UNIT 3  PLANNING FOR EFFECTIVE INSTRUCTION OF MATHEMATICS

Structure

3.1 Introduction
3.2 Objectives
3.3 Desirable Characteristics of a Good Instructional Programme in Mathematics
3.4 Formulation of Objectives
3.5 Selection of Content or Learning Material
3.6 Designing Learning Experiences
3.7 Preparation of Unit/Lesson Plan
3.8 Let Us Sum Up
3.9 Unit-end Activities
3.10 Answers to Check Your Progress
3.11 Suggested Readings

3.1 INTRODUCTION

The objectives of teaching mathematics may be achieved accurately through effective planning of instruction. A teacher should help students to develop an understanding of mathematical concepts through desired experiences. Students should not fear or dislike mathematics, rather they should be enabled to enjoy mathematics. The success of the teacher is indicated by a change in the attitude of students towards mathematics learning. Therefore, it is necessary for the teacher to understand the principles of learning and identify (or design) various learning experiences for the effective involvement of students in the transfer of the knowledge of mathematics. This will facilitate learning and take care of individual differences. This unit is designed to help teachers develop the ability to plan instruction in mathematics effectively.

3.2 OBJECTIVES

At the end of the unit, you will be able to:

- know the principles of learning mathematics;
- explain different types of instructional objectives;
- write instructional objectives in the teaching of mathematics;
- design learning experiences in the teaching of mathematics;
- analyse the content and to see the relevance of unit planning in mathematics;
- develop a unit plan;
- prepare a lesson plan; and
- appreciate the role of planning for effective instruction in mathematics.
3.3 DESIRABLE CHARACTERISTICS OF A GOOD INSTRUCTIONAL PROGRAMME IN MATHEMATICS

The mathematical competence of many of our present students is certainly not as high as it could be expected under optimum conditions. Problems caused by large classes, inadequate teacher preparedness, non-availability of good textbooks and other material aids, too much dependence on external examinations and unsatisfactory and outdated course content still confront us. The spirit of innovation is lacking in our system. The traditional and conservative point of view has resisted any effort for change. There are a variety of new ideas and practices available for consideration. Any teacher of mathematics must make his/her own choice while organising instruction. A few such ideas are listed here.

i) Recently many topics, found to be outdated have been deleted. Many new topics are now being introduced. A few notable once are sets, probability and statistics, inequalities and computer science. These have been included because, in the recent past, mathematics has been used widely in the social sciences, in the biological sciences, in business, and in industry. The gradation or placement of many topics has been changed. Examples are informal geometry and algebra at the elementary stage. The treatment of many topics has been changed. The deductive approach has been extended to branches other than geometry. In a few cases, such as Euclidean geometry, the subject matter has been condensed. There is an attempt to teach more mathematics in less time.

ii) It has been established that children who understand a process before practising it learn it more efficiently and can use it more effectively. Rote learning has been replaced by functional learning. It is also assumed that a knowledge of basic or key ideas and their relationships helps children understand and appreciate mathematics better than knowing isolated facts. An integrated approach to teaching is preferred to teaching different branches as isolated from each other.

iii) Perhaps the most important aspect of an effective teaching plan is to teach the child in the way in which he/she learns best. This involves teaching children how to learn and how to be creative. This can be achieved if teaching is planned keeping in view the way in which growth, development and learning occur. Piaget's studies of child growth and development are useful in this task. Teaching that does not change what the learner does, thinks, feels and acts does not achieve the desired goals. Learning by doing is better than memorized learning of inert ideas. Learning through meaningful activities creates interest and satisfies needs. Desirable behaviours, including skills in using mathematics, are developed by practising them in problem-solving situations:

Thus, successful teaching involves (i) setting functional problem situations (ii) selecting learning activities which are life-like and related to needs, and (iii) proper gradation of subject matter that will assure the pupil’s understanding, practice and attainment of the desired behavioural changes including skill in using mathematics.

iv) Pupils within a group differ widely in interests, experiences, abilities and rates of learning. To plan for effective and meaningful instruction, the teacher must discover the range of what is to be understood, and the skills of different pupils in his/her class. Creative work, community projects, construction activities and experiments that utilize the skills and mathematical abilities, challenge the thinking of the pupils and give them opportunities to discover at their own pace should be introduced.

