5E Lesson Plan in Mathematics

5E approach to Constructivist Learning

The 5 E Approach This approach was introduced by Roger Bybee, of The Biological Science Curriculum Study (BSCS). The 5 Es are Engage, Explore, Explain, Elaborate and Evaluate.

Engage: This stage assess the previous knowledge of the learner and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The aim is to organize students' thinking toward the learning outcomes of the current activities.

Explore: Expose the students to a variety of experiences at this stage. These experiences may involve observations of events or objects, manipulations of materials, work with simulations, examinations of representations, viewing a short video, or reading. These experiences provide a common basis for all students that the teacher can use to assist them in identifying and developing concepts and skills.

Explain: Here students are provided with opportunity to explain their understanding of their experiences from the explore phase. The questions and discussion lead students to patterns, regularities, and/or similarities and prompt them to describe concepts or skills in their own words.

Elaborate: The next phase challenges students to extend their understandings or skills and/or to practice them. Through new experiences at this time, students develop deeper understanding, an extended conceptual framework, and improved skills. Some of the tasks, such as reading an article, may be done as homework and discussed during the following class period.

Evaluate: The final phase of the instructional model encourages students to assess their understanding and abilities and provides opportunity for the teacher to evaluate student progress toward achieving the learning objectives for the activity. The tasks may involve writing summaries, applying concepts and skills to novel situations, constructing a concept map, or taking a quiz.

Subject: Geometry Class: IX

Topic: Length of segment parallel to either X or Y axis. Technique: 5 E Model

ENGAGE	Show pieces of straws to the class and ask them how they can find the length of the same. Obviously they will want to use a measuring scale. Ask them for methods to find the length of a straw without using a measuring scale. Show them different types of paper as plain paper, graph paper, craft paper and see if the length of the straws can be measured. Apparently a graph paper comes in handy. That is because there is a relationship between the co-ordinates of points and the length of the segment determined by two such points. Here the teacher announces that the class is going to discover this relationship to find the length of a segment.
EXPLORE	Have points and their co-ordinates put up on the chalkboard as follows: Group I: (i)A(3, 6) B(5,6) (ii)T(5, 8) V(1,8) Group II: (i)X(7, 14) Y(7,10) (ii)M(3,2) N(3,8) Is their any common characteristic of each group? Where would the pair D(8, 8) and E(8,4) go? Students are encouraged to plot one pair on their graph papers. All students of group I compare their segments and derive one common property. The same is done by Group II. Can the length of the segment be found out? Is there a relationship between the co-ordinates of the endpoints and the length of the segment?
EXPLAIN	The students are encouraged to explain this relationship in their own words. On basis of their work they devise a formula to find the length of the segment parallel to X axis. Similarly find the length of the segment parallel to y axis.
ELABORATE	Where will this formula be useful? Here the teacher can probe for an answer
EVALUATE	Give each student a card with co-ordinates of a point. Students pair up and try to find the length of the segment formed. Be sure that the co-ordinates are such that the segment formed must be parallel to one of the two axes. Pair up with a different student and now find the length of the new segment.

The students devise the formula on their own. They get adequate practice through the game. The teacher only facilitates through use of appropriate questions.

Inquiry Training Model

Inquiry training model is used for giving training of inquiry to the student. By using this model in the classroom, inquiry skill can be developed. Development of inquiry skills needs individuals attention. This model was developed by J.R. Suchman. The inquiry may be carried out at the individual level or at a group of the level.

This type of training gives the learners practice of thinking and speaking,

(1) Assumptions:-

All knowledge is tentative. A scientist puts a theory or principle and after some time, it may be pushed aside by a new one. We are always curious and eager to learn new things. In this model, there is more emphasis on self-learning. The student learns better when they participate in any inquiry. New strategies can be taught directly and added to pupils existing once. There is no one answer. We can always be more sophisticated in our explanations and most problems hence several possible explanations.

(2) Basic elements:-

Focus

The inquiry training model has following goals.

1. To enhance the thinking ability of the student.
2. To enable them to form conclusions based on facts.
3. To enable them to have fluency in their thinking and speaking.
4. More specialty to impart training of inquiry skills.

Syntax

Syntax means the description of the model in action. The inquiry training model has five phases.

Phase 1:- Encounter with the problem

In this phase, the teacher presents a puzzling situation before the students and explains the inquiry procedures. Its aim is to create new knowledge. The initial inquiry is based on simple ideas.

Phase II:- Data collection and verification

The students here try to collect detailed information about the problem. They try to seek clarifications about the doubts concerning the problem. Teacher virtually prepares the ground for the success of the model. The teacher should have an encouraging attitude. During verification, they can ask a question regarding the object, even property etc.

Phase III:- Data gathering for experimentation

This is a stage when the student actually starts putting questions and the teacher is reacting to their questions by saying yes or no as the case may be. This questioning by the student is continued till they are able to reach the stage where mystery could be solved.

Phase IV:- Formulating an explanation

In this the phase, the teacher will invite the pupils to explain things. Through explanation, rules may be formulated. The deviation is also checked so that efforts are applied in the right direction and no energy goes waste.

Phase V:- analysis of the inquiry process

In this phase, the students analyze and reflect on the methods they adopted for inquiry. This helps in finding out a suitable solution to the various issues involved i.e the main problem, the right strategy for it etc.

Social system

The social system is an important element of this model. Here both teacher and students play a significant role in teaching learning process. The success of this model depends on mutual cooperation between teacher and the student

Principle of reaction

Ensuring that question are framed so that they can be answered by "yes" or "no". Following points should be kept in mind:-

1. Asking students to refresh the question.
2. Encouraging the students to give a clear statement.
3. Neither approving nor rejecting students theories.
4. Encouraging interaction among students.
5. Using the language of the inquiry process.

Support system

While working with Inquiry Training Model, a teacher requires additional support in the form of

(1) a set of confronting the material

(2) technical understanding of the intellectual process and strategies of inquiry.

(3) Teacher may require resource material related to the problem.

Application

This model is generally used in teaching for scientific subjects. The student learns to analyze the various type of collected information. Any topic from a curriculum area which can be converted into problem situation or puzzle can be selected for inquiry training.

5.4.2 Concept Attainment Model

In 1956, psychologist Jerome Bruner published a book called "A Study of Thinking." Being a psychologist, Bruner was interested in cognitive processing–how people think, and how those tendencies might be used to inform teaching and learning processes. He developed a new way of introducing learners to new concepts called Concept Attainment.

Concept Attainment

It can be thought of as game of "find the rule." Concept Attainment is a "backwards conceptualizing" approach to making sense of new ideas. It is a teaching strategy characterized by "a pattern of decisions in the acquisition, retention, and utilization of information that serves to meet certain objectives" (Bruner et al 1956). Concept Attainment is a "close relative to inductive thinking (Joyce and Weil 1967), (and) focuses on the decision-making and categorization processes leading up to the creation and understanding of a concept." Neff also explains that there are several advantages to this approach, including learning "how to examine a concept from a number of perspectives, learning how to sort out relevant information", the benefit of seeing multiple examples of ideas, and maybe most importantly, moving beyond mere concept–definition association. This allows for the idea to be seen in its native context, and a more authentic and fuller definition to emerge.

Process of Concept Attainment

In the concept attainment process, new ideas are introduced–and defined by students–inductively through the "act(s) of categorization" (Bruner, Goodnow, and Austin 1956). Students see attributes, examples and non-examples, form theories, and then test those theories against the data given until they are able to name the idea.

This reverses the typical process of introducing an idea (e.g., gravity) by narrowly defining it (e.g., the force that attracts a body toward another physical body having mass). The Concept Attainment process requires learners to focus on attributes, categories, and relationships rather than simply mirroring an idea with a definition.

Benefits of Concept Attainment

Concept attainment is designed to clarify ideas and to introduce aspects of content. It engages students into formulating a concept through the use of illustrations, word cards or specimens called examples. Students who catch onto the idea before others are able to resolve the concept and then are invited to suggest their own examples, while other students are still trying to form the concept. For this reason, concept attainment is well suited to classroom use because all thinking abilities can be challenged throughout the activity. With experience, children become skilled at identifying relationships in the word cards or specimens. With carefully chosen examples, it is possible to use concept attainment to teach almost any concept in all subjects.

A Math example:

- First the teacher chooses a concept to developed. (i.e. Math facts that equal 10)
- Begin by making list of both positive "yes" and negative " no" examples: The examples are put onto sheets of paper or flash cards.
- Positive Examples: (Positive examples contain attributes of the concept to be taught) i.e. 5+5, 11-1, 10X1, 3+4+4, 12-2, 15-5, (4X2)+2, 9+1
- Negative Examples: (for examples choose facts that do not have 10 as the answer) i.e. 6+6, 3+3, 12-4, 3X3, 4X4, 16-5, 6X2, 3+4+6, 2+(2X3), 16-10
- Designate one area of the chalkboard for the positive examples and one area for negative examples. A chart could be set up at the front of the room with two columns - one marked YES and the other marked NO.
- Present the first card by saying, "This is a YES." Place it under the appropriate column. i.e. 5+5 is a YES
- Present the next card and say, "This is a NO." Place it under the NO column. i.e. 6+6 is a NO
- Repeat this process until there are three examples under each column.
- Ask the class to look at the three examples under the YES column and discuss how they are alike. (i.e. 5+5, 11-1, 2X5) Ask "What do they have in common?"
- For the next tree examples under each column, ask the students to decide if the examples go under YES or NO.
- At this point, there are 6 examples under each column. Several students will have identified the concept but it is important that they not tell it out loud to the class. They can howevershow that they have caught on by giving an example of their own for each column. At this point, the examples are student-generated. Ask the class if anyone else has the concept in mind. Students who have not yet defined the concept are still busy trying to see the similarities of the YES examples. Place at least three more examples under each column that are student-generated.

- Discuss the process with the class. Once most students have caught on, they can define the concept. Once they have pointed out that everything under the YES column has an answer of 10, then print a new heading at the top of the column (10 Facts). The print a new heading for the NO column (Not 10 Facts).

Individualised Instruction

- Individualised instruction is a method of instruction in which content, instructional technology and pace of learning are based upon the abilities and interests of each individual learner.
- It refers to those classroom practices of teaching which recognize the uniqueness of each student learner and thus provide for adequate tutorial guidance, and other support services suited to bring about a wholesome development in the person (mind, body, and spirit).
- It is about using teaching strategies that connect with individual student's learning strategies. The ultimate goal is to provide a learning environment that will maximize the potential for student success.
- In this strategy the teacher shouldn't always stick to the same pattern of teaching rather they should adapt new ways such as teaching through audio, video, field trip, etc. so that students have multiple options for taking in information and making sense of ideas.
- To differentiate or to individualize instruction is to recognize students varying background knowledge, readiness, language, preferences in learning, interests, and to react responsively.
- The intent of individualizing instruction is to maximize each student's growth and individual success by meeting each student where he or she is, and assisting in the learning process.
- It provides the opportunity for students to learn at their own pace, in their own way, and be successful.

Purposes of individualised strategy

Every student is an individual and a class of students is heterogeneous regarding background and prior knowledge of a subject. Self pacing helps to smoothing the initial inequalities in a group. Students can be diverted to complementary study packages remedial material, materials constructed for specific needs or study in small groups of two or three. Individualised learning includes a variety of practices that enables a student, on his own, to formulate problems, finding answers through systematic procedures of reference work, hypothesizing, experimenting , field work etc and evaluate one's own progress and achievement.

Principles of Individualized Instruction Strategy.

1. Make the students clear about the key points and generalization to make sure that all learners gain a powerful and strong understanding so that they can have a good foundation for their future learning. Teachers are encouraged to identify essential concepts and instructional focuses to ensure all learners understand.
2. Use assessment as a teaching tool to extend versus merely measure instruction. Assessment should occur before, during, and following the instructional episode. The assessment carried out before and during can be incorporated into classroom practice; it provides information needed to adjust teaching and learning while they are happening. E.g. Observation, questioning strategies, self and peer assessment, student's record keeping. The assessment carried out before and during instructional episode is called formative assessment. And the assessment evaluated after instruction is called summative assessment. It is carried out every few weeks, months, or chapter tests. E.g. End of unit or chapter tests, end of term or semester exams.
3. Emphasize and stress more on critical and creative thinking while designing a lesson. Whatever task and activities that we provide to the students should be up to the student's level and understanding, so that they can understand easily and will apply meaning. Instruction may require supports, additional motivation, varied tasks, materials, or equipment for different students in the classroom.
4. Engaging all learners is essential. We should engage and make the students participate in class activities. For that teachers should develop their lesson to engage and motivate the students.
5. Provide a balance between teacher-assigned and student-selected tasks. If there is a balance between the task and activities that are assigned by the teachers and the tasks selected by the students, the learning will be most favorable and desirable.

Advantages of Individualised instructions

Advantages for **students**

1. It enables the students to proceed at their own pace through the study of each subject
2. It permits the students to get an immediate response and greater sense of satisfaction
3. It enables the students to understand better the structure of the subject he is studying

4. It enables indepth study of a various aspects of the subject
5. It enables a student to proceed in a subject as far as his ability will permit.

Advantages for the **Teachers**

1. It frees the teacher from teaching many of the routine basic skills of a subject
2. It enables him to meet more accurately the instructional needs of each students
3. It furnishes the teachers with diagnostic devices
4. It allows him to spend more time with students who need the most help
5. It enables the teachers to bring a structured carefully thought out programme to the students
6. It helps the teachers to serve as a guide to the students activities

Disadvantages of individualized instruction

1. Time and effort in planning and developing materials to suit individual needs will be greater compared to a class centered instruction
2. Appropriate resource materials may not be available
3. Requires specialized skills to assess the needs of each students
4. Requires individualized evaluation strategies

Types of individualized instruction:

Individualised learning generally takes up some of the following forms-assignment work, laboratory work, reference reading, programmed learning, mastery learning, learning by Keller plan, learning through audio-visual aids and computer assisted instructions

1. Keller plan: This strategy advocates the use of sequential set of self study units pursued by each student at his own pace
2. Programmed Instruction: Programmed learning is a self instructional self corrective technique in which all the leaning material is presented to the learner stage by stage through sequentially arranged smaller units called frames.
3. Computer assisted instruction: This type of instruction provides flexibility for individualizing the educational process. It makes use of computers in imparting education
4. Mastery Learning: The underlying assumption of this approach is that most students can master a major portion of the syllabi if enough time is given

Conclusion

Individualised instruction comes in many forms, all of which seek to improve instruction in some way. It has the potential to improve instruction by varying the pace of instruction, the instructional method, and content. Most approaches allow for self pacing, yet variation in method and content are rare. If implemented properly individualized instruction proved to be a good method to improve students' accomplishment substantially.

PROGRAMMED INSTRUCTION

INTRODUCTION

- Programmed Instruction or Programmed Learning is one of the important innovations in the teaching-learning process.
- The term *'Programmed Learning'* has been coined from principles of operant learning, developed in psychological laboratories on the basis of experimental studies conducted on animals by B.F Skinner of Harvard University (1943).

DEFINITIONS

- "Programme*d learning refers to the arrangement of instructional material in progressive sequences". -Harold W.Bernard*
- *"Programmed learning is a systematic, step by step, self-instructional programme aimed to ensure the learning of stated behavior". -Edger Dale*
- *"Programmed learning is the first application of laboratory technique utilized in the study of the learning process to the practical problems of education". -Skinner*

Assumptions Regarding (About) Programmed Instruction:

The programmed instruction has the following basic assumptions:

- The student has learnt micro teaching procedure.
- The student learns better if the content matter is presented in small steps.
- The student learns better if he/she is motivated to learn by confirming the responses.
- The student learns better if he/she commits minimum errors in learning.
- The student learns better if the sequence of content is psychological workable.
- The learning may be effective if the pre-requisites are specified on part of the learner.

Concept (Origin) of Programmed Instruction:

- The origin of modern programmed instruction is from the psychology of learning and not from technology.

- It is an application of operant conditioning learning theory to teaching-learning situations.
- It has got a historical momentum, after the publication of "The science of learning and art of teaching" article by B.F. Skinner. In this article, Skinner listed the problems of education system. He also discussed the potential of instructional programs to provide more feedback.

CHARACTERISTICS OF PROGRAMMED LEARNING

- ❖ The content is broken into small step and each step is presented in several sentences, each step is called a *frame.*
- ❖ The frames are arranged sequentially.
- ❖ Most of the frames require that the learner makes some kind of responses-an answer to a question, an activity to demonstrate the understanding of the material.
- ❖ The student is provided with immediate confirmation of the right answers (i.e.) the learner is provided immediate reinforcement.
- ❖ In case he is correct, his response is reinforced and if he is wrong, he may correct himself by receiving the correct answer.
- ❖ It is the interaction between the learner and learning material which is emphasized in programmed learning. Here, the learner is active and is motivated to learn and respond.

FUNDAMENTAL PRINCIPLES OF PROGRAMMED LEARNING

Basic principles of programmed learning are as follows:

a. Principle of Small steps

b. Principle of Active responding

c. Principle of Immediate confirmation

d. Principle of Self-pacing

e. Principle of Student evaluation or Student testing

a. Principle of Small steps:

- The subject matter is broken down into a sequence of small step.
- A student can take a step at a time.

- He has to read a small step by being active.

b. Principle of Active responding:

- Programmed learning is based on the principle of active response.
- A student learner better if he actively participates in the lesson and he learns best if he is actively responding while learning.

c. Principle of Immediate confirmation:

- The student learns the best if this confirm his response immediately.
- The confirmation provides the reinforcement to the learner.

d. Principle of Self-pacing:

- In programmed learning each student proceeds at his own rate or pace.
- Some students naturally learn more rapidly or more slowly than others.
- One learns most effectively if one learns at one's own pace.
- This principle is based on individual differences in the process of teaching and learning.

e. Principle of Student evaluation or Student testing:

It helps the students to learn and grasp the material given in each frame.

The aim of this arrangement is not to test the student but to improve the quality of programmed materials through checking the number of errors at each step.

TYPES OF PROGRAMMED LEARNING

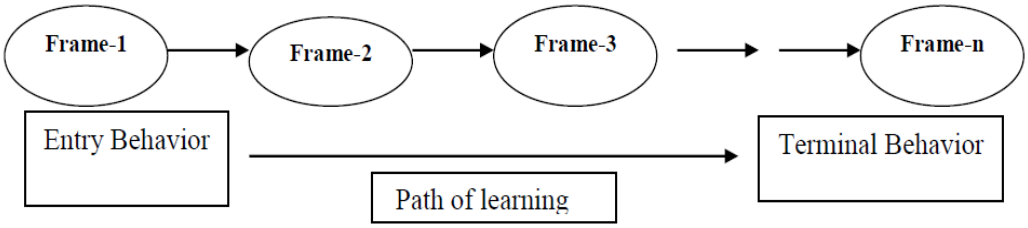
1. Linear Programming/ Skinnerian Programming
2. Branching Programming/ Crowderian Programming
3. *Mathetics Programming /* Thomas F. Gilberterian Programming

1. Linear Programming/ Skinnerian Programming

- ❖ This was developed and used by B.F Skinner and his associates (1954).
- ❖ In this type of programme, every learner starts from the initial frame and ends at the terminal frame following the same sequence.
- ❖ Every student must go through each and every frame in a straight line fashion- hence it is called as a linear programme.

- It is also called single track programme.

Structure of Linear Programme



PRINCIPLES OF LINEAR PROGRAMMING

1. Principle of Small steps
2. Principle of Active responding
3. Principle of Immediate confirmation
4. Principle of Self pacing
5. Principle of Student testing

CHARACTERISTICS OF LINEAR PROGRAMMING

1. A linear programme is a single track or a straight line programme.
2. In this programme, learning material is presented into a series of small steps (frames).
3. Every learner follows the same path in a linear programme.
4. In a linear programme, the learner is given a small programme and a small amount of information.
5. The sequence of steps remained unchanged.
6. The learner is expected to compose his own answer to each question.
7. The learner is expected to respond actively to each step or frame.
8. The responses of the learner get immediate reinforcement.
9. Linear programme provides for self pacing i.e. one can learn according to one's own speed.
10. It moves slowly but a steadily in leading a learner from initial to terminal behavior.

11. In a linear programme, the programmer controls the response of the learner.
12. In a linear programming, the linear learners by avoiding the error.
13. Immediate knowledge of results acts as a great motivator and release anxiety and tension.

LIMITATIONS OF LINEAR PROGRAMMING

1. In linear programming every learner has to follow the same linear path.
2. It can be used only to achieve the lower cognitive objectives. The psychomotor and affective objectives cannot be realized by linear programming.
3. It doesn't provide the freedom to the learner for emitting the responses. It generates controlled learning situation.
4. The linear programme does not suit to the creative or bright students. (Crowder says that linear programming is an insult to intelligent students).
5. It is difficult and time consuming process to develop and prepare a good programmed instruction material.
6. It encourages guessing.

2. BRANCHING PROGRAMMING/ CROWDERIAN PROGRAMMING

- Branching programme was developed by Norman. A Crowder, hence it is also known as Crowderian Programme (1954).
- In comparison to linear programming the frame size and amount of information given is more and is followed by multiple choice type of question.
- Out of the choices, only one answer is correct.
- If the learner chooses the correct answer he is informed of the correctness of the answer and is motivated to proceed to the next frame along the main path of learning of the programming.
- If the answer is wrong the learner is told why he/she is wrong and he/she either returns to the main line or he/she is routed back to the original frame to reread along a remedial frame till he chooses the right answer.
- In a branching programme all the learners do not follow frame route. Rather the route depends on the response made but the learner. Thus learners branch acc. to their responses.

