socialist Secular Democratic, (d) Equality of status, (e) Five]

Frame 4: Another important feature of the Preamble is that the people themselves adopted and enacted the Constitution. Thus, the representatives of the people frame the laws of the country and they have the power to change or amend the Constitution.

(a) Who frames the laws of the country?

(b) Who has the power to amend the constitution?

[*Ans.* (a) Representatives of the people, (b) Representatives of the people]

Frame 5: The Constitution of India has many unique features which distinguish it from constitutions of other countries. The framers of the Constitution freely borrowed ideas but took care to adapt these to the needs of the country.

The Constitution makes India a Sovereign, Socialist Secular, Democratic Republic. The word Sovereign means that India is completely free from external control. No outside power has the right to interfere either in her internal administration or direct her in the conduct of her foreign policy.

This was emphasized to ensure that India was no longer 'dependent' on the British Empire as she had been before the Indian Independence Act 1947 or a 'dominion' as she had been from 15th August, 1947 to 26th January 1950.

(a) What kind of status did India enjoy during 15th August 1947 to 26th January 1950?

(b) Was India sovereign between 15th August 1947 to 26th January 1950?

(c) What is the meaning of the word 'sovereign'?

(d) Does the Constitution of India have unique features?

(e) Did the framers of the Constitution borrow ideas?

[*Ans.* (a) Dominion, (b) No, (c) India is completely free from external control, (d) Yes, (e) Yes]

Programme No. 2 Biology Taxonomic Categories Class XI

Introduction. (On the pattern of Programme No. 1)

Frame 1: We see several kinds of animals and plants around us. They all exhibit varying degrees of differences and similarities. One feels the need to arrange these numerous living things in some logical sequence. The method of arranging and grouping of animals and plants in various divisions is known as classification.

(a) All animals exhibit various degrees of ..... and .....

(b) The numerous organisms can be better studied if they are.....in some..... sequence.

(c) ..... is the method by which various organisms are grouped.

[*Ans.* (a) Differences, similarities, (b) Arranged, logical, (c) Classification]

Frame 2: Organisms are classified according to certain characteristics. First they are placed in bigger groups. All living organisms have been put into two groups, viz., plants and animals. These groups are further divided and sub-divided into various smaller groups.

All these different groups are called categories. These categories have been given different names at different stages, e.g., Kingdom, Phylum, Class, Order, etc.

(a) The assemblage of organisms in the groups according to certain characteristics is said to form a .....

(b) ..... and ..... are names of two categories.

[*Ans.* (a) Category, (b) Kingdom, Phylum, Class, Order (Any of these)]

Frame 3: In classification, these categories are placed in a definite sequence. Some categories are higher than others, e.g., Kingdom is of a higher category than Phylum. Each higher category contains all the lower categories.

1. Is there any definite sequence in which to arrange the categories?
2. Which category will be studied first while classifying any organism? (higher, lower)
3. Study the sequence of categories given below:

   Kingdom, Phylum, Class

   (a) If Kingdom is the highest category, which is the lowest?

   (b) Category Phylum will contain category ..... also.

   (c) Will category Kingdom contain all the classes?

[*Ans.* 1. Yes, 2. Higher, 3. (a) Class, (b) Class, (c) Yes]

Frame 4: The arranging of the taxonomic categories in a logical sequence is called a hierarchy. Study carefully the list of categories given below in a descending order, i.e., the first one is the highest category.

Kingdom, Phylum, Class, Order. Family, Genus, Species.

This sequence forms a hierarchy.

(i) If various categories are arranged in a sequence, it forms a .....

(ii) Write whether the sequence of the categories given forms a hierarchy.

Order, Kingdom, Phylum, Genus, Class.

(iii) Make a hierarchy of the categories given above.

(iv) From the hierarchy made by you, answer the following:

(a) ..... is the highest category.

(b) ..... is the lowest category.

[*Ans.* (i) Hierarchy, (ii) No, (iii) Kingdom, Phylum, Class, Order, Genus, (iv) (a) Kingdom; (b) Genus]

Programme No. 3 Class X History Topic: Hinduism

Introduction. (Pattern of Programme No. 1)

Frame 1: Hinduism is considered to be the oldest religion in the world. It made significant progress during the Golden Age of the Guptas.

(i) Which is considered to be the oldest religion in the world?

(ii) During which age did Hinduism make great progress?

[*Ans.* Hinduism, (ii) Golden Age of the Guptas]

Frame 2: Main tenets of Hinduism are: (i) Belief in an Omnipotent God. (ii) This belief does not debar them from worshipping several gods signifying the different forms of the same divine, (iii) Worship of several gods gave birth to numerous religious sects of which two are more important, having their respective God as Head.

Religious Sects	*Godhead*
Vaishnavism	Lord Vishnu
Shaivism	Lord Shiva

(i) What is the main belief of Hinduism?

(ii) Name two important religious sects in Hinduism.

(iii) Name the Godheads of these sects.

[*Ans.* (i) Belief in an Omnipotent God, (ii) Vaishnavism and Shaivism, (iii) Vishnu and Shiva]

Frame 3: The principal Hindu Scriptures are the Vedas, the Upanishads, the Darshanas, the Gita, the Ramayana and Mahabharata.

Name any five principal Hindu scriptures.

[*Ans.* The Vedas, (ii) The Upanishads, (iii) The Darshanas, (iv) The Gita, (v) The Ramayana and Mahabharata]

Frame 4: The Hindus believe in salvation or 'moksha' as the supreme objective of one's life. This objective can be realized by exercising full control over one's own senses. There are believed to be three paths to achieve salvation—the 'Karma Marga', or the way of good deeds; the 'Gyana Marga' or the way of true knowledge and 'Bhakti Marga' or the way of Divine devotion.

(i) In Hinduism, what is the supreme objective of a man's life?

(ii) How many paths to salvation have been prescribed in Hinduism?

(iii) What is the meaning of the word 'Karma Marga'?

(iv) What is the other word used for salvation?

[*Ans.* (i) Salvation, (ii) Way of good deeds, (iii) Three, (iv) Moksha]

Frame 5: The soul is immortal. It is involved in an unending cycle of births and deaths and rebirths and deaths. The Hindus believe in the theory of 'Karma' which means that actions in one's present life bear their fruit in the next life.

(i) Does the soul die?

(ii) Is the soul Immortal?

(iii) The soul is involved in an ..... cycle of .....and .....

(iv) Do Hindus believe in rebirth?

(v) What is the theory of 'Karma'?

[*Ans.* (i) No, (ii) Yes, (iii) Unending, births, deaths, (iv) Yes, (v) Actions in one's present life bear their fruit in the next life]