3.4 FORMULATION OF OBJECTIVES

Aims and objectives are our guideposts. These are best expressed as desirable changes in what the learner actually does. Desirable changes in what the learner does do not develop automatically as a by-product of the teaching of the subject matter. Each type of behaviour, including skills in the use of mathematics, requires direct provision for its practice in active learning situations. The underlying premises in formulating the objectives of teaching mathematics are:

i) The goals and objectives of teaching mathematics must have bearing on the objectives of
Nature, Objectives and Approaches to Teaching of Mathematics

general education (as proposed in the National Policy on Education). These should also reflect the needs of society and strengthen the salient features of our culture.

ii) Mathematics education has been passing through a period of unprecedented change in content and methodology. The emerging trends and expanding frontiers of knowledge should form the basis for the formulation of objectives.

iii) The objectives should indicate both the desired behaviour and the type of situation in which it is to occur. It should be expressed in terms of desired pupil behaviour rather than of teacher behaviour. It should also be specifically stated so that it is possible to infer some appropriate learning activity.

Generally speaking, the objectives are grouped under the six broad categories:

i) Knowledge/understanding
ii) Skill
iii) Application
iv) Appreciation and interests
v) Attitudes
vi) Personality and character.

In specifying the objectives in terms of the behavioural changes of the pupil, the following criteria may be kept in view:

a) The behavioural change should flow from the objective.

b) It should clarify what is implied by the objective.

c) It should indicate what exactly the pupils should do to attain the objective and what they are expected to do after the objective is attained by him.

d) It should be appropriate to the level of pupil’s development. For the purpose of guidance two appendices are provided:

1. National Goals and Their Implication for Mathematics Education.

2. A-List of Objectives Obtained from Different Syllabus and Other Sources.

Check Your Progress

Notes:  a) Write your answers in the space given below.
        b) Compare your answers with those given at the end of the unit.

1. Given below are two statements of objectives. Give your comments on these statements:

   a) To impart to the students the knowledge of mathematical terms, symbols, ideas, principles, relationships, etc.

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   b) To develop personal qualities, e.g., honesty, heartiness, truthfulness, etc.

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2. Find out the differences between the ‘skill’ objective as formulated for teaching geometry and for teaching algebra at the elementary stage.

3.5 SELECTION OF CONTENT OR LEARNING MATERIAL

As indicated earlier, an objective has two aspects: content and behaviour. Therefore, some decisions about subject matter are taken while formulating objectives. These form broad areas from which specific topics are selected after giving careful thought to the nature of the learner as well as the learning and the social needs. These broad areas (topics) are then arranged according to the “spiral plan”. The easier or simpler concepts are followed by more difficult concepts. Since mathematics is treated as one indivisible whole in which the many skills and techniques composing it are tied together by a few basic ideas, it has been thought proper to organize the learning material under these ideas and then spread over all the school years. A few ideas identified for “Mathematics for all”, i.e., general mathematics, are (i) Numbers and Operations (ii) Geometry (iii) Sets (iv) Functions and Graphs (v) Measurement (vi) The Mathematical Sentence (vii) Applications of Mathematics.

The content selected should reflect all the four significant aspects of mathematical learning—concepts or meanings, computational skills, problem-solving (reasoning) and attitudes as recognized in the formulation of the objectives. Applications as envisaged in the objectives should not be restricted to the traditional use of mathematics in problems of personal finance, home, business and geometry but greater emphasis should be placed upon uses in technology, industry and new emerging areas in economics, management and computer science. The continuity and sequence of the learning material is mainly determined by the nature of the subjects. Since in mathematics it is easy to find out (i) what needs to be reinforced in the course of learning which had begun in earlier courses, and (ii) what ought to be reinforced and treated further in depth at a higher level of generality, the logical continuity in mathematics facilitates looking in both directions.

In actual practice the subject matter is provided in the form of textbooks. Textbooks give the scope of each topic at a particular level. Some textbooks organize content into suitable units or sub-units taking into consideration the relationship between the various topics. The competencies for each unit are also listed. For organizing instruction the teacher should identify objectives for each unit, analyze the content for locating understanding, skill and attitudes and work out suitable activities of learning experiences to give maximum opportunities to children to develop desired behaviors.

Check Your Progress

Notes: a) Write your answers in the space given below.
       b) Compare your answers with those given at the end of the unit.

3. List the principles for curriculum construction.
3.6 DESIGNING LEARNING EXPERIENCES

The achievement of objectives depends upon suitable and well-organized learning experiences which are presented to the pupil in order to produce effective learning. Learning experiences place great importance on the learner and the learning situation, instead of on the teacher and the content. A learning experience is thus a desired change in the mental make up of a child brought about through "activities leading to the discovery of connections, relationships and meanings which are significant in monitoring the conduct of the pupil". The following suggestions should be kept in view while selecting and organizing learning experiences.