PRINCIPLES OF BRANCHING PROGRAMME

The branching programme is based on the three fundamental principles:

1. Principles of Exposition:

- The learner should perceive whole phenomena which should be so exposed to him.
- It means a student learns better if the whole concept is presented to him.
- The complete information is provided on *Home Page*/or paragraph or a page.

2. Principle of Diagnosis:

- This principle refers to identify the weakness of learner.
- After exposition it is assessed whether he could learn the concept or not, if he could not learn what the causes are for it.
- A multiple choice format is used to diagnosis the weakness of the learners.

3. Principles of Remediation:

- The diagnosis provides the basis for remediation.
- The remedial instructions are provided on wrong page.
- If a learner chooses wrong alternative, he has to move to a wrong page.
- Where remedial instruction is provided to him a direction to return to home page. He is asked to choose the right response. It is known as principle of remediation.

CHARACTERISTICS OF BRANCHING PROGRAMMING

1. The instructional material is divided into frames in each frame, information running into one/two paragraphs or even a page is provided.
2. After going through the frame, the learner has to respond to a multiple choice question. He has to discriminate among the choices provided and choose a correct response.
3. The learner moves forward if he answers correctively but is diverted (branched) to remedial frames if he chooses the wrong answer.
4. This cycle goes on till the learner passes through the entire material at his own pace.
5. Branching programme can be produced in a teaching machine or in a book form.

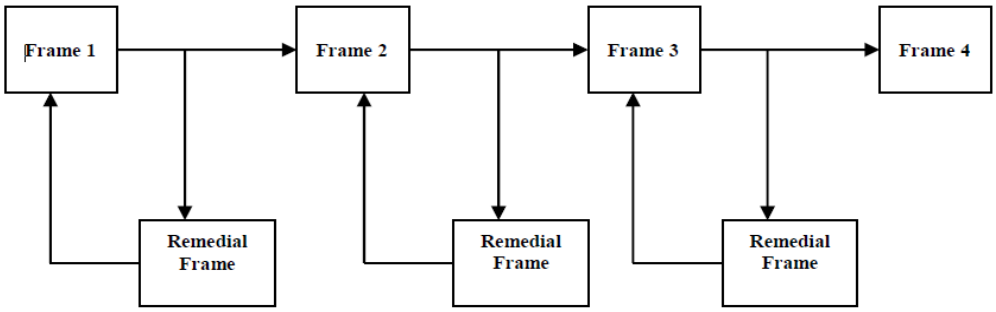
The book will be in the form of a *scrambled text* as the matter does not follow a normal sequence.

TYPES OF BRANCHING PROGRAMME

a. Backward Branching

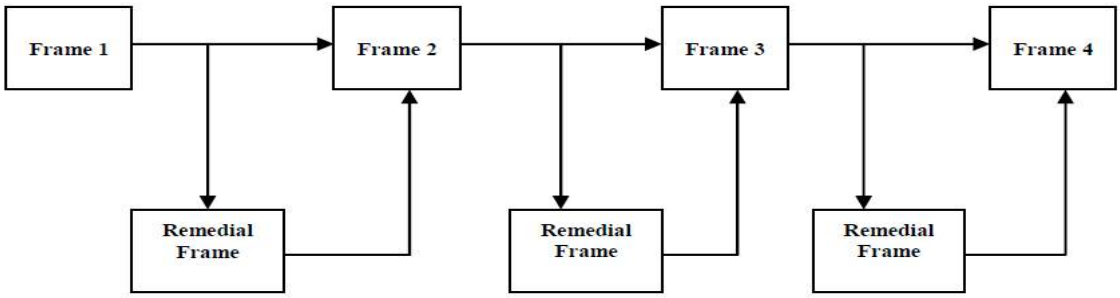
b. Forward Branching

a. Backward Branching:



- As shown in the diagram the learners of frame No.1 of the stream goes to frame No.2 of the main stream only if he makes a correct choice.
- But if he makes a wrong choice, he is led to a remedial frame where in he is given some more help in understanding the concept and in solving the solution by a better logic.
- He will be then directed to the original frame No.1. So that he can read it again and answer it correctly in the light of the remedial materials he has received.
- So the learner who has committed error goes through the same frame twice. (Once before the remedial material and once the after the remedial material).

a. Forward Branching



- In this type of programming, the learner is always going forward to a new page irrespective of his choosing the right or wrong answer.
- When he makes a wrong choice, he is directed to a remedial frame where his mistake is explained.
- At times the learner is asked another parallel question and then after he gives the correct answer the learner proceeds to a new page.

LIMITATIONS OF BRANCHING PROGRAMMING

1. The multiple choice questions provided in this programming may lead to guess work on the part of the learner and he may not understand the subject matter on the frame.
2. The setting of appropriate multiple choice questions suiting to the entire materials of the frame proves a difficult task.
3. The cost of branching programme is very high when compared with traditional teaching approaches.
4. It is difficult to cover the entire subject matter.
5. It is suitable only for high school (older) children, not suitable for small children.

DIFFERENCE BETWEEN LINEAR AND BRANCHING PROGRAMME

Aspect	Linear Programme	Branching Programme
1.Propenet	*B.F Skinner(1954)*	*Norman A. Crowder (1954)*
2.Learning theory	Operant conditioning based on response centered approach	Configuration theories based on learning i.e. Stimulus centered approach
3.Principles	Five fundamental principles: Small steps, Active responding, Immediate confirmation, Self pacing & Student testing.	Three fundamental principles: Exposition, Diagnosis, Remediation.
4.Application	Modification of behavior	Remedial to the difficulties of the learner.
5.Frame size	Small steps-1 or 2 sentences	Large step-one or two paragraphs /one page.

6.Number of steps	Large	Small
7.Response	Constructed response- controlled by programmer (fill up the blanks type)	Multiple choice-choosing controlled by learner.
8.Purpose of response	Fixing of learning	Measurement/ Diagnosis of learning.
9.Reinforcement	Confirmation of correctness of response- wrong response is ignored.	Correct response is confirmed and approved and wrong response is remedied.
10. Utility and appropriateness	i) Lower classes. ii) Knowledge & understanding objectives. iii) Normal & less intelligent students.	i) Higher classes. ii) Higher order teaching objectives i.e. analysis, problem solving etc. iii) Talented & creative pupils.

***4. MATHETICS PROGRAMMING /*GILBERTERIAN PROGRAMMING :**

This Instruction was developed by **Thomas F. Gulbart**. The methetics word is taken the Latin word **'Methin'** which means '**Learning**'. It is related to transfer of learning. In this method motivation is essential factor. It gives more emphasis to the actives of learner instead of content. The main objectives of methetic programming is 'Mastery of content'. Actually, it is a new concept.

In this programme the whole content is arranged systematically in a linear form. For the study of this linear form student create many activity. Pre-planned activities are done after the last activity. For this activities going on methetic sequence, on the basis of this it is called Methetic programming.

According to **Thomas F. Gilbert,** "Methetics is the systematic application of reinforcement theory of the analysis and reconstruction of those complex behaviour repertories usually known as subject matter mastery, knowledge and skills ..... methetics if applied diligently, produces teaching material that exceed the efficiency of lessons produced by any known method."

Characteristic of Methetic Programming

Methetic programming have following characteristics :

1. It gives emphasis on the mastery of content.
2. In this presentation of content in a small frames, which are helpful to understand the student.
3. In this programme student gain the mastery of content in the absence of the teacher.
4. The responses of students are in decreasing order.
5. In this method use the discrimination, chain and generalization to the achieving the learning.
6. For the each correct response student gain reinforcement, which is helpful to motivation.

Assumptions of Methetic Programming

Some assumptions are :

1. This instruction is more effective to motivating task.
2. This instruction is more useful to mastery of content.
3. The structure of content is decided by the stimulus and response.
4. Reinforcement gives success of works.
5. Discrimination, generalization and chain are more effective in the learning situation.

Principle of Methetic Programming

Three principle are essential to the presentation of lesson :

1. Law of chaining
2. Law of Discrimination
3. Law of Generalization

1. Law of Chaining–In this content is presented in a one sequence. We can present the element of stimulus–response from for the analysis of content. Each response are work to stimuli of next step. For example :

Stimuli (1) → Response (1) → Stimuli (2) → Response (2) → Stimuli (3) → Response (3)

$$S_1 \rightarrow R_1 \rightarrow S_2 \rightarrow R_2 \rightarrow S_3 \rightarrow R_3$$

2. Law of Discrimination–Where the response and stimulus are different type then we use law of discrimination. For example–

$\text{Stimulus}_{(1)} \rightarrow \text{Response}_{(1)}$

$\text{Stimulus}_{(2)} \rightarrow \text{Response}_{(2)}$

$\text{Stimulus}_{(3)} \rightarrow \text{Response}_{(3)}$

3. Law of Generalization–When one response is used for different stimuli then law of generalization is use. For example–

$\text{Stimulus}_{(1)}$

$\text{Stimulus}_{(2)}$

$\text{Stimulus}_{(3)}$

Preparation Method of Methetics Programming

It has five steps :

1. Data collection and task analysis
2. Assessment of students characteristic
3. Characterisation and lesson plan
4. Exercise Writing
5. Editing

1. Data Collection and Task Analysis–In this step contents are analysed into the elements and it is synthesied. The whole process is done by a systematic way.

2. Assessment of students characteristic–In this step find out the mistake and characteristic of the student and then control it.

3. Characterization and Lesson Planning–In this step prepare the lesson plan. For this purpose analyse the chapter in a broad way.

4. Exercise Writing–Whose content are taken in lesson plan, prepare a questionnarire to that lesson which are helpful to mastery of content.

5. Editing–Editing are two type :

(i) Copy Editing

(ii) Empirical Editing

In empircal editing student feel the difficulty in stimulus response, then remove the difficulty by this method.

From above shortly presented,

- The founder of Mathetics is Thomas F. Gilbert. "Mathetics is defined as a systematic application of reinforcement theory to the analysis and construction of complex repertoires which represent the mastery in subject matter." It is based on connectivist theory of learning. It is a reverse chaining approach. It is based on Principle of chaining, Discrimination and Generalization.
- Mathetics programming is based on following assumptions.
  1. Chaining of responses helps in learning to reach up to mastery level.
  2. Reverse chaining of stimuli helps in learning, i.e. from whole to part, from Complex to simple.
  3. Completion of task provides motivation to students.
- Frames size is organized in small step but in a reverse chain i.e. from complex content to its small, simple units to attain mastery level; Frame structure is based on Demonstration-prompts-release. There are two types of frames- 1. Demonstration frames 2. Prescription frames.
- Responses are structured responses and responses determined by the programmer. Completion of task provides reinforcement. Wrong responses are ignored. Error helps in discrimination but not in learning. Its main purpose is to develop mastery of the content. Main focus is on Mathematics and grammar.
- It used for higher classes useful for complex and difficult task. It is useful for developing concepts of mathematics and grammar. It can be used in Distance Education.

Limitations of Mathetics programming:

1. Main emphasis is on mastery of the content rather than changes in behavior of the learner.
2. Retrogressive chaining of stimuli if not effective for terminal behavior. 3. It is very difficult to develop retrogressive learning package.

Advantages of Programmed Instruction

Following are the advantages of this teaching strategy

1. The main emphasis is on individual differences and students' involvement.
2. There is not fixed time interval for learning. Students may learn at their own pace.
3. Learning by doing maxim of teaching is followed to involve learners in the learning process.

4. Students are exposed only to correct responses, therefore, possibility to commit errors in reduced.
5. Immediate confirmation of the results provides reinforcement to the learners and encourages the learners to proceed further. Feedback is provided to wrong answers, so that learner is able to develop mastery over the content.

Disadvantages of Programmed Instruction

1. It is very difficult to develop an instructional programme

2. Only cognitive objectives can be achieved

3. Due to tight schedule of time table, students cannot be left to learn at their own pace. It would be very difficult to learn the content the subject matter in a limited period of time.

4. There is no chance for students' creativity, their responses are highly structured.

5. Development of programme is not economical in terms of cost and time

6. In absence of the teacher, students may spoil the disciplinary tone of the class, or they will be helpless when any problem arises.

7. It cannot be applied at primary level of education or at higher education

Suggestion for this Teaching Strategy

1. A programmer should have thorough knowledge of the content and technique of content analysis.
2. This strategy should be used as a supplementary device for remedial teaching in the class room.
3. It should be used in distance education or continuing education programs where no rigid time table is applied.
4. If no at a primary level or higher level of education, this strategy may be useful at secondary level of education where many new subjects are introduced in the curriculum and they create problems in learning.

If applied in classroom teaching, teacher should be present in the class. He can maintain discipline in the class and help in eradicating the difficulties of the learners. Personal touch of the teacher can be more fruitful and effective in student's learning.

MATHEMATICAL TEXT-BOOK

"Text-book is a book designed for classroom use." —*Becon*

In each subject text-book is an essential aid and has occupied a pivotal role in educating the children. Text-book is a way of learning which is used, to complete the teaching programme in school and colleges. On its basis a direction is obtained to classwork. In this sense text-book is an important and useful apparatus of the teacher's hand, which is essential to effective teaching. Achieving or gaining of knowledge from the direct experiences and others experiences. Through text-book we gain knowledge from other experiences. So, text-book is the main teaching aid of teaching-learning process. Hence,

"As the text-book, so the teaching and learning."

Meaning of Text-book

According to **Lang,** "It is a standardized book for any branch of study area."

According to **Raymont,** "The text-book must be regarded as strictly subordinate and supplementary to teacher's lesson."

A text-book contains the subject matter according to a plain and with a specific purpose. The text-books are the keys of knowledge and considered almost synonymous with schooling. These are the most influential instrument in determining the subject matter and the approach of teaching and learning. A text-book is a planned collection of all those content which has to be taught to the students of a certain stage or age level.

In the text-books subject matter is presented in a well planned way to facilitate the learning of new concepts and skills and to maintain the knowledge already acquired. Therefore the text-books are the keys of knowledge and considered almost synonymous with schooling.

According to **Kothari Commission,** "The question of text-book is the most important and urgent one for our country. Energetic on state and national basis is required to progress the preparation of high quality school text-books."

HOW TO USE THE TEXT-BOOK

The text-book is valuable only when it is used in proper way. The text-book should not be used as the only source of instructional material. It should be used as an aid in teaching, not a substitute for teaching. It is a means and not an end in itself. Its place in teaching can only then be real if the teacher supplements it by his oral exposition, by reference reading and by all his illustrative and objective techniques. It should be followed carefully and not lavishly.

An average teacher, the text-book is all his stock-in-trade. The greater the capacity, knowledge, professional training and experience of the teacher, the less he needs to depend on his text-book. The contribution of the text-book can be increased by creating situations, where the pupils have a real purpose for turning to the text-book.

Need and Importance of Text-book

"In the analysis with great majority, the text-book is a potent determinant of what and how they will teach." —***Hurl R. Duglas***

In mathematics teaching we can demonstrate the need and importance of text-book in the following ways :

1. For the guidance of teacher–Text-book is helpful for the guidance of teachers. It provides certain well illustrated examples which work as guide to the teachers as well as to the students. It also suggests possibilities of correlation and related project activities.

2. Economical–Text-books are cheaper than other teaching material or aid or sources, so each student can purchase of easily which are helpful in increasing their knowledge.

3. For preparing the complex work to easy–Mathematics is a complicated and difficult subject. So it is essential to read the text-books to make it easy. In this the whole curriculum is in a sequence. This sequence is from 'Simple to complex.'

4. For preparing the outline–By the help of text-books both the pupil and teacher get the outline of curriculum the area of study is decided.

5. For planned and systematic teaching–A text-book contains various topics in a proper sequence. It also suggests the steps of planning, suitable method of teaching and appropriate illustrative material to the teacher.

6. Study Facility–Text-book provides the faculty of various types of study at one time. In which the pupil or student can achieve knowledge according to his requirement or need.

7. Opportunity of use as per requirement and desire of pupil–Text-book plays the role of teacher out of classroom. If a student wants to

understand and clear something which he could not understood in the classroom, he may consult the text-book. It also contains some solved problems which are helpful to students in solving the other similar problems. Thus, a student can use the text-book as per his requirement.

8. Useful for mentally retarded and backward children–Text-books are more useful to those children who can not proceed with other students in the class. This type of students are called backward children. Their speed of learning is slow. With the help of text-book they learn and proceed according to their capacity. Thus, text-book helps them as a teacher at home.

9. For Reference material–Text-book also serves as a reference book to the teacher and the students because it is most reliable source of information to them. Text-books are generally written by experienced teachers and references are quoted about original source of informations. So, if required a teacher may consult the original references given in the text-book.

10. For evaluation–Evaluation is an important part of education. Most of teachers are unable to construct a good achievement test. Text-book helps in the selection and construction of various types of problems for a test.

11. Helpful in the self-study–Text-book is very helpful in the self-study. When a student is eager and highly motivated, he can learn a topic in advance with the help of text-book by self-study. If there is any doubt he may clear it in the class. Self-study of the topic by the students in advance is helpful to teacher in the development of lesson. It saves the time of the teacher. Text-books are also quite useful to those students who remain absent from the class due to any reason.

Instead of this text-books are also useful or important by following ways :

1. It stimulates the thinking and reasoning in the minds of pupils beside supplying necessary information.
2. It helps in improving teaching efficiency.
3. It helps in saving time and energy.
4. It helps to solve the problems given in the exercise by understanding the solved examples.
5. The mathematics teacher can assign homework and assignment to the pupils.
6. It is probably a cheapest and reliable source of information.
7. It helps the teacher in teaching and correlating mathematics with other subjects and aspects.

On the basis of above points it can be concluded that text-book occupies an important place in the classroom teaching. A good text-book of mathematics provides not only the content of mathematics but also determines the methods of teaching.

Essentials of a Good Text-book

Text-book helps the teacher to know what he has to teach. It helps the students to revise what has been taught to them in the classroom. But, only a good text-book can be helpful in this matter.

According to **Hall Quest,** "A good text-book is a source of knowledge, a guide, an instruction to the pupil, a tool, and a means of interpreting truth. Hence, there are certain criteria for a good mathematics text-book :

1. It should be easily available in the market.
2. The subject matter should be arranged from simple to complex and concrete to abstracts.
3. The symbols and terms used must be well recognised and authorised.
4. The language used should be simple and clear.
5. The author of text-book should be well-qualified and experienced in the subject.
6. It should conform to the recommendations of important committees.
7. Text-book should have relevant, simple and pin-pointed title.
8. The language of text-book should be easy and within the comprehension of the students for whom the text-book is written.
9. The content of the text-book should be consistent with pupils needs, interest and previous knowledge.
10. The statements of facts, principles, laws and the theorems must be correct.
11. The external appearance of a book- i.e. its get-up, paper and printing should be good and attractive.
12. A good text-book of mathematics should be written according to aims and objectives of teaching of mathematics.
13. It should contain sufficient number of examples to motivate the students to solve the problems given in exercise work.
14. There should be suggestion for students to improve their study habits.
15. It should be moderately priced so that every student can have it.
16. The shape and size of the text-book should be proportional neither too large nor too small.
17. The exercise should develop thinking and reasoning power of the pupils.

18. A good text-book of mathematics should mention the audio-visual aids and other supplementary reading materials.
19. There should not be any irrelevant matter.
20. It should conform to the recommendations of important committees.

Utility of Text-book

The mathematics teacher should not consider that his/her work is confined to transferring the contents of text-book into the minds of the pupils. The text-book of mathematics should not be allowed to dominate the teaching programme. In mathematics teaching it can be used in the following ways :

1. For using Lesson Introduction–Success of teaching depends upon the law of readness of the students. In the process of learning motivation plays an important role. Teacher should motivate and mentally prepare the students before teaching the lesson. It is difficult way that any lesson start in a interesting way. So the text-book can be used as a effective medium for the introduction of a new lesson.

2. For self-study–Both teacher and students use the text-books for self-study. By this teacher acquire new methods and new teaching material can make their teaching work more effective.

3. In the laboratory–Sometimes the experiments given in the book without the help of the teacher can be given to the students. By this self-confidence can be developed in them.

4. For the class work and home work–Experienced teacher evaluates the progress of student or pupils on the basis of the good quality questions present at the end of the topic on books.

5. For the construction of Question Paper–From the text-books we known the mental and intellectual level of the students. On the basis of given examples and questions in the text-book teacher constructs the question paper.

6. For Using the illustration diagrams–Teacher uses chart, model etc. teaching aid to explain the lesson. By this teaching becomes effective and permanent.

7. For revision of previous chapter–After the ending of a lesson it is necessary to revise the most important points of that chapter. By this the progress level of student is known, that how much he learns?

8. For the helping retarded students–Normal child easily learns any work but for retarded children more attention is required, but always it is not possible that teacher can give attention to them. For this the text-book provid them help.

Hence, text-book is a source of more effective knowledge on the basis of this **Douglas** says that, "The teacher and text-book make the school."