1. Learning experiences should be appropriate to the behavioural changes defined under the objectives. It is the experiences of the pupil that are important as it is through these that the child matures in his behaviour. The child learns more about mathematical ideas as he observes, analyses and discovers relationships and formulates generalizations from a number of problems or situations. Many valuable experiences are unplanned. However, for the most part the teacher has to plan situations which provide a challenging experience to the pupil.

2. Learning experiences should be suitable for the content area or the topic. Mathematics by nature is structural. As such there is continued and repeated expansion and fusion of all previously learnt ideas. This expansion is possible only when each experience is reinforced and used repeatedly.

3. Learning experiences should be varied in order to be effective. Children differ in maturity, interests and abilities. To meet the requirements of individual differences the learning experiences should be imaginative and easily adaptable to the interests of the pupil.

4. The learning experiences may be planned for various purposes such as:
   a) to explain a complex mathematical idea by making children do or think in parts;
   b) to provide an opportunity to analyse and make a generalisation;
   c) to develop new vocabulary and to use known vocabulary;
   d) to coordinate the idea of mathematics and some other ideas, social or related to other branches of knowledge;
   e) to provide experience in the process of problem-solving, i.e., planning a situation, gathering information, solving the problem and verifying the result;
   f) to provide for applications of mathematical ideas; and
   g) to provide an insight into various methods of proof in mathematics.

In an actual teaching plan learning experiences are effective when they are organized as a related whole. Generally in any particular lesson or unit the activities are organized at four levels.

Level 1: The preparatory or readiness stage

The learning experiences are motivational and secure the interest of the pupil in the topic. The pupil should be given first hand experience with concrete objects or real life situations so that he/she observes, locates and discovers some known mathematical ideas involved in the situation.

Level 2: Exploratory or developmental stage

These learning experiences provide for experimentation, doing and thinking analytically. These help in exhibiting connections or relationships between what is known and what is to be concluded.

Level 3: Symbolization stage

These learning experiences encourage the pupil to express the relationships precisely, using mathematical language, symbols and methods of representation.
Level 4: Generalization stage

These are culminating activities which encourage the pupil to come out with the abstract rule or generalized understanding. At this stage the pupil’s mind has matured and he can express mathematical ideas more meaningfully. Exhibits, reports, discussions, individual notes, etc., fall in this category of activities.

At all stages in school mathematics, learning can be very interesting and effective provided there is the right atmosphere or the right type of conditions for carrying out the activities. The rooms in which mathematics is taught make their own contribution. The rooms should be equipped with worktables convenient for drawing and construction activities; sufficient wall space for display; a wide variety of instruments and models; teaching aids, etc. In many schools it is preferred to designate one room as “Mathematics Room”. Teachers of mathematics have their own approaches, ideas and preferences. Some like to use teaching aids while others do not like to use many teaching aids. However each pupil, whatever his ability, can derive benefit from making and using simple aids and devices. Simple home-made aids are preferred to costly equipment purchased from the market. The best teaching aid is a large size chalk board (painted green) with a non-reflecting surface.

Although, the classroom itself can contribute to a certain extent, the responsibility of bringing life into mathematical work rests firmly on the teacher. A mathematical class is lifeless and dull if the teacher fails to communicate with the pupils. Fluent expression in ordinary language of speech and correct, precise interpretation of mathematical statements, symbols and situations is a necessary condition to create an atmosphere of mental alertness, confidence, enjoyment and humour. Further, the teacher’s work can be helped or hindered according to the arrangement of his/her class. Sometimes for different purposes he/she may find it valuable to vary the arrangement. A class with students having a wide range of abilities may be divided into smaller groups for personal attention or remedial work. Practical work which involves the use of instruments and movement of children needs the most careful organization by the teacher. Detailed planning of any lesson requires attention to the topic, treatment of the discussion, written examples, individual assignments, home work, projects, practical work, etc., in order to successfully accomplish the objectives.

Check Your Progress

Notes: a) Write your answers in the space given below.
       b) Compare your answers with those given at the end of the unit.