Characteristics of Text-book

Text-books are important for both teacher and students because it is a medium or way of learning which is used to run the teaching programmes in schools. Text-book increased the research and scientific attitude in the students, so the text-books should have following characteristics:

1. Author of Text-book–Before purchasing a text-book it should be seen that how much is the academic qualification of the author, how much knowledge of the language? etc. Author's qualifications and training ability should be good. For writing the book of mathematics teaching it is essential that the author has the knowledge of various techniques. He should have the knowledge of teaching process. For this he can demonstrate the current knowledge in front of pupil by the help of text-books.

2. The size of text-book–Text-book is not only write in good but its paper, cover, prining etc. should also be good. Title should be printed in bold letters. There should be no mistake in printing. The shape and size of text-book should be proportional neither too large nor too small. It should be handy.

3. Based on syllabus and subject matter–Text-books should include the whole curriculum decided by the education department. For this the following points should be kept in mind:

(i) The mathematics text-book should be favourable to the objective of teaching.
(ii) It is very essential that at the beginning of each lesson or chapter there should be an introduction and at the end a summary in a text book.
(iii) At the end of each lesson there should be assignment.
(iv) Title and sub-title should be written on bold and clear letters.
(v) Text-book should be favourable to age, class and intelligence of the students.
(vi) The subject-matter should be arranged from simple to complex and concrete to abstracts.
(vii) Proper examples should be used to explain the facts and theories.
(viii) The statements of facts, principles, laws and the theorems must be correct.
(ix) In the beginning of each text-book, an index is essential, which are helpful for learner.

4. Language of Text-book–In a good text-book the language should be according to age and mental level of the students. In other words the

language of mathematics text-book should be easy and within the comprehension of the students. The sentence should be simple, short and correct. The text-book of mathematics should be written in lucid, simple precise and scientific language.

5. Selection of the best and new teaching methods–In the text-book for the proper guidance of pupils and teachers it should emphasise the modern and technical methods as project method, laboratory method, lecture-demonstration method etc.

6. Uses of pictures and diagrams etc.–In other sense it is called the teaching aid, which is helpful to achieving the knowledge of child. It is a necessity of teaching. In mathematics book various apparatus, pictures, models etc. should be demonstrated according to the needs. They should be printed in proper places. If possible then the picture should be coloured.

Instead of these characteristics some characteristics should also kept in text-book, that is :

- The problems should be graded in difficulties at the end of each chapter.
- The exercises should develop thinking and reasoning power of the pupils.
- The illustrations should be attractive and useful.
- At the end of book there should be tables and appendices.
- New terms and concepts should be accurately and clearly defined.
- The contents should contain only the established facts aiming at shaping integrated modern world out look.

According to this **Maxwell** says that, "Text-book is at least the medium through which the teacher presents a subject to the class."

Selection of Text-books

"The text-book is probably the most important tool in this country."
—Barr and Burton

There are so many text-books available in the market on the same course of study. Selecting the text-book it should be kept in mind whether it is completing teaching tools or not. To select an appropriate text-book for the student is a very difficult task. The teacher has to select those book which is useful to students. For selection of a good text-book following criteria are helpful:

1. According to Syllabus–While Selecting the text-book firstly it should be seen that whether it is according to the syllabus or not. If the book is not according to the syllabus then it is not useful to the students. Subject matter should be according to the standard of students in the text-book. In this maxims of teaching is from simple to complex, from known to unknown, from specific to general and from example to formula etc.

2. Organisation–The organisation of text-book can be done by two types :

(i) Logical Organisation

(ii) Psychological Organisation

(i) Logical Organisation–Its base is text-book and according to it various parts are written in systematic way. It is more useful for higher classes.

(ii) Psychological Organisation–Its centre point is student. Its base is student's interest, age, intelligence and experience. It gives more emphasis on developing scientific attitude at secondary level. It is more useful to the logical organisation.

3. Writer of the Book–The text-book should be always written by the capable, experience and subject knowledge writers. He or she should be expert of the subject and have specialisation in that subject. The writer should have all the information related to the book he is writing.

4. Language Style–The language of text-book should be simple and clear. His presentation style is interesting and comprehensiable, use of well defined and authorised technical words, free from errors and mistakes, comprehensiable illustrations and readable. The text-book should not have longer sentences, because the child feel difficulty to understanding them. So the length, structure, etc. of the sentences should be is clear and short form.

5. Picture and Illustration–The mathematics text-book is incomplete without pictures and illustration. So it gives more emphasis in their quantities. In some books the pictures, graph etc. are unclear by which the students face difficulty to understand them. Hence, it is kept in mind that the picture, maps, graphs etc. are effective.

6. Printing of the Text-book–The printing used on the text-book should be good and along it the size of the words should be big. The title should be printed in bigger size. The printing should be in straight words. The use of ink on printing should be in same quantity. The type of print according to age group of students. The printing should be good and mistakeless and clear printing of figures and graphs.

7. Mechanical make-up and appearance–As it is said that first impression is the last impression. Like this the first impression of the text-book is due to its mechanical make up and appearance. The cover of book is based on its paper and typing size. Following precautions are kept in mind for the mechanical make up and appearance:

- The paper used on the text-book should be of good quality.
- It should not much bigger or much smaller in size.

- Its printing should be clear, dark and correct.
- The binding of text book should be solid.
- The text-book should be moderately in price.

Procedure for text-book selection in India

In different state of India, various processes are use in the selection of text-book at their objectivity. But all of these are used in reviewer's form. Indian Government published it on the medium of minastry or education and scientific research. On the basis of this reviewer give the explanation.

Reviewer's Form–

(1) Syllabus

(i) Are the instructions being followed during writing time? (If given then)
(ii) Are the text-books according to current curriculum?
(iii) Are the outer things added in the current curriculum? (If any then tell us)
(iv) Are the distance to any where in curriculum? (If yes then tell)

(2) Subject-Matter

(i) Is some importance given to various types.
(ii) Are facts incorrect at any place? (If any then tell).
(iii) Are some things there which are harmful to persons?
(iv) Are the some which as harmful to molarity or politicaly?

(3) Treatment of Subject Matter

(i) Is the text-book divided into appropriate teaching points and are these teaching points are organised on better way?
(ii) Are the topics correlalated?
(iii) Is the presentation of text-book according to the objectives and instruction of the curriculum?
(iv) Is the language easy, appropriate and correct? (If not then tell)
(v) Is the special thing in the presentation of syllabus?

(4) Teaching Aids

(i) Are the proper work in books, by which we can known the achieve knowledge and evaluation to the students?
(ii) Are this work is proper, ptype, proper level and full of intelligence?
(iii) Is the proper illustration in books?
(iv) Are the diagram etc. are natural and pure which attract the students?

(5) Mechanical Aspect

(Only for published books)
(i) Is the paper of book good quality?

(ii) Is the printing good, clear and attractive?
(iii) Is the binding satisfactory or not?
(iv) Is the proper distance in between printed two lines? (For easy learning)
(v) Is there proper distance in between the words?

Note—End of each explanation of book should be acceptance or rejection of reviewer. If it is rejected then write the causes of this rejection.

Evaluation of Text-book

Most of the text-books of mathematics are not according to the nature of the subject. Books are only information of scientific knowledge. by which scientific interest and scientific attitude are not developed.

Teacher should evaluate the text-book before the purchase of book by the students, so we pay attention following points in evaluation :

1. Size according to Content

(i) Outline Related to text-book
(ii) Selection of syllabus
(iii) Presentation of syllabus
(iv) Uses the teaching-learning materials

2. Physical Basis

(i) Size
(ii) Quality of used paper
(iii) Size of type
(iv) Printing
(v) Lay-out
(vi) Binding
(vii) Values

On the basis of above points we focuse main points:

I. Planning of Text-Book

(i) Page number in the book
(ii) Appropriate the unit for the clarification of syllabus.
(iii) Completion of the units teaching made.
(iv) Logical sequence of teaching units.
(v) Whole Curriculum
(vi) Give summary at the end of the lesson.

II. Selection of Text-book

(i) Helpful to developing the attitude of socialization.
(ii) Helpful in the development of view point related life conservation.

(iii) Form of the previous and future classes syllabus.
(iv) Appropriate to subject teaching at definite time.
(v) Selection of vocabulary to the interest, age and maturation of the subject.
(vi) Based on the previous knowledge of students.
(vii) Based on algebra.
(viii) Use the norms vocabulary.
(ix) Including the new factors, process and concepts.

III. Presentation of Text-Book

(i) Developmental view
(ii) Encouragement of the observating attitude in the student by the syllabus.
(iii) Helpful in the development of investigate attitude.
(iv) It is related to scientific development, reinforcement, generalization, identification and practical utility according to syllabus.
(v) Equal to aim of mathematics.
(vi) Helpful to understand the concept of algebra.
(vii) Helpful in the development of problem-solving skill.
(viii) Helpful in the development of interest in mathematics.
(ix) Helpful in the development of scienctic attitude.
(x) Development of the concept of science in sequence.
(xi) Adequate aids is used for the motivation of the mathematics study to the students.
(xii) Based on the theories of learning.
(xiii) Effective communication.
(xvi) To use the easy and simple language.

IV. Teaching Learning Aids

(i) Adequate the examples, pictures and diagrams.
(ii) In the diversification presentation of examples, diagrams and pictures.
(iii) Diagram, picture and graph etc. are helpful to clearifying the syllabus.
(iv) Adequate, appropriate, learning exercise.
(v) Presentation of syllabus.

Functions of a Mathematics Textbook

A textbook is used as a primary aid in studying any subject or for a particular topic.

A Mathematics textbook –

i. Must contain relevant matter according to the syllabus.

ii. Must provide valuable knowledge and information collected from various sources.

iii. Must provide information in an organized manner, following the logical and psychological sequences.

iv. Must include solved examples, problems for review, problems for talented children and summary of the whole chapter.

v. Must explain basic concepts and facts in a simple way.

Organization of Material

The organization of textbook material consists

i. The subject should be developed in a sequential manner. Care must be taken regarding the level of maturity of the student in grasping the concepts.

ii. The textbook must be consistent with the objectives of mathematics teachings. It should try to impart problem solving nature and various approaches of solving a problem.

iii. Chapters should begin with introduction and end with summary. This provides a fast review and insight about the chapter.

iv. The headings and sub-heading should be self-explanatory.

v. Each textbook should have contents at the beginning and index at the end. This provides a quick search for a topic inside the book.

vi. Interesting problems and practice exercises must be included at the end of every chapter. Answers for every problem can be given at the end of the textbook.

vii. The used mathematical terms can be provided in glossary at the end of the book.

Demerit of Text-book

In mathematics teaching generally text-books are a good servant but a bad master. So its use should be limited. Following demerits are found in text-books :

1. Lack of Self-thinking–The students get the teaching material in arranged and logical form from the text-book. By this the self-thinking is decreased or lessended in the students. In this condition the study of students become memory centred.

2. Lack of broad and deep study–The text-book is only centred to syllabus, so the students are not motivated for the deep and broad study of any thing.

3. Lack of new achievements–In the field of maths new descoveries and achievements are found, but these achievements are not easily and frequently available in the text-books. Due to which both teacher and students are depried from the knowledge of achievements.

12.3 Workbooks in Mathematics

A workbook is a modification of the textbook and it is slowly coming into the mathematics classroom. A workbook should be written by an experienced teacher with care and foresight.

Functions of a Workbook

A good workbook serves the following functions;

- It suggests appropriate activities and exercises in addition to what the text book does.
- It saves time for the students as they need not recopy the problems and exercises from the textbook. It eliminates the mistakes due to the wrong copying of numbers and digits.
- It facilitates uniformity in students' work and facilitates easy correction of their work.
- It serves as a supplementary teaching device
- It provides opportunities for pupils to develop computation and problem-solving skills.
- It provides activities and exercises in addition to the textbook problems and exercises
- Slow learners can learn at their own pace.

Characteristics of Workbook

A workbook has the following characteristics:

- It should be written by an experienced teacher of mathematics.
- The author should clearly specify the educational outcomes that he tries to bring about.
- A variety of well-graded exercises should be provided for each topic
- Enough space should be provided in the book far working out the problems.
- The exercises should cater to the individual differences and individual needs.
- It should be accompanied by a list of answers to various graded assignments or exercises given in the workbook to enable the pupils to verify their answers.
- It can be made attractive and appealing by suitable illustrations and diagrams.
- Physical features of the book such as cover page, print, paper, and binding should be good.
- It should be reasonably priced.
- It should be easily available.

A textbook-cum-workbook, which is of American origin is gradually replacing the text book and workbook. It is cheaper and more comprehensive than a separate textbook and workbook. Since the textbook-cum-workbook is authored by the same person, a better coordination and integration of ideas is possible. However, it forfeits one advantage of the textbook, namely the scope for resale and reuse because a workbook once used cannot be reused again.

Mathematics Library

9.1 IMPORTANCE OF LIBRARY

Mathematics is quite a vast subject. Even if a teacher is to restrict himself to a certain amount of subject-matter according to a particular class, that too can be done in so many ways. A Mathematics teacher should not follow only the text-book. The teacher must study some standard books from the library. This will provide him a deeper insight into the subject and thorough command of the same. The teacher will be able to plan and organise his teaching in a better way, better than that given in the text-book.

Mathematics library is quite useful to the students. When students read or consult some books from the library, their doubts become clear. Moreover, the study of library books acquaints them with new exercises or problems and prepares them better for the examination. A good Mathematics library also helps in inculcating proper attitudes, interests and appreciations in the students. It can acquaint them with the historical background of different topics and the contribution of various Mathematicians.

Library Facilities in the School

In our schools, there are two types of libraries:

(*a*) General School Library.

(*b*) Mathematics Department Library.

(*a*) *General School Library*. In most of our schools, there is a general school library which contain books and magazines on all subjects. Then there should be separate sections for Mathematical books. For the teachers, there should be good books on methodology of teaching, historical background of topics and the contributions of famous Mathematicians. Some literature of Mathematical teaching can be obtained from N.C.E.R.T.

For the students, there should be books on recreational activities in Mathematics, well selected text-books some reference books and works of Mathematicians.

(*b*) *Mathematics Department Library*. If resources permit there should be a separate Mathematics library. It may be housed in Mathematics laboratory. The librarian or the incharge of it must classify the books properly so that the students do not find any difficulty in getting the books issued. Mathematics teacher should keep himself in touch with the latest books or magazines on the subject and make additions in the library. A number of copies of a good book should be purchased. A few copies of the prescribed text-books may be purchased for the use of poor students.

9.2 IMPORTANCE AND NEED OF MATHEMATICS LIBRARY

Importance of Mathematics Library

Library has a key role in scheme of education. Class room teaching must be supplemented with the dissemination of knowledge through library. In Mathematics the students are required to do a lot of practice work which they can do so most efficiently in Mathematics library. Different types of books in Mathematics library can help the students to tackle all types of problems emerging from different topics prescribed in their syllabus. They are also acquainted with different types of approaches in solving the problems.

Class room teaching sometimes leaves many gaps and doubts. They can be removed if the students make use of

good books available in the library. Mathematics teacher can help the students in the selection of good books in the library.

A Mathematics library, is not only a source of learning and inspiration for students but it also serves the need of the teachers. A teacher must keep his knowledge ever fresh and up to date, this is possible only by making a free use of Mathematics library. He can also learn the latest methods of teaching Mathematics from the new books available in the library. Thus, a good Mathematics library helps to keep the lamp of Mathematics knowledge burning so as to kindle light in the minds of the students as also the teachers.

Need of Separate Mathematics Library

In most schools, there is a general library in which all kinds of books related to different subject are kept. Such libraries serve purpose of encouraging the students to make use of library services, but the students cannot get proper guidance for removing their deficiency in a particular subject. For this a separate library of the subject concerned is essential. A separate library for Mathematics is a great necessity for rendering proper help to needy students. Such a library can be housed in Mathematics room and can be put under the charge of Mathematics teacher. There should be a period of library reading in the time-table so as to enable the students of every class to make use of the library. A separate Mathematics library is essential because of the following reasons:

(1) Separate arrangement of Mathematics library helps to bring efficiency in the organisation of library service.

(2) Mathematics teacher remains in constant touch with the latest books in Mathematics.

(3) It provides a sense of separate identity to Mathematics and helps to inculcate interest in the subject.

(4) The students get better library facilities.

(5) It helps the activities of Mathematics club.

(6) It can be of a help to gifted and bright students.

Thus, it is essential that all out efforts be made to establish a separate Mathematics library in every school.

Suggestion for Effective Use of Library

A well-equipped library is useful only when it is properly used by the teachers and the students. Suggestions given below will help in the proper use of Mathematics library:

(*i*) There should be an incharge of library books. Even if there is librarian, the Mathematics teacher should be actively associated with the functioning of Mathematics section of the library.

(*ii*) The Mathematics teacher should himself read library books, only then he can suggest books to the students.

(*iii*) While teaching in the class, the Mathematics teacher should make reference to related books or magazines in the library.

(*iv*) The teacher should give some assignments or work based on certain books in the library.

(*v*) The students should be involved in the maintenance and classification of library room.

(*vi*) There should be certain meeting of Mathematics club where the students have to study library books for active participation.

(*vii*) The Mathematics teacher should suggest Mathematical riddles and recreations from library books.

(*viii*) Library room should be made attractive by depicting pictures relating to the history, progress and application of Mathematics and portraits of eminent Mathematicians.

(*ix*) There should be proper display of the new books on the bulletin board, along with brief comments.

(x) There should be some provision in the time-table for library reading. Teacher should see that every student goes to the library and borrows books regularly, from the library.

(xi) There should be some sort of test based on suggested books from the library.

So we have seen that a good Mathematics library is quite useful for properly developing good study habits in students. Library also is quite useful to students for updating their knowledge and develop a taste for the subject. To achieve maximum benefits the Mathematics teacher shall have to take pains by putting in more efforts.

9.3 MATERIAL FOR MATHEMATICS LIBRARY

Mathematics library should contain useful visual aids in teaching Mathematics. The educational pictures, charts, maps and posters about Mathematics be displayed on walls of library.

In Mathematics library there should a good collection of useful books in Mathematics. The Mathematics teacher should be responsible for making a wise selection of books for the library. The books be kept in separate almirahas under the following heads:

(A) **The Prescribed Text-Books** of Mathematics for the different classes.

(B) **Books on Teaching of Mathematics** meant for teacher such books should be of high standard, published in India as well as in foreign countries.

(C) **Books of Recreational Activities.** There are very few good books of this type published in India. Hence good books published in foreign countries should be procured for this purpose. Following books are suggested:

(1) Puzzle Mathematics by Gamow published by Macmillan & Company.

(2) Amusement in Mathematics by Dudney published by Nelson & Company.

(3) Mathematics Recreation by Ball & Coxeter published by Macmillan & Company.

(4) Mathematical Recreation by Maurice published by Dover Publication, New York.

(5) Riddles in Mathematics by Northop published by Nelson & Company.

(6) Ganit Manoranjan by Kotharia & Om Prakash published by NCERT.

(D) Books on Biographies and History of Mathematics

A few of such books are given here:

(1) History of Mathematics by Boyer published by John Wiley & Sons.

(2) Men of Mathematics by Bell published by Simon & Co., New York.

(3) Hindu Ganit Ka Ithas by Dutt and Singh published by Govt. of U.P., Lucknow.

(4) World of Mathematics by Newman published by Simon & Co., New York.

(E) Books Showing Contribution of Mathematics to Other Fields

A few books in this area are:

(1) Mathematical Advantages in Social Science by Davis published by American Mathematical Magazine.

(2) Mathematics in Human affairs by Ko Komer published by Prentice Hall.

(3) Mathematics for the millions by Lance lot published by Norton & Co., New York.

(F) Mathematics Journals

(1) The Mathematics Teacher Journal, SITU Colony, Madras-28.

(2) The Mathematics Education Journal, P.O. Siwan, Distt. Saran (Bihar).

(3) NCERT and SCERT Mathematics periodicals and magazines.

4. The Mathematics Laboratory

The mathematics laboratory provides our opportunity for individualized instructions, an introduction to the use of calculators and computers. It is a setting with in which students can develop their independent study programmes. The literal meaning of the word laboratory is a room where a group of pupils learns the subject matter actually performing experiments. Dr. D.S. Kothari has emphosized that "To learn science is to do science. There is no other way of learning science." The concept of laboratory is not new. E.H. moore, prof. of mathematics, University of Chicago, make statement in his address before the American mathematical society in 1902—"Would it not be possible for the children in the grades to be trained in the power of observation and experiment and seflection and deduction so that always their mathematics should be directly connected with matters of a thoroughly concrete character ?.....This program of reform calls for the development of a thorough going laboratory system of instruction in mathematis and physics....."

The laboratory approach embodies the concepts of active learning, pupils involvement and participation and relevance. It is a demonstration of the concept of an activity oriented mathematics programme. Nowadays laboratory approach to mathematics instruction is being used effectively with all pupils.

Importance of Mathematics Laboratory

Mathematics laboratory in a school is very important and useful. The importance of mathematics laboratory is discussed under following points—

1. Habit of critical thinking and logical reasoning can be developed.
2. Complex theoretically concepts can be made clear by performing sintable experimenters.
3. Learning of subject matter can be given a practical shape.
4. Practical mindedness is developed among the students.
5. Interest in learning mathematics can be developed.
6. Scientific attitude or temperament is developed among the students.
7. Bookish knowledge of the students can be correlated practically with their daily life.
8. Sense of keen or sharp observation of the child can be developed.
9. Problem solving attitude can be developed in pupils.

Various Components for a Mathematics Laboratory

(A) ***Staffing***—The mathematics teacher or head of the department and his staff must be ready and willing to incorporate the mathematics laboratory, Initially establishment of mathematics laboratory requires only one or two members of the department but the development of the laboratory as a mathematical learning centre is dependent upon total staff involvement.

(B) ***Physical Facilities***—New school should include a specific area for a mathematics laboratory. It is recommended that the laboratory be located adjacent to another mathematics classroom and separated from it buy a movable partition, so that a large group instruction area can then be made available when desired.

(C) ***Furniture***—The following furniture is required—

Calculatery center, measurement center, Game center, Reading center, Diagnostic and tutorial center, Total number of chair and tables, Filing cabinets, Shelving, A storeroom and one large, permanent screen.

(D) ***Equipments***—Equipment such as—calculating equipments, Measuring equipments, Audio-visual aids, Equipment related with games and puzzles etc.

(E) ***Instructional Materials***—Instructional materials; such as: computational skills development materials (e.g. work books, calculator etc.), Individual students records of diagnostic and progress reports, Problem-solving materials (e.g. collection of real life problems, other commercial material), instruments that will assist in diagnosing students needs, weaknesses and in determining the level of performance, an evaluative procedures to accompany each developmental stage, essential and abbreviate audio-visual aids (e.g. charts and models, geometrical

figures, tape recorder, improvised and commercially developed materials, materials related with recreational mathematics (e.g. various games and puzzles).

Arrangement of Mathematics Laboratory

Before ranging needed equipments, instruments or apparatus to be used in the process of teaching and learning mathematics practically in the mathematical laboratory, a proper provision should be made for a spacious room having Almirahs side shelves. Demonstration tables etc.

List of the Instruments/Apparatus/Instruction Material

1. Black Board
2. Demonstration table in the front of Black Board.
3. Tracing material: Graph papers, Tracing papers, Carbon papers, Coloured pencils, Inks, Brushes, Drawing boad, Drawing papers etc.
4. Reference material: Reference books, Text books, Magazine, books containing old and latest literature related to subject meter.
5. Drawing instruments like a pencil, chalk, foot rule, Compass, Divider, Set Squares etc.
6. Projective aids: like sound projector, Step projected, Slide projector, Epidea scope, over head projector etc.
7. Laboratory material: Logarithm tables, Ready recliners, Tables of constants.
8. Computer, electronic calculators etc.
9. Measuring instruments i.e., measuring tape, metre rode, sextants balances, weighing machine etc.
10. Teaching Aids: Like sound projector, charts, models of solid figures like cube, cuboid, cylinder, cone, sphire etc.

Mathematics Club

Mathematics Club and Recreational Activities in Mathematics

12.1 INTRODUCTION

For supplementing the teaching of Mathematics in the class-room and to widen the knowledge of his students a good Mathematics teacher can involve his students in a number of cocurricular activities such as *Mathematics club, visits and excursion, broad-casts, gramophone lectures* etc. There is no limit to such extra curricular activities and teacher is free to undertake one or more such activities in his school for the benefit of his students.

Some of these activities and their organisational set up are taken up in the next few pages.

12.2 MATHEMATICS CLUB

Importance of Mathematics Club

As in some other subjects so also in Mathematics, the students be encouraged to organise themselves into *Mathematics clubs* and *Mathematics associations*. Under the auspices of these organisation, discussions and lectures etc. are arranged. Such functions are quite helpful in creating interest in Mathematics. Under the auspices of such organisation certain games based on some concepts of mathematics and mathematical problems can also be

arranged. This is likely to help the students in having an idea of the practical utility of Mathematics in addition to creating their interest in Mathematics.

The values of Mathematics clubs may be summarised as under:

(*i*) It is useful in arousing and maintaining interest in Mathematics.

(*ii*) It stimulates the active participation of the students.

(*iii*) It develops in the students a habit of selective study. This helps them to make a distinction between relevant and irrelevant material.

(*iv*) The knowledge gained by students in various functions of such club activities supplements the class teaching.

(*v*) It provides the students an opportunity of free discussion and they are benefited from one another's view.

(*vi*) Gifted students get an opportunity to satisfy their needs and interests by actively participating in the activities of such clubs and associations.

(*vii*) Studentsget an apportunity to listen to some will known and distinguished Mathematicians.

(*viii*) It gives the students basic training in organising such programmes.

(*ix*) It is helpful in making proper utilization of leisure time.

(*x*) Through participation in such clubs students get acquainted with the contribution of Great Mathematicians in their fields.

Organisation of Mathematics Club

A Mathematics club, if properly organised, will be a great help in enlivening the teaching of Mathematics. Such a club

should be run by the students under the guidance and supervision of his or the teacher. For proper running of a club the most important thing is the preparation of a draft constitution of the club. This draft be prepared by the Mathematics teacher in consultation with the head of the institution. This draft constitution should provide all important details about the name of the club, aims and objectives of the club, details regarding membership and the fees etc. To be paid by members, purposes for which the expenditure can be incurred and person competent to approve such an expenditure. Various offices available to members and the procedure for filling up such offices by other relevant details.

For efficient and successful working of Mathematics clubs in expert body has suggested the organisation as under:

(*i*) Such a club should have the head of institution as its patron.

(*ii*) One of the senior maths teachers be asked to be the sponsor of the club.

(*iii*) Membership of the club be open to all the Mathematics students of the school.

(*iv*) Associate-membership may be allowed to some other students interested in Mathematics.

(*v*) The club may have an elected executive committee. The members of executive should include the *following* and should be elected or nominated from amongst the students:

(*a*) Chairman

(*b*) Secretary

(*c*) Asstt. Secretary

(*d*) Treasures

(*e*) One or two class representatives from each class.

The executive committee may also include a librarian, a store keeper and a publicity officer.

(*vi*) Only a nominal membership fee be charged from the members.

(*vii*) The club members be asked to tap other resources and carry out the club activities in their own locality.

Assignment of Duties to Officer Bearers of a Mathematics Club

For a cohesive and efficient functioning of a club, there must be a clear demarcation of duties to be assigned to its office bearers. Following suggestions have been made in this regard.

Patron. He is expected to take a keen interest in all the activities of the club and to extend all the possible facilities to the club.

Sponsor. He is the main force to start the club and he has to take initiative to start such a club and make it a hub of activities. His role should be that of an advisor, guide and supervisor and he should refrain from becoming a dictator. He should always be alert to avoid any mishap. He should keep a strict watch on the activities of the club members.

Chairman. He being the elected representative of the student should be asked to preside over all the formal functions organised by the club. He has also to convene and preside over the meetings of the executive committee of the club.

Secretary. He is also an elected member and is to look after and maintain a proper record of various activities of the club. He should call a meeting of the executive committee in consultation with the chairman and in accordance with the constitution of the club. He should keep a true record of the meetings of the executive committee. He is also responsible to carry out all correspondence on behalf of the club and to extend invitation to speakers and guests for various functions of the club.

Asstt. Secretary. His main role is to assist the secretary in performance of his duties. In the absence of secretary he has to carry out all the functions of the secretary.

Treasurer. He is the person who is responsible for collection of subscription/membership fee for the club. He has also to maintain a proper account of receipts and expenditure of the club. He must present his accounts of the executive for audit and scrutiny at least once a year.

Members of Executive Committee. A member of executive committee is expected to extend his active cooperation and participate actively in formation of club's policy and programme. He should use his contacts and influence to make the programme of the club a success.

Suggested Activities for a Mathematics Club

(*i*) Organising inter-class, inter-school competitions on some interesting Mathematical topics.

(*ii*) Arranging a lecture by some renowned Mathematics teacher or scholar.

(*iii*) Celebrating days and events pertaining to the history of Mathematics or men of Mathematics.

(*iv*) Organising discussions about the practical applications of Mathematics.

(*v*) Organising recreational activities in Mathematics such as puzzles, riddles, catch-problem, number games etc.

(*vi*) Making or collecting charts, models, picture, graphs etc. for the Mathematics laboratory.

(*vii*) Conducting related project activities.

(*viii*) Preparing items for wall magazine.

(*ix*) Organising mathematical exhibitions or fairs.

(*x*) Organising certain outings of mathematical interest

such as visits to post-offices, banks, market places, big business concerns etc.

(*xi*) Organising paper reading contests about certain important topics of Mathematics.

(*xii*) Making arrangements to listen to certain radio broadcasts on mathematical topics.

(*xiii*) Organising seminars and career courses relating to Mathematics.

Thus we see that Mathematics club can cover a wide variety of topics relating to the subject. If the students participate in such activities whole-heartedly, then we derive great benefit. The club can go a long way in arousing and maintaining interest of the students. They will develop love for the subject. The utility of Mathematics club depends upon the interest shown by the teacher and the extent to which the students are motivated to take part in the activities of Mathematics club.

Mathematics Club and Classroom Teaching

The activities of Mathematics club and a supplement to classroom teaching. Such clubs play an important role in making Mathematics education more meaningful and effective. Various charts, models, improvised apparatus prepared by members of the club can be used as important teaching aids for teaching of Mathematics in the classroom. References could be made to various Mathematics projects undertaken by the club members and the club members may be asked to explain their projects in the class. The explanation of a project by a student in a class may then be put to open discussion in the class which would make other students more interested in learning Mathematics.

To make best use of the trips and excursions arranged by the Mathematics club, the students be given a questionnaire so that students may be more attentive to provide their answers. Answers given by the students may

then be discussed in the classroom and teacher can coordinate all the facts observed by the students into a complete lesson.

Some method can be used to correlate and coordinate various club activities with classroom teaching.

There is no doubt about the fact that if the club activities are organised properly they will never interfere with classroom teaching. Various activities of the club are expected to develop the skill of the student, his power of reasoning, understanding, his power to distinguish between relevant and irrelevant etc.

Evaluation of Mathematics Club

To find out the extent to which a club has succeeded in achieving its stated objectives it is necessary to carry out regular periodical evaluation of the activities of the club. Such an evaluation may be external or internal or it may be a mixture of both. For internal evaluation the views of patron, sponsor about the activities of the club may be obtained. They should express their views along with their suggestions for improvement in the working of the club. For external evaluation the sponsor of some other near by Mathematics club be asked to visit the club activities and express his opinion. He may also be asked to give suggestions for improvement. An effort be them made to further improve the working of the club in the light of suggestions given for improvement.

Mathematics Exhibition and Fair

THE IMPORTANCE OF MATHEMATICS FAIRS

The place where models, pictures, chart-depicting mathematics are arranged and where the exhibitors explain the visitors about their work is called a mathematics fair.

In most schools, functions like parents day, sports day, annual day are a regular feature. In the same way every school must conduct mathematics fair annually.

Articles, models and exhibits prepared by the students under the guidance of mathematics teacher should be exhibited and demonstrated in the fair.

Talks by experts, film shows or slide shows on mathematics related topics, debates and declamations, music shows, mathematics plays etc., can also be conducted.

Mathematics fairs are more appealing to the general public and can provide useful knowledge to them.

Schools can utilize this opportunity for fund-raising for their mathematics clubs.

Need for the Mathematics Fairs in the Schools

- A mathematics fair is an excellent opportunity for the students to display their work, which they have done in their mathematics club.
- They get better understanding of experiments and methods when they prepare models.
- By organizing mathematics fairs students not only develop manipulate skills but also communicating skills.
- Such fairs also enhance the students' hidden creative skills.
- A sense of responsibility, self-confidence will develop among the students during the course of mathematics fairs.
- Mathematics fair also exposes to the parents and others the type of work they are engaged in schools. Thus, they could come to know about their children's skills, talents, knowledge and abilities.
- Students feel good, confident and encouraged when they are appreciated for their work in these fairs.
- During the mathematics fairs, students from different science clubs and schools can interact with each other. They could share their views, ideas and future work and could come up with great ideas for the development of mathematics.

The respective mathematics club normally organizes a science fair. In recent times, various government agencies encourage the organization of several fairs.

Values of Mathematics Fairs

- They have social, psychological, intellectual and educational values.
- The instincts of curiosity, construction, acquisition etc., among the students get satisfied.
- Students learn and understand the subject better and in an amicable surroundings during these fairs than when listening in the classrooms.
- Students' talents and skills are recognized and stimulated.
- Mathematics fairs play an important role in discovering and encouraging science talent.

TYPES OF EXHIBITS IN MATHEMATICS FAIRS

Number Games

- **Fabulous 15** – This is a two-player game. Each player takes turns choosing a number from 1-9. The goal is to get any three numbers that add up to 15 before your opponent does. The numbers can only be used once.
- **The Game of 99** – Two to Five players can join in this card game to practice mental computation. Five cards (regular playing cards) are dealt to each player. The remaining cards are stacked face down in the center. Each player takes turns laying a card down from their hand and then replaces the used card by drawing from the deck. When the player lays a card down, they must also add the value of their card to the running total of the discard pile. Play continues in this manner until one player is forced to go over 99, which means they are out of the game. Special value cards include: 4 = reverse order of play, K = sum immediately goes to 99, 7 = skip my turn, 10 = subtract 10, A = add 1, and all other face cards = add 10.
- **Diffy** – Herbert Wills created this game. Place a 2-digit number in each of the four corners of the Diffy game. Subtract the two numbers from each other and place the difference between them. Continue in this manner until you get to all zeros or complete the entire game sheet.
- **The Factor Game** – The game board consists numbers 1-30 on a laminated poster board. Two players take turns choosing a number. Once a number is chosen that player circles it. Then the other player circles all factors of this number. Play continues until there are no numbers remaining with uncircled factors. After adding up the numbers each player circled, the player with the greater total wins!
- **Large Number Planet** – A ten foot high dodecahedron attracted the attention of the students. The solid represented the Sun; so the measurements such as the diameter could be taken. Based on this model, students are asked to choose various sized balls to represent the other planets.
- **Estimation** – A series of estimation contests (one each half hour) are presented at this booth. Students are voted on each contest. Contests include: How many paper clips would it take to go from floor to ceiling? How many pretzels are in the jar?

Logic Games/Puzzles

- **Tower of Hanoi** – This ancient puzzle consists of three pegs and seven discs of different sizes. The object is to shift all the discs from the center peg to one of the outside pegs. You can only move one disc at a time while never place a larger disc on a smaller disc. How many moves does it take?
- **We Can Read Your Mind** – The two leaders of this booth dressed up like swamis will "read the minds" of the kids. Six binary number cards are used. The swamis ask the students to think of a number between 1 and 63. Then after asking whether or not that number is on card 1, card 2, card 3, etc. they announce the number that the student had chosen. The student is then asked whether they could figure out the "trick".
- **Pico, Fermi, Bagels** – Use deductive thinking through the process of elimination to guess a 3-digit number. The person in charge of the booth thinks of a 3-digit number. The student must identify the number. Clues are offered in the way of "Pico", "Fermi", or "Bagel". "Pico" indicates to the student the number of digits that were correct and in the right place. "Bagel" indicates the number of digits that are incorrect. This continues until the student deduces the mystery number.

- Scope of the fair
- Procedure
- Finance
- Place, time and duration
- Other factors and basic facilities.

The planning should be in detail and clear to the members. Enough finances should also be available.

- **Distribution of work:** After planning, the work should be distributed among the participants according to their interests and talents. The work can be taken as individual responsibility or as a team. There may be different committees like advisory, executive, reception, etc., that could look after the different needs of the fair.
- **Execution:** The execution of the plans should be quick and systematic. The exhibition should be managed with the help of different committees; other programs like demonstrations, films, models etc., are also to be organized. Each exhibit should be self-explanatory with proper titles and may be supplemented with simple explanation. One day before the exhibition all the participants should explain their work in front of the teacher and should incorporate the suggestions and corrections given by him/her. The fair can be inaugurated by some popular personality from the mathematics field.

  Students from different schools, people from all walks of life should be invited. Nominal charge or free entry could be offered for general public.
- **Judging:** Different committees of judges should judge the exhibits in the fair. Judgment may be based keeping in mind different criteria like originality of the concept, technical skills, simplicity, and neat presentation and most important its scientific approach.
- **Evaluation:** After the completion of the fair, teacher and students should evaluate it and see whatever the objectives are fulfilled or not. And if there is any mistake that has place, then try to improve in the next exhibition.

Guidelines for a Mathematics Fair

PROJECT GUIDELINES

- Students should do all work. Teacher, parents, or others may provide appropriate assistance.
- In compliance with the guidelines put student name(s) or school name on data sheets, notebooks, or reports, should not be put. A removable cover Sheet with your name(s) on it for turning in assignments.
- Food samples (liquid or solid) should **not** be a part of the **Display** (but may be part of your project). Please use photographs or drawings, plastic food or the labeled containers.
- Valuable equipment should **not** be a part of your **Display** (but may be part of your project). Please use photographs or drawings to document their use during your experiments.
- **Please Keep in Mind:** Judges will be looking at the following characteristics in the projects (not necessarily in this order):
- Originality: Has this been done before?
- Good Scientific Procedure.
  - Do the experiments provide the quantitative information needed to answer the student's question?

Community Resources and Laboratory

Introduction

We may come across by an interacting the people regarding their opinion on mathematics subject; a majority of people says that mathematics is a dry and difficult subject, full of abstract things. The result is that students take very little interest in it. To create the necessary interest is a constant problem for the teacher. This subject demands the use of resources at every stage. Therefore, a mathematics teacher should not depend on mathematics text book only to transact. He may use comprehensive mathematics teaching by use of aids, community resources and laboratory. A stimulated environment of learning mathematics demands many resources of learning. All these materials may not be available in the school. In such a situation the teacher may have the knowledge upon resources available in the community. There are a number of community resources that can be used for facilitating the learners in the construction of knowledge of mathematics and to find the relevance and meaningfulness of this knowledge in the context of the world beyond the four walls of the classroom. These resources can be utilised in two ways—either community can be brought to the class or class can be taken to the community. In fact, teachers, students, administrators and community can collaboratively work to utilise various community resources.

8.1 Learning Resources from Immediate Environment

The environment around the student is called immediate environment. This will be used as learning resource for learning of mathematics. The playground, the poles used for games and sports will help to understand the concepts of geometry and trigonometry. If the teacher is fully aware of learning resources from immediate environment will create great interest on mathematics subject and students also feel a sense of ownership to their earning when it is related their own experiences.

In fact many learning opportunities are available in the school ground/ classroom/ markets/on the roads itself. Outside the classroom, experiences of the learners can be used in teaching-learning of mathematics to provide them first-hand experience for enhanced learning and a sense of appreciation to the environment. It may consist of a wide range of materials. Some examples from the immediate environment and the concepts that can be explained using these examples are given below:

- How much paint is needed to paint all the cupboards in the school?
- What is the traffic flow near the school?
- Count the exterior squares wall of house?
- Build the car/house by using plastic toys.
- Checking of grocery bills
- Volumes of tanks
- Use of money when they were out shopping
- To introduce of volume, the teacher may ask the students how much water in a bath tub or a pool.
- Observing the patterns of buildings, etc.

Learners should be encouraged to construct and reconstruct their knowledge from observing, classifying, categorising, questioning, reasoning, arguing, and interacting with the natural world and people around them. A mathematics teacher should think on the line of flexibility, contexuality in designing curricular experiences.

In order to relate teaching-learning of mathematics with immediate environment of the learners, a number of carry home activities can be identified as an extension of classroom activity. Many such activities can be suggested, such as:

- Students should be encouraged to collect data, cuttings and materials of mathematical interest.
- Sometimes there are published very fine graphs in magazines and papers. These are data on percentages, averages, ratios, investments, incomes, wastages, budgeting, etc.
- The students should be on the look –out for these things, so that such collections can add to the bulk of the laboratory material and are helpful to them and to future students.

8.2 Using Community Resources: Bringing Community to the Class, Taking Class to the Community: Field Visit

Community resources can be used in teaching-learning of mathematics either by bringing community to the class or by taking class to the community.

8.2.1 Bringing Community to the Class

Teacher must explore opportunities for active engagement of the parents and the community in the teaching-learning process of mathematics. Different members of the community also hold a large variety of valuable knowledge. Many of these members may be willing to share their knowledge and experience with the students. These members can be invited to school and learners can interact with them. Teacher should remain aware of the range of community, individuals and organisations that can be accessed to provide significant learning experiences to learners. Learners can visit their places of work also. The expertise of members vary from community to community. Some examples are:

- *Surveyor:* measuring the areas
- *Statistician:* for data analysis
- *Architecture:* How to plan for construction
- *Mathematician:* for guest teaching
- *Bank Manager:* for teaching the concepts of banking, share market, loans, interests, profits and loss and discounts etc.
- *Business man:* How mathematics can be used for his business planning, handling of resources, time and money etc.
- *Computer programmer:* How the software tools will be used for earning of mathematics, etc.

8.2.2 Taking Class to the Community: Field Visit

Taking students on field trips or using other community resources in their classes is not a new idea for teachers. The use of community resources provides a shared memory for the class. For example, going on a field trip is only part of the total experience. As students and teachers talk about the trip and think about it after it is over, they are building shared understanding. The event becomes part of the common knowledge of the class and can be referred to in subsequent lessons. What was learned is, thus, reinforced and extended in later discussions as the teacher refers to field observations. Learners get an

opportunity to discover the concept and their connection with their environment. They can use this opportunity to earn various skills in interacting with the physical world, materials, technology and other people.

Visits to places of mathematical interest can be some use. There are a few places which must be visited by every student of mathematics, such as banks, post offices, booking offices, insurance, market, auction pace, shops, big business concerns, big industrial concerns, etc. these visits can be more useful if they are combined with some preparatory and follow up work.