4. Give three important principles which help in selecting and organizing learning experiences.

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3.7 PREPARATION OF UNIT/LESSON PLAN

With the rise in pupil enrolment in schools, it has become difficult to maintain an adequate supply of competent and efficient teachers. The individual teacher needs guidance not only in
the methods of teaching but also in finding out suitable techniques for bridging the levels of individual differences among the students and providing a varied degree of application for the subject as such. It is necessary that a variety of material be made available to reinforce the teacher's effort. It is felt that teaching units are one of the most effective ways of helping a teacher in the solution of curriculum materials and in planning and executing his/her work. Teaching units supplement the textbook which has often been found inadequate to meet the needs of the pupils. Units range in types from the purely subject-centred ones to the life problem-centred ones. A teaching unit is usually the product of more than one person's work—although it is very much possible for a single teacher to develop a unit. The unit envisaged here is a "resource unit" which can be split up by any teacher into different learning units or lessons. The unit consists of the following essential parts:

(a) Purposes (b) Subject matter contents (c) Teaching-learning activities and other hints to teachers (d) Evaluation.

If necessary a few other features may also be provided such as enrichment material references etc.

a) Purposes on which teaching units are based are:

i) general objectives of education or the National Goals of Education;

ii) characteristics of pupils;

iii) interests, abilities and growth potential; and

iv) the nature of learning and the maturity of the learners.

b) The subject matter for a teaching unit can be based on:

i) the scope of the topic;

ii) the identification and listing, if necessary, of competencies desired to be developed; and

iii) materials from other fields pertinent to the study of the problem.

c) Activities for the unit are:

i) selected to specify the behaviour indicated in the statement of objectives;

ii) experiences which are varied, practical and contribute to the allround growth of the pupils;

iii) broad enough to provide for a range of interests and abilities.

d) Means of evaluation of a unit are for:

i) judging the achievement of pupils;

ii) finding out the weaknesses of pupils; and

iii) suggesting the level of attainment of objectives.

e) Reference material for a unit may include:

i) sources of inexpensive or free teaching-learning aids;

ii) a list of reading material;

iii) a list of community resources; and

iv) a list of audio-visual aids.
The basic task of the teacher is to analyse the instructional problems involved in the unit and anticipate the particular difficulties and errors that are likely to occur in connection with it.

While a teaching unit provides the broad framework for planning instructions, a teacher needs guidance in planning day to day lessons. No action takes place without a goal. Hence, there is no such thing as an unplanned lesson. A planned lesson is one in which goals have been set by the teacher. A lesson plan worked out before going to teach has many advantages. When the lesson is written the procedures are naturally practised beforehand. Further, after the lesson the teacher can review his/her performance and have a sort of self-criticism. A written lesson plan can be successively improved and thus ensure a continuous improvement in teacher’s performance. The teacher, while planning his/her lesson must take into consideration the class organization, the nature of the lesson to be taught, the subject matter already taught and the next day’s lesson. The lesson for today must continue from yesterday’s lesson and must supply some motivation for the lesson tomorrow. Pre-lesson assignments and part-lesson assignments are important in planning the lesson for any day. The following steps are suggested for planning a lesson.

**Step 1**: Listing of specific objectives.

**Step 2**: Planning for motivation. This is to ensure preparedness of the mind of the learners. This may be a reference to home work done, a situation or a few suggestions which will make the problem clear.

**Step 3**: Planning development. This aspect is most important and has the following elements which should be carefully considered:

- Content to be taught may be analysed to list the competencies, understanding skills and interests of the students.
- Suitable activities should be selected for pupils.
- Questions to be given to pupils should be carefully framed.
- Blackboard work and use of other teaching aids should be practiced.
- Drill or practice exercises should be worked out.

**Step 4**: Planning the post-lesson assignment.

**Step 5**: Planning for evaluation, which may be done even after a group of lessons.

Thus a well-prepared teacher is a master technician who is capable of deciding what kind of learning is worth most.

**Check Your Progress**

**Notes**: a) Write your answers in the space given below.

b) Compare your answers with those given at the end of the unit.

5. List the important parts of a good lesson plan.

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This unit has presented a few important points which a teacher should keep in view in order to work out an effective instructional strategy. The main points are:

a) how children learn;
b) new conceptions of the child as a learner;
c) the recognition of individual differences; and
d) the role of social needs and applications in everyday life problems.

a) Much of the current practice in classroom instruction is based on the "meaningful theory of learning" which conceives mathematics as a closely-knit system of understandable ideas, principles and processes. According to this theory, the test of learning is not merely mechanical facility in "figuring" but is an intelligent grasp of number relations and the ability to deal with situations with proper comprehension of their mathematical as well as practical significance. Mathematics is abstract in nature and most of the learning is related to concept formation and generalization. Abstract ideas of mathematics develop out of a great amount of concrete, meaningful experiences. Discovery plays an important role in learning.