This is not a laboratory aid, because it takes the earner outside the four walls of the laboratory. This can help laboratory work, if the students from the habit of collecting data and materials on these visits for later use in laboratory work.

Advantages of the field visits

The field visit:

- helps in providing first-hand experience to the students which is not possible within the four walls of the classroom;
- enriches general knowledge of students. It supplements the classroom learning;
- helps in broadening the outlook, deepens insight and widens vision of students;
- gives the students new ideas and vision for taking up projects;
- helps to deepen understanding of the concepts and brings clarity in the subject. It also helps in concretising the abstract ideas;
- helps the students develop an inquiry attitude towards the environment;
- develops skills in mathematics processes like observation, collection, classification and analysis of data;
- brings the awareness that mathematics is all around us and not just in books;
- relates the community to the learners, teachers and school and encourages sharing of responsibility of child's learning with the community;
- Acknowledges the authenticity of community knowledge, etc.

Organisation of the field visits

Planning: The entire planning can be done by students under the guidance of a teacher.

First a guide sheet can be prepared. It should have learning details, physical details and administrative details.

Learning details: Consist of sites to be visited, data to be collected, list of questions to be asked to the persons working at the site and any process which is to be studied, etc.

Physical details: Route to be taken, time schedule, personal equipments, provisions for refreshments, meals, first aid box, materials to be carried such as umbrella, camera, etc.

Administrative details: Teacher needs to give details, purpose and outcome of the trip for getting permission from the administration of the school for the field trip.

The checklist of a planned field trip can be

- objective of the field trip;
- date of the field trip;
- time of departure;
- date and time of return;
- name of the supervisors accompanying students;
- rules of conduct for students;
- materials students need to bring for the trip, such as water bottle, umbrella, field diary, etc;
- cost for the trip; and
- permission from parents.

Transport facility should be also planned in advance.

Prior to students field visit, the place to be visited should be seen by the teacher and a student representative. They should find out, whether learning objectives would be achieved or not. The main aim of the visit should be providing learning experiences; pleasure should be the secondary aim. The objective of the visit should be clear to all learners in order to optimise learning.

Teacher should plan follow-up activities in order to make learning experience, a fruitful one. After coming back from the field visit students can discuss their observations and experiences, ask questions and share photographs. Teacher needs to encourage students to submit the report and mention explicitly what they learned from the visit. Evaluation of the field visit can be done in the light of the planned objectives.

8.3 Pooling of Learning Resources

In the school the classroom is the first physical space that a child associates herself with and feels closest to. Thus, the first pooling of resources can start right from the classroom itself. In modern educational point of view, the theoretical principles which are discussed in the classroom should be practically tested in the laboratory. Even every concept is not possible to check in the laboratory, therefore, one or two tables can arrange the classroom for demonstration/activity purpose. Children should be encouraged to bring materials they think are relevant for discussions and display. These materials can be used to provide them hands-on experience.

As we discussed in the above paragraph, systematic experimentation as a tool to discover or verify theoretical principles is an important part of curriculum at secondary and higher secondary stage. Thus, schools require well equipped laboratories for students at this stage. But, the school authorities and administrators have misconception that since mathematics is not listed among the laboratory subject, it requires no special laboratory equipment. This is absolutely wrong attitude; the authorities should give up the wrong attitude. Some place for storage is prerequisite of mathematics laboratory. There must be some almirahs and a room to store and stock the articles. The place may be provided having an almirahs in every classroom or by having a few almirahs on one room. Without a place, the material will lose half its age. The things will remain scattered, unarranged exposed to dust, etc. they are likely to lose their colour and attraction.

As a part of an effort to provide all children with necessary hands on experience of equipment and experiments given in their mathematics curriculum, at least at cluster level, a resource centre may serve as cluster laboratory. Schools of the cluster could plan their timetable so that for half a day, once a week, their mathematics laboratory class is held at the cluster level laboratory.

Specific equipments could be shared among schools if they are placed at the cluster centre, which can then serve as a resource centre. For the period of teaching-learning on the concerned concept, the teacher can borrow materials from the centre and thereafter, return them to enable other teachers to borrow them. In fact teaching aids and other learning materials or models selected in the mathematics exhibition can also be placed at the cluster centre. In this way, the resources gathered by one teacher can also be utilised by others, and it would become possible to have multiple sets necessary for the whole class to use. Neighbouring schools, colleges or training colleges, institutions may allow

students to work in their laboratories. Teachers need to be resourceful to utilise such opportunities.

There is a growing emphasis on Information and Communication Technology (ICT) for effective learning. Many schools are now equipped with computers, and in some areas radio and TV based learning and interaction are being introduced. Some selected schools may also have teleconferencing facilities. These Information and Communication Technology (ICT) facilities can also be shared between schools.

In many parts of the country, community libraries are functioning in rural areas, and government libraries exist in many district headquarters. A network of school libraries with cluster level/block level library can be established for its enrichment.

Pooling of various learning resources can be a part of the overall curricular plan of the school to enhance participation of various schools and agencies.

MATHEMATICS TEACHER

AS IN THE case of other teachers, many things are expected of the teacher of mathematics. His obligations not only are confined to the classroom but extend in many other directions also. It must not be forgotten, however, that his first and foremost obligation is to teach his subject effectively. Teaching mathematics is a task which, if sincerely undertaken, will challenge the best efforts of the best teacher.

No teacher can do a thoroughly good job of teaching mathematics unless he is willing to make a careful analysis of his job and to be guided by that analysis.

There are two equally important aspects of any true profession viz., significant knowledge and effective technique. One cannot be efficiently professional if there is any serious weakness in either of the two.

The beginning teacher will need to spend most of his time in improving his knowledge of his field and techniques of teaching, and becoming familiar with the traditions and administrative policies of the school.

Gradually, however, his responsibilities outside the classroom also multiply. These semi-professional duties will assume an importance second only to that of his classroom work. It will be appropriate here to discuss the nature, purpose and successful performance of these multifarious possibilities.

THE RANGE OF TEACHER ACTIVITIES AND HIS PROFESSIONAL QUALITIES

His qualities and activities may be classified as follows :

1. Prerequisite qualifications.
2. Professional training.
3. Selective academic training.
4. Supervised practice teaching.
5. In-service training.
6. Professional activities.

7. School activities.
8. Mathematical organisations.
9. Departmental duties.
10. Administrative duties.
11. Community activities.

The scope of each of these activities varies considerably from school to school and community to community. But they are all significant and call for serious consideration by the teacher.

1. PREREQUISITE QUALIFICATIONS

Mastery of the subject is an absolute necessity for effective teaching. The teacher must possess a basic qualification in the subject. The level of his information should be much higher than that of the information he is expected to impart. Not only should he be the holder of a degree in the subject but his aptitude in the subject also must have been distinctly testified by his college teachers.

His personal characteristics are no less important. These include general appearance, health, voice, poise, ability, energy, enthusiasm, cooperation, sense of humour, sense of justice, etc.

He should prepare himself professionally not only by a scholarship in mathematics, but by having background courses in other fields as well, such as physical and biological sciences, social studies, etc. This general education will give the teacher a broader outlook and better perspective which are essential for an efficient discharge of his duties.

Successful teaching experience prior to professional training is also a valuable asset. It will enable a person to acquire certain commendable characteristics such as adaptability, efficiency, the knack of arousing interest, command of instructional material and ability to face the class with confidence.

2. PROFESSIONAL TRAINING

Before going in for this training, he should make sure that he has enthusiastic interest in mathematics and in teaching profession.

The teacher should know not only mathematics but also other subjects of the curriculum. It is essential for the purpose of correlation.

He should possess a fair knowledge of the applications of mathematics. This is an extremely important factor in imparting to mathematics greater meaning and usefulness.

He should acquire a good knowledge of educational psychology to be familiar with the laws of learning. A knowledge of the various factors governing attention, interest, fatigue, perception, understanding, etc., vitally affects his success in the classroom.

A course in the "Principles and Philosophy of Teaching" is also important for it will reveal to him the overall picture of the theory and practice of teaching. An elementary understanding of the history and the development of the educational system in the country is also necessary. Thus his mind will be oriented towards the present aims and purposes of education.

As a part of his preparatory training he is usually required to observe frequently the classroom work of experienced teachers in the practising school.

Teaching practice is also very important. It demonstrates the important factors of able classroom management and effective teaching techniques, which include many items of professional, training. This practice enables the trainee to gain self- confidence. During this trial period the pupil teacher should have the advice and assistance of expert teachers in the subject concerned.

3. SELECTIVE ACADEMIC TRAINING

This is to be acquired through college education in the subject. It is, in a way, a prerequisite for becoming a mathematics teacher. He should acquire a fair understanding of the broad field of mathematical analysis and reasoning.

Recent trends in the applications of mathematics demand that a course in Mathematical Statistics and Probability be incorporated in teacher training. Statistics has numerous applications in educational, economic, industrial, scientific, social and other problems. The would be teacher should have acquaintance with effective and reliable methods of collecting, organising, analysing and concluding about statistical data.

To enable him to understand applications of geometry and trigonometry, courses in surveying and in the use of instruments including mechanical drawing are of considerable value.

A course in consumer mathematics will also provide a useful preparation for the profession.

He should first acquire a fair knowledge of the fields closely allied to mathematics and finally grasp all the useful techniques of teaching.

4. SUPERVISED PRACTICE OF TEACHING

The importance of this part of training has already been emphasised. It should be done under the direct supervision of experienced teachers. The pupil teacher

should get an opportunity of observing a few demonstration lessons by experienced teachers, and then he should be required to teach classes on those lines. He should also give a few discussion lessons. These lessons should be minutely observed and thoroughly discussed by a group consisting of his class-fellows and a few experts. The chief aim should be to offer suggestions for the improvement of student teaching. His lessons should be supervised and evaluated. Such evaluation should take into account aspects such as class preparation, teaching techniques, management and control, personal and professional qualities and achievements.

This practice teaching should truly mark the beginning of mature, reflective and analytic thought in examining and solving teaching difficulties.

5. IN-SERVICE TRAINING

It has been introduced recently in the profession. Its value and effectiveness in continuing the training of teachers to a higher plane of efficiency and competence are commonly recognised.

The extension services departments attached to different teacher training institutions are organising it. Seminars and workshops are occasionally arranged for the subject teacher, but much depends on the teacher's desire to learn and improve. The teachers should bring their problems and difficulties for free and frank discussion on such occasions. They should utilise the library service of the extension services departments. They should attend seminars and workshops with an open mind to learn. This is the training which should be availed of by them for keeping themselves up-to-date in respect of subject-matter and teaching techniques.

6. PROFESSIONAL ACTIVITIES

Each teacher should make definite provisions for his own professional growth and development. Many ways may be found for this purpose. The teacher should study mathematical journals and modern books of professional interest. Any facilities of in-service training should be availed of. Schools of outstanding merit may be visited to investigate the quality and nature of the work done. The teacher may do professional research work and write professional articles or books for publication.

The teacher may participate in providing for the programmes and discussions of professional organisations by becoming an office-bearer of an organisation or a committee member. He should at least join their deliberations and try to contribute his best views.

7. SCHOOL ACTIVITIES

The heads of the institutions are chiefly responsible for the actual carrying out and development of these activities by which the pupils can be offered the best opportunities for intellectual and physical development. Their effective formulation and execution, however, require the cooperation of the individual teachers. The teacher should enthusiastically participate in the following activities :

(i) Faculty meetings. (ii) Student projects for a special group or class. (iii) School clubs, social events, school publications. (vi) Execursions and other cooperative activities. (v) Committees for special school activities. (vi) Programme for a more effective cooperation of the mathematics department with other departments in educational fairs, tournaments, exhibitions, etc.

8. MATHEMATICAL ORGANISATIONS

Even a beginning in this field has not so far been made. Every teacher at his place has to think seriously about it. Such an organisation is long overdue. The subject teachers should organise themselves at district, zonal and state levels for mutual professional advantages. Such an organisation should provide a channel for exchange and sharing of experiences regarding different aspects of the teaching process. The objectives of these organisations should be academic and pedagogic rather than political.

9. DEPARTMENTAL DUTIES

For smooth functioning of a department each teacher must accept his share of responsibility. Similarly, the successful administrator has to secure active and willing cooperation of his staff through democratic procedure. A few common departmental duties are given here : (i) Participation in departmental meetings and discussions. (ii) Selection of text-books. (iii) Acting as sponsor of the mathematics club. (iv) Organisation of course, syllabuses. (v) Selection and ordering of library books and periodicals. (vi) Selection and ordering of classroom equipment. (vii) Selection and ordering of Laboratory equipment. (viii) Preparation of departmental tests. (ix) Liaison committee, especially for cooperation with other departments. (x) Organisation of exhibitions, contests and assembly programmes. (xi) Administration and scoring of standardised tests. (xii) Taking charge of a remedial class in mathematics.

Many other such duties demand teacher's attention. These may be so distributed that a teacher usually need spend only two to three hours a week.

10. ADMINISTRATIVE DUTIES

Many administrative duties require the cooperation and assistance of the teachers.

The teacher has to keep records of attendance and tardiness of pupils. These records serve teaching as well as administrative purposes. The records of an individual student achievements have to be kept. Summarised results have to be periodically reported to the administrative officer. Similarly the deficiencies of individual students have to be reported. The teacher may have to serve on administrative committees. He has to administer and score mental tests, and their results are to be used for diagnostic purposes and student adjustment purposes. He has to undertake guidance work.

11. COMMUNITY ACTIVITIES

In most communities, the school is the centre of educational life for parents as well as children.

Teachers should cooperate with parents to improve school and community relations and opportunities. There should be arranged meetings of social or civic groups, parents' association and old students' organisations.

Teachers should explain to parents and visitors the facilities offered by the school.

Teachers usually organise and direct local fairs or celebrations, variety programmes which are of interest to the community.

Teachers have to direct any service undertaken by their students for the uplift of the community. Teachers have often to work or direct work in an evening school for adults.

The teacher is not an individual but an institution in himself. His work is great and his responsibilities are many. He is to be service incarnate.

EXERCISES

1. What type of personality should a mathematics teacher develop in himself ? Discuss and elucidate.
2. What are the qualities of a mathematics teacher ? What qualities should be possessed by him in addition to the common qualities of every teacher ?
3. Enlist and explain the qualities and characteristics of a teacher of mathematics ?

MATHEMATICS TEACHER

The teacher plays an important role in the system of education as in the case of other teachers, many things are expected of the teacher of mathematics. Teachers are considered to be "builders of nation". If there had been education in the society in any form, there is no education without the existance of teacher. His obligations not only are confined to the classroom but extend in many other directions also.

Teaching mathematics is a task which, if sincerely undertaken, will challenge the best efforts of the best teacher. The influence of teacher shapes the personality of the child. A teacher should try to present himself as an "Ideal Examples" to the students and bear some qualities. The foremost quality that a mathematics teacher should possess love and respect for learning and teaching mathematics. No teacher can do a thoroughly good job of teaching mathematics unless he or she is willing to make a careful analysis of his job and to be guided by that analysis. Like a gardener, caressing the plants, he caresses young human beings and looks after their physical, mental and social growth and development. Good created man in the shape of his own image, the teacher fashions the child in the shape of his own image. Hence, it is said, as the teacher, so is the child.

Definitions of Teacher

It needs no description that the teacher is the pivot of any educational system of the younger students. On him rests the failure or the success of the system. If the teachers are well educated and if they are intellectually alive and take keen interest in their job, then only, success is ensured. But if on the other hand, they lack training in education and if they can not give their heart to their profession, the system is destined to fail. Hence, the teacher is another vital component of the school.

The teacher is a dynamic force of the school. A school without a teacher is just like a body without the soul, a skeleton without flesh and blood, a shadow without substance.

The teacher is the yardstick that measures the achievements and aspirations of the nation. The worth and potentialities of a country get evaluated in and through the work of the teacher.

According to Secondary Education Commission, "The most important factor in the contemplated educational reconstruction is the teacher- his personal qualities, educational qualifications, professional training and the place that he occupies in the school as well as in the community. The reputation of a school and its influence on the life of the community variably depends on the working of the teacher working in it."

According to Mannu, "A teacher is the image of Brahma."

According to Swami Vivekananda, "The true teacher is he who can immediately come down to the level of the student, transfers his soul to the students soul and sees through and understands through his mind. Such a teacher can really teach and none else."

According to Radhakrishan, "The teacher place in society is of vital importance. He acts as the pivot for transmission of intellectual traditions and technical skills, from generation to generation and helps to keep the lamps of civilization burning."

According to Tagore, "A teacher can never truly teach unless he is still learning himself. A lamp can never light another lamp unless it continues to burns its own flame. The teacher who has come to the end of his subjects, who has no living traffic with his knowledge, but merely repeats his lessons to his students can only load their minds. He cannot quicken them."

According to **John Adams,** "The teacher is the maker of man."

According to **H.G. Wells,** "The teacher is the real maker of history."

According to **Humayun Kabir,** "Teachers are literally the arbiters of a nation's destiny."

Therefore, a dynamic teacher is he who can understand the process of education, can relate education to other aspects of life, can eradicate contradictions in educational problems and suggest improvement and reforms in education system.

Importance of Teacher in Modern Education

Modern education is child centred. Here teacher is more like a gardener who has to look after and nourish each plant (child) of the garden (school) very wisely and carefully. So the teacher has to study the child. Without knowing the student he cannot impart proper education to him. We very well know that education is a tri-polar process. Its three poles are teacher, student and content. Teacher imparts education to his students by means of subject matter prescribed for them. Hence, a teacher should have a thorough knowledge of subject matter to be taught. The purpose of education is the harmonious and all round development of the child.

The most important work for a teacher is to transmit the knowledge to the students and it is not a easy job. He apply various methods and techniques of teaching for transmission of knowledge to the students. Besides the transmission of knowledge, he has to develop in the students the qualities like self-confidence, self-reliance, good habits, competency to work with speed and accuracy, good citizenship etc. In this way he has to realize the ultimate aim of education i.e. the desired change in the behaviour of child.

Thus, in the field of education, a teacher has a great importance and his role in multi-dimensional. He is pivot of education system.

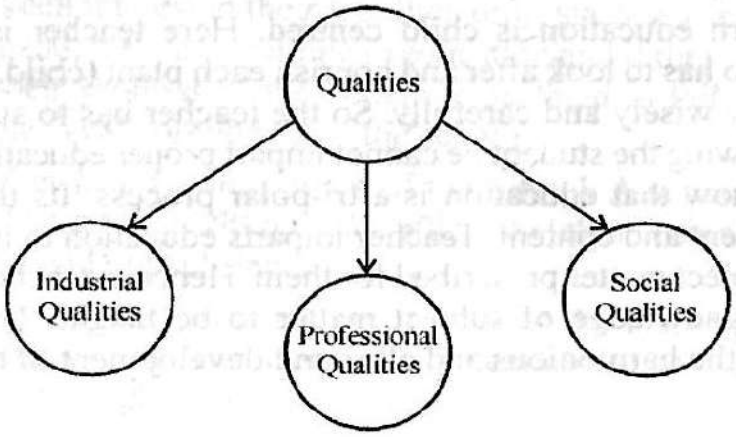
Qualities and Characteristics of a Mathematics Teacher

According to **Kothari Commission,** "Of all factors which determine the quality of education and its contribution to national development, the teacher is undoubtedly the most important. It is on his personal qualities and character, his qualification and professional competence that the success of all educational endeavour must ultimately depend."

This definition indicates that success of any educational system depends upon its efficient teachers. In an efficient teacher, there must be some specific qualities. So some essential qualities which are expected in a good mathematic teacher are as :

1. To understand the ability and capacity of the students.
2. Self ability of educational and teaching.
3. Capacity of adjustment and work with the students.
4. Efficiency of work done.
5. Capacity of leadership.

It is essential in curriculum to use teaching method, content, teaching-aids etc. in a correct method in mathematics teaching. For this purpose we need a good and capabile teacher. On the basis of these factors or qualities develop the power of thinking, analysis in the students. Hence some qualities in a mathematics teacher are as follows :



(A) Individual Qualities

Following individual qualities are essential in a good mathematics teacher :

1. Teacher's Personality–Every teacher must have a good personality. His personality influences directly and indirectly to the students. It means he should have a good physical and mental health. Radiant, pleasing and impressive personal appearance, pleasent manners, industry, enthusiasm, drive, initiative, open mindedness etc. are some of the essential traits of an ideal teacher. A teacher should firstly know the previous knowledge of the students then he should make efforts to link it with the new knowledge.

2. Good Health–A mathematics teacher should be mentally and physically healthy. Students develop interest in those subject, which are taughts by pleasing and genial teachers. The teacher makes the emotional atmosphere in the classroom. A neurotic teacher may spread far, nervousness and worry in the classroom. A fanatic-teacher may spread hatred, prejudice and hostile feelings among the students. If he has a good mental health, he can create love, interest and enthusiasm for learning and a taste in the subject he teaches.

A teacher should possess a sound body along with a sound mind. He should have a sound physical heath, physical energy, vitality and he should be free from physical defects. He can maintain emotional stability.

3. Self-confidence–A mathematics teacher should necessarily have self-confidence. Lack of self-confidence makes a mathematics teacher a irritative in nature and it costs bad influence on the children. This leads him to failure in his teaching and self-confidence makes a maths teacher able to solve the problems of his students in very efficient number.

4. Interest in mathematics subject–A good mathematics teacher should have interest in the subject. Without interest in the subject he cannot teach it efficiently. He should know the importance of the subject. A mathematics teacher should have full command over subject matter. It is possible, when he has interest in mathematics.

5. Patience and Tolerance–For average student, mathematics is a difficult subject. They take more time in understanding the mathematical concepts. Sometimes their responses are totally absurd. Few students are unable to learn after several repetitions. So, there are vaious chances for a mathematics teacher to be impatient. But, a good teacher should not loose his patience. He should be optimistic and should have confidence in their students.

6. Resourcefulness–The teachers who have the qualities of resourcefulness make arrangement of different means timely according to their needs and thus, succeed in making their teaching effective. The use

of teaching aids helps him for successful teaching. A teacher may present complex things in a simple way by using the appropriate aids and thus a good interest for the subject could be developed in the students. So, resourcefulness is a quality of good teacher.

7. Positive attitude–A mathematics teacher should have positive attitude towards his teaching subject. Because his self attitude directly influences the learning process of the children, the right or positive attitude by introducing them to life history of mathematicians and history of mathematics.

(B) Professional Qualities

1. Knowledge of Subject–No teacher can teach properly unless he has a thorough knowledge of his subject. Therefore, knowledge of the subject is an absolute essential for effective teaching. In real sense his knowledge and information about the subject should be much higher than the students to whom he has to impart education and he should have a good aptitude in the subject and its application.

2. Scientific Attitude–Mathematics is an exact science. A mathematic teacher should have a scientific attitude in his work and behaviour. He should always have an effort to proceed on scientific approach. His thinking should be original and logical.

3. Knowledge of Application of Mathematics–The mathematics teacher should clearly know the use of the knowledge of his subject in various fields of real life. If he has a good knowledge of the application of mathematics in real life, in various vocations, in other subjects etc., he can communicate and transfer it to his students. If a student know the utility and application of subject matter to be taught to him in his real life, he grasps it with interest.

4. Knowledge of Individual differences–A good mathematics teacher should necessarily have knowledge of psychology to make him able to understand interest, ability and capacity of different students and thus, he can guide them properly. A mathematics teacher is he who has the knowledge to judge individual difference because every student is different in reading and writing, understanding and work speed.

5. Knowledge of mathematical Skills and Analysing Ability–A mathematics teacher should possess essential mathematical skill such as computational, problem solving, drawing and sketching skill etc. He should also possess the ability of anlaysis since he has to explain many things to his students.

6. Knowledge of Different Teaching Method–A good mathematics teacher should teach the students by effective teaching methods as analysis,

synthesis method, project method, laboratory method, inductive method, deductive method etc. so that the students may get the opportunity of learning by doing and the knowledge they have learned can be more permanent and solid.

7. Psychological Outlook–A mathematics teacher should acquire a good knowledge of educational psychology to be familiar with the laws of learning. A knowledge of the various factors governing attention, interest, fatigue, perception, etc, vitally affects his success in the classroom.

A course in the "Principles and Philosophy of the teaching" is also important for it will reveal to him the overall picture of the theory and practice of teaching.

8. Professional Growth and Development–Each teacher should make definite provisions for his own professional growth and development. Many ways may be found for this purpose. the teacher should study mathematical journal and modern books of professional interest. The teacher may participate in providing for the programmes and discussions of professional organisations by becoming an office-bearer of an organisation or a committee member. He should at least join their deliberations and try to contribute his best views.

9. Teacher's Academic Achievements–A mathematics teacher should possess knowledge of the fundamentals of the subjects he teaches. He should have a sound academic and cultural background. A teacher must have the required professional training, without which he will commit serious pedagogical blunders.

10. Interest in Research-Work–A good mathematics teacher should be interested in the field of research work. For this following characteristics should be in teacher :

(i) For a scientist he should solve the questions neatily and clearly.
(ii) Priority should be given to experimental work.
(iii) A good mathematics teacher should be a physicological and psychological discover.

11. Knowledge of New Innovations–A mathematics teacher should be abrest of new knowledge and innovations in the field of his subjects. Therefore, he should be a regular reader of important mathematical journals and other new books on the subject. He should also participlate in seminars, workshops and conferences of the subject. He may attend refresher courses. He may also join as member of various mathematical associations and may be in contact with eminent teachers and scholars of mathematics.

(C) Social Qualities

With individual and professional qualities, a mathematics teacher should have social qualities as :

1. Ability to Leadership–A mathematics teacher has to inculcate proper habits and attitude in his students. He is ideal for them. Teacher's leadership is totally based upon his character and personality. If a teacher is sound in character and personality, he can inspire the students to participate in different activities in a group.

2. Democratic Dealing–A mathematics teacher must be just and fair minded. He should treat all the students alike and should not favour them on the basis of caste, creed, nepotism etc. For democratic dealing, he should have a sense of justice and willingness to seek the facts. Only a just teacher can inspire confidence in his students and through which he can carry them along with himself.

3. Ability to Organising–A mathematics teacher should be a good organiser. He is required to organise various activities related to his subject and also some other activities in the school. Through these activities he can influence his students.

4. Community Activities–In most communities, the school is the centre of educational life for parents as well as children. Teachers should co-operate with parents to improve school and community relations and opportunities. There should be arranged meetings of social of civic groups, parents association and old students organisations.

5. Justice Loving–Behaviour of a mathematics teacher should be so, as the students can consider him ideal. So a teacher should be both just-loving and refined in character and thus, he can develop in the students qualities of justice-loving.

6. Impartial Attitude or Behaviour–A teacher should behave, with all the students equally. It is injustice and unsocial to have affection with an individual. A teacher should make no difference of rich or poor, weak or intelligent, low or high. His behaviour should be impartial with all students.

In shortly, we can say that a good mathematics teacher should have following characteristics :

1. In a democracy, a teacher, being a good citizen fulfills all his duties. He is related to all the aspects of society. He has a knowledge of maths related problems, needs of society and solves them in a democratic manner.

2. The mathematics teacher teaches the theoretical, experimental and practical aspects of every subject or topic.

3. He is familiar with the techniques of evaluation to evaluate his students correctly.

4. He makes his teaching successful by knowledge acquisition process by obtaining complete knowledge of the personal needs, understanding capacity and problems of the students.

5. An ideal teacher provides systemetic instructions to his students. He takes part in all instructional activities.

6. A good mathematics teacher gives introduction of his capabilities in laboratory, work sphere and school community and helps others.

7. He is proud to be a teacher. In order to improve his teaching skills he takes part in various conventions, clubs, mathematics group activities, inservice teaching experiments or research. In this way he is always aware about his responsibilities.

8. In the class-room and laboratory the teacher uses the best knowledge acquisition process.

Teacher having above mentioned attributes can definitely be called ideal or good teacher.

DUTIES OF A GOOD MATHEMATICS TEACHER

Every good mathematics teacher should take a note of the following :

1. The syllabus should be changed according to the need of community, level of students, problems of community, the availability of time and examinations. In this reconstructing the co-operation of students should also be taken.
2. He should select proper audio-visual aids, all appratus and make use of them correctly and completely.
3. He should select appropriate teaching methods to make teaching lively and activity oriented.
4. He should have clear and novel knowledge of the subject.
5. He should have a positive attitude towards school management, teaching and students.

EVALUATION OF A GOOD MATHEMATICS TEACHER

A good mathematics teacher should evaluate himself from time to time. The following questions will help the teacher to evaluate himself better :

1. As a teacher of the school, how well are you fulfilling your duty?
2. Are you making efforts to increase your professional qualifications?
3. What opinion do the students, other teachers and the principal have of you?
4. Are you a nucleus of activities for students, parents and local leaders in rural and urban areas?
5. In teaching your subject, how far are you imparting latest knowledge by appropriate methods?
6. Do you organise the curriculum at the appropriate time, according to the needs for the student community?

If the teacher is able to evaluate his/her performance honestly with the help of these questions, he/she can go a long way in improving the teaching competencies, creating appropriate learning experiences for qualitative as asset to the institution and society.

Improving Professional Competence of a Mathematics Teacher

In the programme of Action-National Policy on Education 1986, the present situation of teachers and their training is mentioned in the following words :

"Traditionally teachers have enjoyed a position of great respect in our country. The religious leaders and social reformers have been addressed as teachers of the pupils. Hundreds of thousands of teachers are still held in esteem by their people and the community. However, on the whole the status of teachers has diminished during the last five decades. The reasons are deterioration in work, phenomenal expansion of the educational system, lowering of standards of teacher training, a general impression that a very large number of teachers do not perform their duty properly, changes in value system in society etc. The status of teachers has had a direct bearing on the quality of education and many of the ills of the latter can be ascribed to the indifferent manner in which society has looked upon the teacher and the manner in which many teachers have performed their functions."

To get over the above mentioned situation, following measures may be adapted :

1. A comprehensive and effective professional training for prospective teachers.
2. Selection of candidates for pre-service teacher education on the basis of aptitude test.
3. Organisation of selective academic training programmes.
4. In service training and continuing education of teachers.

PROBLEMS OF THE TEACHERS

The teacher in schools faces a number of problems. Those teachers who aim at perfection and try to attain it, get only disappointed and frustration. The following are some of problems which are by faced the teachers:

1. Feeling of Frustration–There are trained graduate teachers with post-graduate and sometimes with research degree. They have been in the department or in an aided school for years but have failed to get better jobs. They develop a sense of frustration and fail to perform their duties with devotion.

2. Feeling of Rejection–This is the feeling of highly qualified and experienced teachers who apply for better jobs but do not get them. This is very common in aided schools where the principal is not selected from amongst the staff members.

3. Feeling of Insecurity–Some teachers on transfer might have some sad experience of other principal. They abhor every action of the principal and try to trace evil intentions behind every more.

4. Groupism–Sometimes there is a tussle for leadership between two or more teachers. This results in the formation of groups which view all actions of the principal from the angle of their group without caring for the larger interest of the school and the students.

5. The problem Teachers–There may be some 'foot draggers' who may like to criticize and even condemn the headmaster right or wrong. Wiles has given the following types of teachers:

(i) The lazy teachers
(ii) The colourless teachers
(iii) The older teachers
(iv) The undemocratic teachers
(v) The disagreeing teachers

Role of Mathematics Teacher in Improving the Image of School

The meaning of school's reputation, is concept and reaction of different programmes of society in a school. Image of a school depends upon leadership of head teacher or Principal cooperative feelings among teachers, and other staff members and good achievements of the students. A mathematics teacher should keep following points in mind to improve the reputation of schools :

(a) A mathematics teacher should teach in the class according to the time tables.
(b) He should give the students sufficient class work, home work and drill work and also make time correction and suggestions.
(c) A mathematics teacher should develop the feeling of co-operation in the boys and girls.
(d) He should motivate the students for the participation in co-curricular activities, games etc.
(e) Teacher should behave with the students impartially, love them, and cooperate them.
(f) He should develop in the students the tendency of discipline.
(g) He should try to bring changes guardian's attitudes towards the school through the activities of parent-teacher association.

(h) He should teach in the class according to the time-table.

(i) He should make efforts to develop power of leadership by organizing students committee, mathematics club.

(j) Parents and guardians should be invited in the various programmes and activities of the school so that they may be enable to know the progress of the school and their children.

SUMMARY

Teaching mathematics is a task which, if sincerely undertaken, will challenge the best efforts of the best teacher. The influence of teacher shapes the personality of the child. God created man in the shape of his own image, the teacher fashions the child in the shape of his own image.

Definitions of Teacher—

According to **Secondary Education Commission,** " "

According to **Mannu,** " "

According to **Swami Vivekanand,** " "

According to **Radhakrishan,** " "

According to **Tagore,** " "

According to **John Adams,** " "

According to **H.G. Wells,** " "

According to **Humayun Kabir,** " "

Importance of Teacher in Modern Education

Modern education is child centred. Here teacher is more like a gardener who has to look after and nourish each plant (child) of the garden (school) very wisely and carefully so the teacher has to study the child.

Qualities and Characteristics of a Mathematics Teacher

(A) Individual Qualities

(1) Teacher's personality
(2) Good Health
(3) Self-confidence
(4) Interest in mathematics subject
(5) Patience and Tolerance
(6) Resourcefulness
(7) Positive Attitude

(B) Professional Qualities

(1) Knowledge of subject
(2) Scientific attitude

(3) Knowledge of application of mathematics
(4) Knowledge of Individual differences
(5) Knowledge of mathematical skills and analysing ability
(6) Knowledge of Different Teaching Methods
(7) Psychological Outlook
(8) Professional growth and development
(9) Teacher's academic achievements
(10) Interest in Research work
(11) Knowledge of new innovations

(C) Social Qualities

(1) Ability to leadership
(2) Democratic dealing
(3) Ability to organising
(4) Community activities
(5) Justice Loving
(6) Impartial attitude or behaviour

Duties of a Good Mathematics Teacher

1. He should select proper audio-visual aids, all appratus and make use of them correctly and completely.
2. He should select appropriate teaching methods to make teaching lively and activity oriented.

Evaluation of a Good Mathematics Teacher

1. As a teacher of the school, how well are you fulfilling your duty?
2. Are you making efforts to increase your professional qualifications?
3. What opinion do the students, other teachers and the principal have of you?

Improving Professional Competence of a Mathematics Teacher

- A comprehensive and effective professional training for prospective teachers.
- Selection of candidates for pre-services teacher education on the basis of aptitude test.
- Organisation of selective academic training programmes.

Problems of the Teachers

1. Feeling of Frustration
2. Feeling of Rejection
3. Feeling of Insecurity

MICRO TEACHING AND ITS COMPONENTS

Introduction

Micro-teaching is one of the most recent innovations in teacher training programme. It aims at modifying teacher's behaviour according to the specified objectives. It was first introduced at the Stanford University in 1961. It is a training procedure aiming at simplifying the complexities of the regular teaching process. In a micro-teaching procedure, the trainee is engaged in a scaled down teaching situation. It is scaled down in terms of class size, class time and teaching task.

A teacher can use several techniques and procedures to bring about effective learning on the part of his students. These activities include introducing the lesson, demonstration, explaining or questioning. These activities form what are called teaching skills? Micro-teaching allows practicing any skill independently and integrating it with other skills in familiar environment.

Definitions

- Micro-teaching is a scaled down teaching encounter, in class size and class time. **(Allen D.W.)**
- Micro-teaching is a system of controlled practice that makes it possible to concentrate on specific teaching skills and to practice teaching under controlled conditions. **(Allen & Eve).**
- Micro-teaching is a training technique which requires student teachers to teach a single concept using specified teaching skill to a small number of pupils in a short duration of time. **(B.K.Passi &Lalitha M.S.)**

Assumptions of micro-teaching

The assumptions on which Micro-Teaching is based areas under:-

1. Teaching is a complex process but can be analysed into simple skills.
2. Teaching skills can be practiced one by one up to mastery level under specific and simplified situation.
3. Teaching behaviour of a teacher can be observed in classroom situations.

4. Drawbacks in the teaching competency can be traced out and then they can be improved upon.
5. Complexities of normal class-room situation can be reduced. The size of the class, the duration of teaching, teaching contents etc., can be reduced for giving training to the beginner teachers.
6. Training of specific skills can be given very well by taking up one skill at a time.
7. Practice of teaching can be controlled by providing regular feedback.
8. Teacher training programme can be highly individualised.
9. In-service teachers can also be better trained through Micro- Teaching technique.
10. Observation of teaching can be done objectively by using video-tape and Closed Circuit Television.
11. Feedback to the teacher trainee can be possible immediately. The earlier the feedback to the teacher trainee, the better is his learning the different skills of teaching.
12. Appropriate feedback if systematically given proves very significant for obtaining mastery level in each skill.
13. When all skills have been mastered taken one by one, they can be integrated for real classroom teaching.
14. The skill training can be conveniently transferred from simulated teaching situation to actual classroom teaching situation.

Principles underlying micro-teaching technique

Micro-teaching is based on the premise that teaching can be analysed into various teaching skills which can be practised and evaluated. Micro-teaching seems to be based on Skinner's theory of operant condition. This theory is the very basis of feedback session. Skinner's theory of shaping successive approximations can be applied to explain the acquisition of new patterns of behaviour in teach →feedback → re-teach pattern in micro-teaching.

Principles Underlying Micro-Teaching

Micro-Teaching is based on a few sound principles which are briefly explained below:

1. Principle of One Skill at a Time: In Micro-Teaching, training of one skill is given till the person has acquired mastery over it. Then the second skill is taken up and so on. Thus, we find that Micro-Teaching is based on the principle of giving training of one skill at a time.

2. Principle of Limited Contents: Micro-Teaching, limited contents are taken up and the teacher is required to use those contents only. It helps the beginner teacher teach that limited material easily and confidently.

3. Principle of Practice: Micro-Teaching is based on the sound principle of practice. Here lot of practice is given by taking up on is skill at a time. Practice makes a man perfect. It helps the pupil- teacher in becoming better and better.

4. Principle of Experimentation: A lot of Experimentation is involved in Micro-Teaching. The experiment consists of objective observation of actions perfumed under controlled conditions. The pupil-teacher and the supervisor conduct experiment on teaching skills under controlled conditions. Variables like time duration of the lesson, contents of the lesson to be taught, number of students sitting in the class etc., can be easily controlled.

5. Principle of Immediate Feedback: The micro lesson lasts for four or five minutes only. Thereafter, feedback is provided to the pupil-teacher. It helps the pupil-teacher to know his drawbacks and improve them effectively without any delay.

6. Principle of Evaluation: In Micro-Teaching, there is continuous assessment of the performance of the pupil-teacher. Evaluation helps the learner know his drawback and then he is able to improve it. In Micro-Teaching, each micro lesson is supervised by the supervisor or the peers. Drawbacks in teaching are pointed out and suggestion for improvement is given. Self-evaluation is also possible. Thus, evaluation ensures good learning by the pupil-teacher.

7. Principle of Continuity: Learning of different skills of teaching is a continuous process in Micro-Teaching programme. The pupil-teacher is learning one skill at a time and learning continues till he has mastered the skill. For each skill, the principle of continuity is implied. It makes the teacher good and effective.

8. Principle of Individualised Training: In Micro-Teaching, each trainee is given training very thoroughly. There is individual attention by the supervisor. The drawbacks in teaching are pointed out, suggestions given one by one and thus improvement is brought about.

Concept of micro-teaching:

Micro-teaching is a teacher training technique which helps the teacher trainee to master the teaching skills. It requires the teacher trainee

1. To teach a single concept of content
2. Using a specified teaching skill
3. For a short time
4. To a very small member of pupils

In this way the teacher trainee practises the teaching skill in terms of definable, observable, measurable and controllable form with repeated cycles till he attains mastery in the use of skill.

Phases of Micro Teaching

Clift (1976) described the following as the phases of micro teaching.

A. Pre-active phase (knowledge acquisition phase)
B. Interactive phase (skill acquisition phase)
C. Post-active phase (Transfer phase)

A. Pre-active phase (knowledge acquisition phase): it emphases the understanding of the teaching skill that is to be learnt by the teacher trainee. It envisages the following steps

1. Orientation to micro teaching.

2. Discussion of teaching skills with their components and teaching behaviour.
3. Presentation of modern demonstration lesson by the teacher educator.
4. Observation of the model lesson and criticism by the teacher trainee.

B. Interactive phase (skill acquisition phase): the main objective of this phase is to enable the teacher trainee to practice the teaching skill following micro teaching cycle. The steps are:

1. Preparation of micro- lesson plan for the related teaching skill.
2. Creating microteaching settings.
3. Practice of teaching skill.
4. Feedback.
5. Re-planning.
6. Re-teaching.
7. Repetition of the micro teaching cycle.

C. Post-active phase (Transfer phase): the main objective of this phase is to enable the teacher trainee to integrate the teaching skill in real or normal class room situation. Integration of teaching skill may be defined as process of selections organization and utilization of different teaching skills to form an effective pattern for realizing the specified instructional objectives in a teaching learning situation.

Steps in Micro Teaching

The Micro-teaching programme involves the following steps:

Step I- Particular skill to be practiced is explained to the teacher trainees in terms of the purpose and components of the skill with suitable examples.

Step II -The teacher trainer gives the demonstration of the skill in Micro-teaching in simulated conditions to the teacher trainees.

Step III- The teacher trainee plans a short lesson plan on the basis of the demonstrated skill for his/her practice.

Step IV -The teacher trainee teaches the lesson to a small group of pupils. His lesson is supervised by the supervisor and peers.

Step V -On the basis of the observation of a lesson, the supervisor gives feedback to the teacher trainee. The supervisor reinforces the instances of effective use of the skill and draws attention of the teacher trainee to the points where he could not do well.

Step VI -In the light of the feed-back given by the supervisor, the teacher trainee re-plans the lesson plan in order to use the skill in more effective manner in the second trial.

Step VII -The revised lesson is taught to another comparable group of pupils.

Step VIII -The supervisor observes the re-teach lesson and gives re-feed back to the teacher trainee with convincing arguments and reasons.

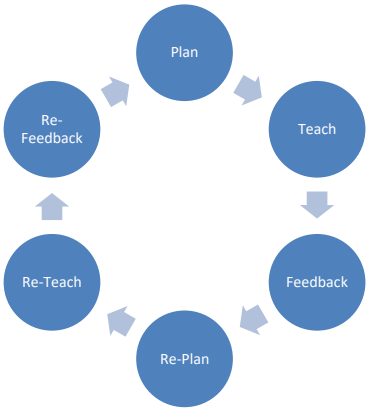
Step IX -The 'teach – re-teach' cycle may be repeated several times till adequate mastery level is achieved.