Children learn through exploration and discovery. For each child and for each stage of development, the teacher must create an appropriate environment which will encourage discovery, impel thinking and extend mathematical experiences to higher levels of abstraction. Drill does not guarantee that learning has taken place. It encourages habituation of immature procedures and seriously impedes necessary growth. Drill should be preceded by understanding.

b) Piaget’s research helps to identify the developmental levels of mental growth in children and emphasizes the importance of readiness, maturation and environment in all learning experiences. Sensory perceptual materials are necessary to help children acquire concepts. The most important conclusion is that the child’s basic cognitive categories for interpreting physical reality (thinking, reasoning and understanding) are the product of slow and painstaking construction.

The concept of readiness as it applies to all levels of teaching mathematics depends on (i) the background of the child’s experience, (ii) his physical development, including intelligence level, maturation, concepts and abilities, and (iii) his language development and emotional adjustment.

c) Individual pupils of the same age vary widely in a large number of traits — emotional, cultural and social background. Varying the subject matter in depth and scope, ability grouping of pupils, differentiated assignments and use of a wide variety of activities are a few ways to meet the requirements of individual differences.

d) Learning experiences and material in mathematics should be selected with due consideration to situations which will (i) fit pupils for useful service to the community, (ii) discover vocational possibilities, and (iii) develop the ability to analyse and to solve the problems of life.

3.9 UNIT-END ACTIVITIES

1. A workable knowledge of mathematics is needed for a better understanding of different subjects. List the areas where mathematics is useful in (a) geography (b) science (c) social studies and (d) arts.

2. Work out some display material for making the teaching of the following topics interesting: (a) Measurement (b) Graphs (c) Similarity (d) Averages.

3. Discuss the features of the curriculum at the secondary stage.

4. Prepare a teaching unit for the secondary stage on the topics listed in Q. 2.
5. Interview teachers and observe their class teaching to find out the variety of activities they use in their teaching.

6. Discuss the principles of meaningful learning.

7. Obtain a copy of the syllabus of the State Board or the Central Board of Secondary Education. Study the objectives of education and the objectives of teaching mathematics as listed in them. Comment on their relationship and appropriateness.

8. Select a textbook in mathematics for Class X and analyse it to answer the following:
   a) Does the treatment of subject matter help in achieving the objectives of teaching mathematics?
   b) Does the book provide for:
      i) individual differences in abilities,
      ii) practical problems from day to day life?

9. Select a syllabus and analyse the content for Classes 1 to 10 and find out if it is arranged according to the "spiral plan" and follows the principles of child growth.

10. Observe a teacher teaching in a class and note down the following:
    a) Selection of a problem:
       i) Source e.g. the textbook, real life situation,
       ii) Appropriateness, e.g., level, quality, etc.
    b) Presentation of the problem: Type of activities chalked out.
    c) Class Work:
       i) Helping students individually,
       ii) Helping them in small groups,
       iii) Teaching the whole class.
    d) Use of motivational devices.
    e) Use of aids
       i) blackboard
       ii) other aids

3.10 ANSWERS TO CHECK YOUR PROGRESS

1. a) The objective is not proper as it indicates what the teacher has to do and does not tell what the student has to achieve.
   b) Even though the objective tells the desired pupil behaviour, the situation in which it is to occur is not given.

2. The skill objectives as formulated for teaching geometry at the elementary stage are that the child has learnt to draw neatly and accurately different constructions in geometry based on the theorem he/she has learnt. On the other hand, the skill objectives for teaching algebra are that the child develops computational skill in working with the variables and the use of different formulae.
3. Some important principles for curriculum construction are:
   a) Topics should be selected according to the needs of the learner as well as of society.
   b) It should be arranged according to the "spiral plan, i.e., the simple to the difficult".
   c) It should reflect all the objectives — knowledge, understanding, application, skill and personality.

4. The three important principles which guide us in selecting and organising learning experiences are:
   a) The objective or the desired behavioural change in the pupil should be clear and the learning experience should be designed according to it.
   b) The learning experience should be suitable for the content area.
   c) The learning experience should be so organised as to make the classroom lively and should not create a dull atmosphere.

5. A good lesson plan should consist of the following parts:
   a) Objectives to be achieved.
   b) Contents to be transferred.
   c) Previous knowledge required.
   d) Teaching-learning experiences for different parts of the contents.
   e) Evaluation technique to be used.
   f) Reference material/enrichment material to be provided.
   g) List of teaching aids to be used.

3.11 SUGGESTED READINGS

Chaddha & Aggarwal; *The Teaching of Mathematics*, Dhanpat Rai & Sons, Delhi, India.
Mangal; *A Textbook on Teaching of Mathematics*, Prakash Brothers, Ludhiana, India.