Micro Teaching cycle

The six steps generally involved in micro-teaching cycle are

1. Plan,
2. Teach,
3. Feedback,
4. Re-plan,
5. Re-teach,
6. Re-feedback.

There can be variations as per requirement of the objective of practice session. These steps are diagrammatically represented in the following figure:



1. Plan: This involves the selection of the topic and related content of such a nature in which the use of components of the skill under practice may be made easily and conveniently. The topic is analysed into different activities of the teacher and the pupils. The activities are planned in such a logical sequence where maximum applications of the components of a skill are possible.

2. Teach: This involves the attempts of the teacher trainee to use the components of the skill in suitable situations coming up in the process of teaching-learning as per his/her planning of activities. If the situation is different and not as visualised in the planing of the activities, the teacher should modify his/her behaviour as per the demand of the situation in the class. He should have the courage and confidence to handle the situation arising in the class effectively.

3. Feedback: This term refers to giving information to the teacher trainee about his performance. The information includes the points of strength as well as weakness relating to his/her performance. This helps the teacher trainee to improve upon his/her performance in the desired direction.

4. Re-plan: The teacher trainee re-plans his lesson incorporating the points of strength and removing the points not skillfully handled during teaching in the previous attempt either on the same topic or on another topic suiting to the teacher trainee for improvement.

5. Re-teach: This involves teaching to the same group of pupils if the topic is changed or to a different group of pupils if the topic is the same. This is done to remove boredom or monotony of the pupil. The teacher trainee teaches the class with renewed courage and confidence to perform better than the previous attempt.

6. Re-feedback: This is the most important component of Micro-teaching for behaviour modification of teacher trainee in the desired direction in each and every skill practice.

Characteristics of micro teaching

1. It is a teacher training technique and not a teaching method.
2. It is a real teaching, though the teaching situation is simulated.
3. In micro teaching teacher trainee practices one a specific teaching skill at a time, till he/she attains mastery over the skill.
4. It is a scale down teaching encounter in class size, content, class time.
5. It operates on a predefined model. Plan, teach, feedback, re- plan, re- teach, re-feedback, etc.
6. It allows for increased control of practice by providing feedback to the teacher trainee.
7. It is not a substitute but a supplement to the teacher training programme.
8. It is a cyclic process. The pre decided model is repeated till the trainee achieves the expected level of mastery.
9. It is a highly individualized training device.

Uses of Micro Teaching

1. Helps in reducing the complexities of the normal class room teaching.
2. Helps the teacher trainee gain more confidence in real teaching,
3. It creates among the teacher trainees an awareness of various skills of which teaching is composed of.
4. It simulates the class room scene and gives the teacher trainee an experience of real teaching.

5. It helps in systematic and objective analysis of the pattern of class room communication through specific observation schedule.
6. It is more effective in modifying teacher behaviour.
7. It is an effective technique for transfer of teaching competencies to the class room.
8. It helps in getting acquainted with class room manners to a certain extent.
9. Feedback enables the teacher trainee to consciously concentrate on specific behavioural modification.
10. It helps the teacher trainees in better understanding of the meaning and concept of the term teaching.

Demerits

1. Micro teaching is skill oriented and not content oriented.
2. It covers only a few specific skills.
3. Lack of material resources like video recording facility and trained supervisors.
4. The question of integrating the skill is quite challenging.
5. Teaching is not just a summation of teaching skills.
6. Sufficient literature on micro teaching is not yet available.

Teaching - Meaning

- Teaching is the stimulation, guidance, direction and encouragement of learning.
- Teaching is the communication between two or more persons, who influence each other by their ideas and learn something in the process of interaction.
- Teaching is to fill the minds of the learner by information and knowledge of facts for future use.
- Teaching is the process in which learner, teacher and other variables are organized in a systematic way to attain some pre-determined goals.
- Teaching is to cause the child to learn and acquire the desired knowledge, skills and also desired ways of living in the society.

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Teaching: Definition

- "Teaching is an intimate contact between a more mature personality and less mature one which is designed to further the education of the latter." - (**H.C. Morrison, 1934**)
- "Teaching means many different things, that teaching act varies from person to person and from situation to situation." - (**Bar,1961**)
- "The behaviour or activities of persons as they go about doing whatever is required of teachers, particularly those activities which are concerned with the guidance or direction of learning of others." - (**Ryan, 1965**)
- "Teaching is the arrangement of contingencies of reinforcement under which students learn. They learn without teaching in their natural environment, but teachers arrange special contingencies which expedite learning and hastening the appearance of behaviour
- which would otherwise be acquired slowly or making scene of the appearance of behaviour which might otherwise never occur."- (**B.F. Skinner. 1968**)
- "Teaching as an act of interpersonal influence aimed at changing the ways in which other persons can or will behave." - (**N.L.Gage, 1963**)

Characteristics of Teaching Skills

1. Teaching skills have three basic components perception, cognition and action.
2. Teaching skills have three basic dimensions- non-verbal behaviour, openness and nature of moves in teaching to which the skill belongs.
3. Teaching skills can be measured by simple observation, by making observation schedule and check list.
4. Teaching skills can be identified by analyzing teaching behaviors. Allen &Ryan (1969) identified 14 skills of teaching.

5. Teaching skills can train pupil teachers in using these skills which can be developed through instruction and training.
6. Teaching skills can be observed and this is the reason they have been identified.

Teaching Skills

Teaching skills are specific instructional activities and procedures that a teacher may use in the class room. (Gage 1968). Skill is an act of teaching. (Allen). A teaching skill is a group of teaching acts/ behaviours intended to facilitate pupils learning activity directly or indirectly.

Identification of Teaching Skills:-

There are many approaches for identifying teaching skills. The prominent among them are the following:

1. Observation of Class Room Interaction
2. Analysis of Teacher Tasks Through Interview and Discussion
3. Analysis of School Curriculum and Objectives
4. Conceptualization of a Good Teaching Model

The Australian Advisory Committee on Research and Development in Education has analysed teaching into 140 skills. Allen of the Stand ford University (2969) has identified 14 teaching skills. In India, BK.Passi has given a list of 13 teaching skills. M.K. Jangira and Ajit Singh(1982) of NCERT provide a list of 20 teaching skills.

Attempts have been made to list teaching skills. Allen and Ryan listed the following teaching skills at Stanford University in the U.S.A.

1. Stimulus Variation
2. Set induction
3. Closure
4. Teacher silence and non-verbal cues
5. Reinforcing pupil participation
6. Fluency in questioning
7. Probing questioning

8. Use of higher questions
9. Divergent questions
10. Recognizing and attending behaviour
11. Illustrating and use of examples
12. Lecturing
13. Planned repetition
14. Completeness of communication

B.K. Passi has given the following list of Teaching Skills in his book "Becoming Better Teacher; Microteaching Approach" .

1. Writing instructional objectives
2. Introducing a lesson
3. Fluency in questioning
4. Probing questioning
5. Explaining
6. Illustrating with examples
7. Stimulus variation
8. Silence and non-verbal cues
9. Reinforcement
10. Increasing pupil participation
11. Using black board
12. Achieving Closure
13. Recognizing attending behavior

NCERT (National Council of Educational Research and Training) in its publication Core TeachingSkills (1982) has laid stress on the following teaching skill.

1. writing instructional objectives
2. Organizing the content
3. Creating set for introducing the lesson

4. Introducing a lesson
5. Structuring classroom questions
6. Question delivery and its distribution
7. Response management
8. Explaining
9. Illustrating with examples
10. Using teaching aids
11. Stimulus variation
12. Pacing of the lesson
13. Promoting pupil participation
14. Use of blackboard
15. Achieving closure of the lesson
16. Giving assignments
17. Evaluating the pupil's progress
18. Diagnosing pupil learning difficulties and taking remedial measures
19. Management of the class

Core Teaching Skills

It is not possible to train all the pupil teachers in all these skills in any training programme because of the constraints of time and funds. Therefore a set of teaching skills which cuts across the subject areas has been identified. They have been found very useful for every teacher. The set of these skills are known as core teaching skills**.**

Core Teaching Skills are:

1. The skill of Questioning.
2. The skill of Reinforcement.
3. The skill of probing.
4. The skill of explaining.
5. The skill of stimulus variation.
6. The skill of introducing a lesson.

7. The skill of illustrating with examples.
8. The skill of using blackboard.

CORE TEACHING SKILLS AND THEIR COMPONENTS:

1. Skill of introducing a lesson or (Set Induction)

Introduction skill is the skill required to begin the teaching – learning process on a good note. The objectives of the skill are to:

1. Get students attention & their readiness for learning
2. Arouse student's motivation
3. Clearly indicate the learning experience to be provided
4. Suggest ways & means of the approaching activity to be done
5. Review previous experiences/knowledge & makes its link to the present content/task

Components of introduction skill

Skill components	How to use them
Gaining attention	By using voice, gesture & eye contact. Use of audio-visual aids. Changing the pattern of teacher-pupil interaction.
Use of previous knowledge	Previous knowledge refers to the learner's level of achievements before instruction begins. Use of previous knowledge is a must, because it helps to establish integration between the pre-existing knowledge of the learner and the new knowledge that the teacher wants to impart him.
Use of Appropriate Device	In order to motivate the learner, the teacher should make use of appropriate devices or techniques while introducing a lesson. For example- dramatization, models, audio-visual aids etc.

2. Skill of stimulus variation

If the class room environment becomes monotonous, then it puts a negative impact on the teaching & learning process. It is therefore, essential to make the class room environment challenging & interesting such that the teaching –learning process becomes lively, interesting, and pleasant and a thought provoking experience. This process of bringing variation in the overall interactive environment of the class with the help of stimuli change is called stimulus variation. It is important because it helps to:

1. Break monotony of the class

2. Bring variation in presentation
3. Bring & maintain attention of pupils
4. Make teaching attractive & interesting
5. Make teaching effective by using various senses
6. Involve students in the teaching-learning process

Components of stimulus variation skill

Teacher movement	The teacher should not be static, he should be moving around the lecture table so that he & the students remain active.
Teacher gesture	The body language & the facial expression of the teacher should be pleasant, relevant to explain the concepts & make teaching a live experience. It should be varied time to time & according to the need.
Change in interaction style	The class room interaction pattern must be changed constantly to make the class lively and everybody participate in the learning process. There may be four types of interaction pattern: a) Teacher to whole class b) Teacher to group of students c) Teacher to individual student d) Student to student
Change in speech pattern	The teacher should vary his speech pattern depending on the relevance of the concept & to break monotony of the class. It also helps in gaining & maintaining students attention & in reflecting the importance of the concept being expressed. The following three speech pattern may be used for this purpose: a) Pausing b) Low pitch c) High pitch
Oral – visual switching	According to the need of the topic, it becomes necessary to shift sensory channels of students. It can be done in the following ways: a) Verbal to visual b) Verbal to verbal-visual c) Visual to verbal d) Visual to verbal-visual
Pupil activity	Students should be involved in organizing activity based learning.

Focusing	Focusing implies drawing the attention of the learners towards a particular point which the teacher wishes to emphasize. Such technique involves verbal focusing, gestural focusing, or verbal-gestural focusing.

3. Skill of using Blackboard

BB is one of the most important tools in classroom teaching. Effective use of BB increases the effectiveness of teaching. The BB serves the following purposes:

1. Effective visual aid
2. Provides clarity in understanding concepts
3. Draws attention of students at relevant points
4. Presents holistic picture of the content

Components of BB use skill

Legibility of hand writing	Distinct difference between letters Adequate space between letters Adequate space between words Slant of the letter nearly vertical All letters of the same size Size of the letters large enough to be read Thickness of the line uniform
Neatness	Adequate spacing between lines Lines parallel to the base of the black board No over writing Focusing the relevant matter
Appropriateness	Continuity in the points Simplicity Proper use of color chalk Appropriate presentation of illustrations and diagrams Underlining only the important points
Organization of black board work	Systematic planning of space Spacing to exhibit the sequence of the items being presented Adjustment of space for presenting related items in totality

4. Skill of Questioning

Questions are the most important tool of thinking, reasoning, learning & teaching. Questions are used at every stage of teaching, ie, pre-active, interactive & post-active stages.

Objectives of questioning are;

1. Finding out previous knowledge
2. Revising the topic
3. Stimulating thought process
4. Encouraging discussion
5. Getting students participation

Questioning approaches

1. Targeting questions – a list of questions is put to a particular student or a group of student. After which it is rotated in the class from one student to another.
2. Delivery – in this type of approach all participants have to consider the questions. Students are given time to think about the answers after teacher calls individual students & asks them to give answers.
3. Acknowledging the answers – sometimes teacher put questions to acknowledge the answer of the previous question & to reinforce their positive response.

Level or order of question

Depending on the complexity of questions, there are three levels of questions; lower order, middle order & higher order questions. The teacher uses any of these levels of questions depending on student aptitude, nature of content, purpose of questioning & levels of teaching.

Types of questions:

1. Open questions – those questions for which there is not a single definite answer.
2. Closed questions – these are the questions which have only one correct answer.
3. Rhetorical/dramatic questions – these are the questions for which there are no easy answers. These are higher order thinking questions.

Components of questioning skill

Structure	Grammatical correctness and lucidity Conciseness Relevance Specificity
Process	Speed Voice Pause Style
Product	Solving problems, making predictions,

	producing original communication ascertaining validity of ideas or judging or justifying artistic to engage pupils in the skill of thinking and of creating knowledge.

5. Skill of reinforcement

Reinforcement is a skill which a teacher uses to increase the frequency of positive or desirable behavior of the learner or to decrease the negative or undesirable behavior of the learner.

Objectives

1. Attract & retain attention of the class
2. Encourage pupils for positive behavior
3. Discourage pupils for negative behavior
4. Increase students confidence level

Components of reinforcement skill

Verbal	a) Positive – repeating students answer & praising them b) Negative – scolding & telling students to improve
Non-verbal	a) Positive – Smile, positive head movement etc. b) Negative – anger, negative head movement etc.
Contact reinforcement	Patting the back, hand shaking & putting hands on the students head.
Proximity reinforcement	Going nearer to the pupils & making them more involved & interested in learning
Activity reinforcement	Giving a task, a project, home work, assignment, etc.
Token reinforcement	Awarding marks, grades, good, excellent, etc. on pupils note book.
Inappropriate use of reinforcement	This is the situation when the teacher does not encourage the pupil with respect to quality of his response. He uses same type of comment for every response.
Denial reinforcement	This is the situation, where the teacher does not give reinforcement when the situation is demanding encouragement.

6. Skill of explaining

This is the skill required to develop understanding & higher order thinking among students. This skill is one of the most important attributes a good teacher must possess.

Objectives

1. Pupils to clarify an issue
2. Students to describe process, structures & procedures
3. Students to state reasons of events & phenomena

Components

Use of beginning statements	Before starting any explanation, the teacher should make the pupils aware of what he is to teach on that day through a clear beginning statement.
Use of explaining links	This technique is used primarily to explain the links in statements with 'so', 'therefore', 'because', 'due to', 'as a result of', 'in order to' etc.
Use of mediators	
Use of concluding statement	This is the statement made at the end of the explanation. It includes the summary of all the main results of the explanation.
Questions to test pupils understandings	These are short questions put to the pupils to test their understanding of the concept after the explanation. The main purpose is simply to judge whether the pupils have understood or not.

Precautions for skill of Explaining:

a) It should be in simple language.
b) It should not be given the shape of an advice.
c) The thoughts included in it should be in a sequence.
d) Irrelevant things should not be included in it.
e) It should be according to the age, experience and mental level of the pupils.

7. Skill of Probing Question

Probing questions are those which help the pupils to think in depth about the various aspects of the problem. By asking such questions again, the teacher makes the pupils more thoughtful. He enables the pupils to understand the subject deeply.

The components of this skill are:

Prompting	When a pupil expresses his inability to answer some

	question in the class or his answer is incomplete, the teacher can ask such questions which prompt the pupils in solving the already asked questions.
Seeking Further Information	When the pupils answer correctly in the class but the teacher wants more information and further clarification from the learner by putting 'how' and 'why' of correct part the response.
Refocusing	When the teacher ask the same question from other pupil for comparison. This is known as Refocusing.
Redirecting Questions	Questions which are directed to more than one learner to answer are called redirected questions.
Increasing Critical Awareness	This technique is used when the pupil's response is correct. The teacher puts higher order questions to stimulate the pupil to think beyond what the pupil knows. This involves the 'how' and 'why' and sometimes 'what' type of questions on the point under discussion.

8. Skill of illustration with examples

When a teacher finds difficult in making students understand an abstract idea, concept or principle despite the best explanation, he or she then resorts to the use of illustrations. The teacher uses his experience to illustrate the concept with the help of examples. The clearer the examples are, the more learning will be taking place.

Components

Formulating simple examples	A simple example is one which is related to the previous knowledge of pupils. It should be according to the age level, grade level and the background of pupils.
Formulating relevant examples	An example is relevant to the concept, when the concept or the rule can be applied to it. This means to say that the rule is explained by the example.
Formulating interesting examples	An example is interesting if it can arouse curiosity and interest of pupils. This can be judged by the attending behavior of students. If the pupils keenly attend to the example, it is

	really interesting.
Use of appropriate media for examples	Appropriateness of media refers to its suitability to age level, grade level, maturity and to the unit taught. The decision about the nature of media, whether verbal or non verbal depends on the nature of concept.
Use of inductive and deductive approach for example	This involves the teacher giving examples relating to the concept or rule to clarify it. The pupils on the basis of the examples given, formulate the rule. After this the teacher asks the pupils to give examples to test whether the pupils have rightly understood the concept or not.

Significance and Importance of Illustration Skill

- With the help of this skill, the teacher becomes enabled to command and to have the **attention** of the pupils with remarkable effectiveness.
- Besides, this skill can stir up emotion and thus may reach the conscience and the heart of the student. The skill; is also an effective memory aid and thus it must be used by every teacher for **result-oriented** teaching.
- Illustration combined with example usually requires only a few words, yet they can paint vivid mental images and if chosen carefully and used skillfully they can prove out to be very **fruitful**. However, a teacher may reinforce their value by adding a brief explanation.
- This specific skill may include numerous illustrations and examples drawn from **practical experience** by the teacher which can be used in the teaching.
- The Illustration with Example Skill of Micro Teaching is so essential in the context of the topic that sometimes the illustration themselves can explain the content of the topic concerned.
- Illustration along with the example, if they are quite accurate and appropriate to the content of the topic concerned as well as **pleasing to the eyes**, then they would serve the purpose of the teacher in a rewarding manner.
- The picture must support the text. The less the number of words, the more the illustration must convey.

- Understanding how illustration shows visual elements such as line, color, shape, texture, and composition can help to appreciate and understand the artists; intention though the artwork. The student would also be to identify illustration; style such as **realistic**, impressionistic, expressionistic, abstract, primitive, and surrealistic.
- Early exposure to the illustration along with related examples helps to develop the **aesthetic sensitivities** amongst the students.

LINK PRACTICE (Integration of Teaching Skills)

The link practice may be defined as a process of **selection, organisation and utilisation** of different teaching skills to form an effective pattern for realizing the specified instructional objectives in a given teaching learning situation

Link practice involves the integration of skills: The main objectives of integration of teaching skills are to help in the transition from microteaching situation to real teaching situation regarding the synthesis of teaching skills in view of the teaching situation and instructional objectives.

Link practice involves when mastery has been attained in various skills, the teacher trainee is allowed to teach the skills together. This separate training programme to integrate various isolated skills is known as 'Link Practice'

1. It helps the trainee to transfer effectively all the skills learnt in the micro teaching sessions.
2. It helps to bridge the gap between training in isolated teaching skills and the real teaching situation faced by a student teacher.
3. Desirable Number of Pupils :15-20
4. Preferable Duration: 20minutes.
5. Desirable Number of Skills :3-4 Skills

Link practice or integration of skills can be done in two ways;

- Integration in parts - 3 or 4 teaching skills are integrated and transferred them into a lesson of 15-20 minutes duration. And again 3 or 4 skills are integrated and are transferred all the skills to one lesson.
- Integration as a whole - Student teacher integrates all the individual teaching skills by taking them as a whole and transferred them into a real teaching situation.

Features of link Practice:

- Link Practice sessions are normally arranged with about 20 pupils for about half the normal class period, that is, 20minutes.
- The trainee prepares a series of eight short lessons on a single unit and teaches each lesson for 20 minutes using the appropriate skills particular to the content.
- The number of lessons used in link practice is also flexible but should cover adequately the topic that the trainee has chosen.
- The skills of set induction and closure which are not practiced in microteaching session are effectively used in the proper place in the link session.
- In the link practice lessons, trainees gain sufficient practice and control over the use of components of the skills appropriately with the content.
- At the end of each lesson, the trainee should have a review with tutor, not only of that lesson but also of the general strategy of the set of lessons.

Micro-Teaching and Traditional Teaching a Comparison

- **Micro-Teaching**: - is a new idea in the field of teacher education. People who have traditional outlook don't want to change their ideologies. They face problems in accepting the innovation of Micro- Teaching. This type of situation always arises whenever new things will come up. The old nations need be converted into the modern ones because the modern ones are undoubtedly unique. The comparison of the two techniques-brings home clearly the view point that Micro-Teaching is an in proved technique in every way and is better as compared to the traditional teaching:
- **Traditional Teaching**:-It does not pose a big threat or fear to the teacher. It usually encourages the beginner teacher for better job performance in future. Here the objective is given in behavioural terms. The number of students in a class is less. It is rather a small group of 5 to 10students. There is provision of immediate feedback. That helps the teacher to know his drawbacks and improve upon them. Teaching is carried on under fully controlled situations. The supervisor is there who is determined to improve teaching.

Comparison between Microteaching and Traditional Teaching

Micro teaching	Traditional teaching
1. Objectives are specified in behavioral terms.	1. Objectives are general and not specified in behavioral terms.
2. Class consists of a small group of 5 to10 students.	2. Class consists of 40 to 60 students.
3. The teacher takes up one skill at a time.	3. The teacher practices several skills at a time.
4. Duration of time for teaching is 5-10 min.	4. The duration is 40 - 60 minutes.
5. There is immediate feedback.	5. Immediate feedback is not available.
6. Teaching is carried on under controlled Condition/situation.	6. There is no control over situation.
7. Teaching is relatively simple.	7. Teaching becomes complex.
8. The role of supervisor is specific and well defined to improve teaching	8. The role of supervisor is vague.
9. Patterns of classroom interaction can be studied objectively.	9. Pattern of class-room interaction can not be studied objectively

RESEARCH IN MATHEMATICS EDUCATION

Research can be defined in the following manner "Systematic investigation to establish facts.

– *www.cogsci.princeton.edu/cgi-bin/webwn*

A systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge. Activities that meet this definition constitute research for purposes of this policy, whether or not they are conducted or supported under a program, which is, considered research for other purposes. For example, some demonstrations and service programs may include research activities.

– *www.clemson.edu/research/orcSite/orcIRB_DefsR.htm*

Research is a systematic study directed towards more complete scientific knowledge or understanding of the subject studied.

– *www.aaas.org/spp/rd/define.htm*

Research is a systematic study directed toward fuller scientific knowledge or understanding of the subject studied. Research is classified as either basic or applied according to the objectives of the research.

– *www.nsf.gov/sbe/srs/fedfunds/glossary/def.htm*

Research is the only solution for all problems in any decline. Research is the systematic study of the problem or establishing new relationships in the variables or designing new methods.

Research in mathematics education means the research related to teaching techniques, curriculum in mathematics, tools for teaching mathematics and tools for evaluation. Educators in mathematics education are doing their job of finding a solution to the problems. But teachers are not looking in this dimension. They are simply following their traditional methods. Teachers have to change their attitude and think globally and act locally for the benefits of human society.

Research over the past decades made major contributions in defining and understanding the complexity of issues dealing with gender and mathematics (Fennema, 2000). That differences exist in the learning of mathematics seems clear, although many scholars believe either that learning differences are diminishing or that, if any differences do exist, they are unimportant. However, the more the tests measure true mathematical problem solving, the more apt one is to find gender differences in mathematical learning that favors males at almost any age. Females also appear to hold more negative values about mathematics and their relationship to mathematics than do males, but there is some evidence that these differences are decreasing. These simplistic statements, however, hide more than they reveal. What mathematics was being measured in tests where gender differences have been studied? How was the information about values obtained? Were females' voices a part of the data-gathering procedures? Too often the research that has reported gender differences has provided an incomplete picture at best and has only helped to perpetuate the belief that females are somehow inadequate in relation to mathematics.

Research at the International Level

Many elements of the present day science of mathematics education started with the curricular reforms in the period from the late 1950s to the early 1970s. In many countries the reforms were introduced from the authorities based on some (few?) experimental projects. Curricula were developed in many countries and mathematicians and teachers of mathematics worked together.

It should be noted that an initiator of the reforms in Europe was the OEEC (Organization for European Economic Cooperation) and later OECD (Organization of Economics Cooperation and Development). Through a series of conferences, a foundation for reform was established. There was a strong belief in what could be accomplished by changing/reforming the curriculum. To implement the new ideas, curricula were written. Work was done by the Nordic Committee on Modernizing Mathematics Instruction (NCMM).

Mathematics educators from the Nordic countries came together and constructed a curriculum for mathematics. At least in Norway this document had some influence on the work on national curriculas that followed. In the same period, mathematics education as a discipline started to develop. Mathematics educators "moved" into the area that was traditionally the domain of educators.

During the 1970s the reform movement came to a halt in many countries. Several analyses of the curricular reforms were published shortly after, for example: Grifftihs & Howson.

In the beginning of the 1980s, a new interest in curriculum in many countries started to emerge. In the United States, the book *A National at Risk* made many Americans aware of the economic situation concerning the competition with East Asian countries, for various subjects, including mathematics, national organizations in the United States took up the challenge, and produced curriculum documents to influence American education.

Towards the end of the 1980s the *NCTM Standards* had gone through several revisions. The first version was released in 1989, (NCTM, 1989). In the United Kingdom, a national curriculum was developed at about the same time, and in the Nordic countries there were activities reforming curriculum around 1990.

Some of these curriculas built on another philosophy of educational management then was the case in most countries earlier. Ideas were imported from production, and the new "Catchword" was *management by objectives.* This was very explicit in Swedish curricular documents, but also very visible in the National curriculum in the United Kingdom. We still have these curriculas in many countries, although several have been changed. What can be said about the present situation? It is difficult to say something about the general (international) situation, but on the other hand, education in many countries seem to adopt to what we might term as international trends.

The Present Situation

We are now in a situation that has some similarities to the situation in the aforementioned period. In the Organization for Economic Co-operation and Development countries they had international comparison projects (Program for International Student Assessment). We also see that some few other countries have participated, showing a broader interest in such comparisons. Moreover, Trends in International Mathematics and Science Study has started again. Replacing "Third" by Trends gives the same abbreviation, and perhaps indicating that this project will be more or less permanent in many countries. International comparisons have been eagerly used by politicians and educational authorities in some countries. An infamous remark by the Norwegian minister of education show this quite clearly. In Norway as in some other countries (e.g. Germany) this has lead to a demand for reform of education. At this time, new curricular documents were constructed.

With the increasing internationalization of education, it will be important that the educational system – and performance – in one country will not be too different from other countries, where it is natural to compare. The view on learning is perhaps also about to change in many countries. In the late 1980s and 1990s it was a strong influence from constructivism on many curriculum documents. It was for instance written in the Norwegian mathematical curriculum from 1997, that students construct their own mathematical concepts. It seems that now, socio-cultural learning theories have a greater influence on curriculum documents.

Another element of (mathematics) education that has been with (some of) us for some time is the role of Information and Communication Technology in Education. Many educators see possibilities by using ICT in education. On the other hand, many politicians see the inclusion of ICT as a measure of being "up to date" in education, as well as the chance to save on resources. The situation has been more or less unchanged since the late 1980s. In 1988 two important pieces of software for mathematics education were released: **Mathematica and Cabri Geometre**. Similar programs have been developed since then, but in my opinion they don't contain radically new elements.

Research Studies Conducted in India

India has a long record of teaching mathematics date back to the Vedic age (1500-200 BC). Jain mathematicians prescribed arithmetic as one of the essential requirements for the child's first education. During the period from 400-1200 AD, a new branch known as GANIT came into existence with three components specifically arithmetic, algebra, and geometry. But mathematics acknowledged as a separate subject only in the 12th century. Up to the period of 18th century, the native system of education maintained its conventional structure.

In the post independent India, the education commission recommended mathematics as a compulsory subject at the school level. The national policy of education has also considered the importance of mathematics in general education and suggested that "mathematics should be viewed as a vehicle to train the child to think, analyze and to articulate logically." In the recent past, there has been tremendous development in the theories of learning and the science of teaching. Though mathematics occupies a place of importance, the researches in this area have been scanty.

Following are some of the research studies conducted in different areas of mathematics:

- Vyas (1983) demonstrated that students who were taught with the help of the Symbol Logic Picture Program showed better achievement in mathematics than the control group students.
- Yadav (1984) reported that the mastery training strategy did not yield the desired gains in the experimental group.
- Bhalwankar (1985) experimented on the expository and guided discovery methods of teaching mathematics, he drew implications from his findings that all teaching methods are effective in certain situations and not so effective in other situations, as objectives and content determine the methods to be employed.
- Rao (1986) confirmed that no significant difference in mathematics achievement was evident when students were taught by the guided discovery and expository methods. This implication about the methods was ratified by Chitkara (1985) who found lecture-discussion, induction-drill and auto-instruction group discussion methods to be equally effective in terms of

achievement in mathematics, regardless of levels of intelligence, sex and personality type, a very useful finding indeed.

- Girdhari Lal (1986) found evidence to show that individualized instruction was more effective than the other two, i.e., programmed and traditional instruction. Programmed instruction was found less effective than even traditional instruction, thereby supporting the general trend of a sort of irrelevance of methods in teaching of mathematics. One is tempted to observe that some very selective methods of teaching may be effective in increasing achievement in mathematics. One cannot help feeling that attempts at investigating the effectiveness of general methods for teaching special subjects may not yield fruitful data. It is surmised that, as recommended in the document 'Teacher Education Curriculum-A Framework' (1978), research should concentrate on identifying subject-specific special methods. It stands to reason that, when the quantum and depth of subject matter (discipline) increases, different kinds of learning processes need to be aroused by the teacher.
- Rao (1983) studied the effect of programmed and conventional learning methods in imparting instruction in mathematics to pupils from two extreme classes, i.e., V and X. Programmed instruction was found to be superior to conventional instruction.

The use of a mathematics textbook (Class II) was studied by Krishna Kumari *et al.* (1980). It was reported that only 15 percent of teachers studied the textbook thoroughly and tried to assimilate the new concepts and methods suggested therein.

The SCERT, AP (1981) reported that the mathematics and physics textbooks not only comprised modem concepts and were in conformity with the principles of syllabus construction but also catered to the needs and interests of pupils.

Paulchoudhury's (1983) investigation of courses of studies revealed that there existed a wide gap between the NCERT mathematics syllabus prescribed for Central Schools and those prescribed by the north-eastern states.

The factor analysis on the tests of number system in mathematics carried out by Mondkar (1984) showed that the ability to learn number systems was chiefly composed of three factors, viz., general intelligence, number factor and perceptual factor.

Dave *et al.* (1988) reported that the national attainment of pupils in mathematics was excellent in Classes I and II (combined means 61.25 percent and 67.08 percent respectively), good in Class III (combined mean = 50.80 percent) and poor in Class IV (combined mean = 32.31 percent). Again, curriculum renewal efforts helped the project school children to achieve higher mean scores in all classes than those in non-project schools.

These are some research studies conducted in the field of education. There are number of topics in the field of mathematics education to do the research. There are funding agencies to support research in education. Today research is a collective activity. Teacher can participate in research activities to solve their problems. There are some research organizations which help in this endeavor.

2. STATUS OF ACHIEVEMENT IN MATHEMATICS AT ELEMENTARY AND SECONDARY SCHOOLS:

To develop the key processes involved in using and applying mathematics children should have opportunities to use mathematics in a range of tasks, including:

a) activities within their everyday experience in the classroom, such as planning their timetable for the day, or grouping children for various activities;
b) identifying and proposing solutions to genuine problems, such as where in the playground staff should park their cars;
c) tackling artificial but realistic problems, such as estimating the cost for a family of four to go on a two-week holiday on the Norfolk Broads;
d) applying mathematics in practical tasks, such as making a box to hold a set of calculators;
e) solving mathematical problems, such as finding two-digit numbers that have an odd number of factors;
f) pursuing mathematical investigations, such as 'find out as much as you can about the relationships between different paper sizes (A5, A4, A3, and so on)'

In developing numeracy, children in primary schools should learn across the curriculum to:

a) represent and model situations using mathematics, using a range of tools and applying logic and reasoning in order to predict, plan and try out options;
b) use numbers and measurements for accurate calculation and an understanding of scale, in order to make reasonable estimations;
c) interpret and interrogate mathematical data in graphs, spreadsheets and diagrams, in order to draw inferences, recognise patterns and trends, and assess likelihood and risk;
d) use mathematics to justify and support decisions and proposals, communicating accurately using mathematical language and conventions, symbols and diagrams.

3. Area in Difficulties of Mathematics

3.1 Introduction

Math disabilities can arise at nearly any stage of a child's scholastic development. While very little is known about the neurobiological or environmental causes of these problems, many experts attribute them to deficits in one or more of five different skill types. These deficits can exist independently of one another or can occur in combination. All can impact a child's ability to progress in mathematics.

3.2 Incomplete Mastery of Number Facts

Number facts are the basic computations (9 + 3 = 12 or 2 x 4 = 8) students are required to memorize in the earliest grades of elementary school. Recalling these facts efficiently is critical because it allows a student to approach more advanced mathematical thinking without being bogged down by simple calculations.

3.3 Computational Weakness

Many students, despite a good understanding of mathematical concepts, are inconsistent at computing. They make errors because they misread signs or carry numbers incorrectly, or may not write numerals clearly enough or in the correct column. These students often struggle, especially in primary school, where basic computation and "right answers" are stressed. Often they end up in remedial classes, even though they might have a high level of potential for higher-level mathematical thinking.

3.4 Difficulty Transferring Knowledge

One fairly common difficulty experienced by people with math problems is the inability to easily connect the abstract or conceptual aspects of math with reality. Understanding what symbols represent in the physical world is important to how well and how easily a child will remember a concept. Holding and inspecting an equilateral triangle, for example, will be much more meaningful to a child than simply being told that the triangle is equilateral because it has three equal sides. And yet children with this problem find connections such as these painstaking at best.

3.5 Making Connections

Some students have difficulty making meaningful connections within and across mathematical experiences. For instance, a student may not readily comprehend the relation between numbers and the quantities they represent. If this kind of connection is

not made, math skills may be not anchored in any meaningful or relevant manner. This makes them harder to recall and apply in new situations.

3.6 Incomplete Understanding of the Language of Math

For some students, a math disability is driven by problems with language. These children may also experience difficulty with reading, writing, and speaking. In math, however, their language problem is confounded by the inherently difficult terminology, some of which they hear nowhere outside of the math classroom. These students have difficulty understanding written or verbal directions or explanations, and find word problems especially difficult to translate.

3.7 Difficulty Comprehending the Visual and Spatial Aspects and Perceptual Difficulties

A far less common problem -- and probably the most severe -- is the inability to effectively visualize math concepts. Students who have this problem may be unable to judge the relative size among three dissimilar objects. This disorder has obvious disadvantages, as it requires that a student rely almost entirely on rote memorization of verbal or written descriptions of math concepts that most people take for granted. Some mathematical problems also require students to combine higher-order cognition with perceptual skills, for instance, to determine what shape will result when a complex 3-D figure is rotated.

3.8 Signs of Math Difficulties

3.8.1 Output Difficulties

A student with problems in output may

- be unable to recall basic math facts, procedures, rules, or formulas
- be very slow to retrieve facts or pursue procedures
- have difficulties maintaining precision during mathematical work
- have difficulties with handwriting that slow down written work or make it hard to read later
- have difficulty remembering previously encountered patterns
- forget what he or she is doing in the middle of a math problem

3.8.2 Organizational Difficulties

A student with problems in organization may

- have difficulties sequencing multiple steps
- become entangled in multiple steps or elements of a problem
- lose appreciation of the final goal and over emphasize individual elements of a problem
- not be able to identify salient aspects of a mathematical situation, particularly in word problems or other problem solving situations where some information is not relevant
- be unable to appreciate the appropriateness or reasonableness of solutions generated

3.8.3 Language Difficulties

A student with language problems in math may

- have difficulty with the vocabulary of math
- be confused by language in word problems
- not know when irrelevant information is included or when information is given out of sequence
- have trouble learning or recalling abstract terms
- have difficulty understanding directions
- have difficulty explaining and communicating about math, including asking and answering questions
- have difficulty reading texts to direct their own learning
- have difficulty remembering assigned values or definitions in specific problems

3.8.4 Attention Difficulties

A student with attention problems in math may

- be distracted or fidgety during math tasks
- lose his or her place while working on a math problem
- appear mentally fatigued or overly tired when doing math
- Visual Spatial or Ordering Difficulties
- A student with problems in visual, spatial, or sequential aspects of mathematics may
- be confused when learning multi-step procedures

- have trouble ordering the steps used to solve a problem
- feel overloaded when faced with a worksheet full of math exercises
- not be able to copy problems correctly
- may have difficulties reading the hands on an analog clock
- may have difficulties interpreting and manipulating geometric configurations
- may have difficulties appreciating changes in objects as they are moved in space

3.8.5 Difficulties with multiple tasks

A student with problems managing and/or merging different tasks in math may

- find it difficult to switch between multiple demands in a complex math problem
- find it difficult to tell when tasks can be grouped or merged and when they must be separated in a multi-step math problem
- cannot manage all the demands of a complex problem, such as a word problem, even thought he or she may know component facts and procedures

4. The Fear of Mathematics

Mathematics is considered as the one of the most prominent subjects in school level education due to its importance in day today function of the people. It has long been recognized as an essential requirement for everyday life and for most occupations.

Mathematics is often considered as a difficult subject by many students in schools education (Capuno, et al., 2019). Feeling mathematics as difficult for students affects not only their liking of mathematics but also their perseverance, interest, boredom and self-efficacy beliefs related to mathematics (Gafoor&Kurukkan, 2015). Fear of mathematics is not only the case of the particular places or the persons. It is a global issue.

The fear about mathematics is causing the students negative attitude towards mathematics and hindrance the learner from focusing on the problem which they are tackling. The fear of mathematics also tends to the learner get nervous especially during the time of the test or examination, fear clouds their minds and the students could not perform as well. Some of the reasons attributed to the fear of mathematics may develop earlier to the learner and may have several possible causes like: hereditary, social and environmental. Fear of mathematics may create due to the influence of the parents, teachers, classmates and seniors. In the same way, negative perception towards mathematics also may cause the fear of mathematics.

4.1 Meaning and Types of Phobia

A type of anxiety disorder or a mental illness that makes someone very worried and affects their life is known as phobia.

It involves an extreme fear of something or irrational fear of a specific situation, activity and object or that leads to compelling desire toavoid it (American Psychiatric Association, 2013). The term 'phobia' is abstracted from the Greek word "phobos" meaning fear, panic fear, or terror. In the simple terms, the meaning of phobia is "fear". Usually a person has phobias to a number of objects or situations.

Phobias can be divided into three categories as: **specific phobias, social phobia, and agoraphobia** (Hamm, 2009).

- Specific phobias include the fear of certain animals, natural environment situations, blood or injury, and specific situations.
- Social phobia appears when the situation is fearful for the person who is worried for being judged by the other persons.
- In the same way, agoraphobia is a generalized fear of leaving home or a small familiar 'safe' area, and of possible panic attacks that might follow. Sometimes the phobias are produced by the negative experience with the object or situation.

4.2 Mathematics Phobia

There are different types of phobia (fear) such as: fear of water (hydrophobia), fear of height (alto phobia), and fear of performance and so on. One of them is mathematics phobia. It is a fear of mathematics. It can be defined as a feeling of anxiety that stops one from efficiently tackling mathematical problems. Mathematics phobia is regarded as mathematics weakness in students that deals with psychological dimension of learning (Olaniyan& Salman, 2015).

Tillfors (2003) defined phobia as learned emotional responses and it causes frequent severe and intense anxiety. Many people have a negative perception about mathematics that it is an extremely hard subject which they cannot master. This negative perception weakens them from focusing on the subject and as a result they get comparatively less performance in the tests or exams. Consequently, fear increases day by day towards mathematics and eventually itdevelops in the form of phobia.

The lack of ability in mathematics innumeracy has received increasing attention in the last few decades. The ability to use basic mathematics is more important as the modern

day's society has become more complex. Some children may have some problems with mathematics due to some reasons.

According to David Geary (2013), one cause of the problem in mathematics may be a fundamentaldeficit in the representation of numerosity. It occurs at different ages in different people for different reasons.

The specific mathematics phobia which is basically comes due to the arithmetic or fear of numbers. Such phobia is called arithmo-phobia or numero-phobia. The words arithmo-phobia and numero-phobia both have Greek origins where the root word stands for 'numbers', and 'phobos' meaning 'deep dislike or fear'. This type of phobia affects student's attitude towards mathematics and often creates ridiculous fear of numbers. There are several reasons behind the mathematics phobia viz. the ignorance for the subject, discontinuity in concept learning, lack of concentration and practice, avoiding participating in teacher learning process, open insult by teacher, parents, and peers, low scores in the subject and the negative perception about mathematics. This fear is somewhat unusual in that it encompasses a wide variety of specific phobias, including a generalized fear of all numbers and fear of specific numbers. It is classified as an anxiety disorder.

4.2.1 Types of Mathematics Phobia

The mathematics phobia is classified into two types as general and specific arithmo-phobia or numero-phobia.

General arithmo-phobia is the fear of all numbers that can seriously affect the ability of the students to do mathematics. This limits both educational and professional opportunities. Specific arithmo-phobia is the fear of some specific numbers that some people may be affected by this phobia. This type of phobia is usually rooted by superstition or religious phobias.

The specific phobia is less serious than general arithmo-phobia. The best example of specific phobia is a fear of the 13 number, it is known as triskaidekaphobia. This fear has been linked to early Christians, and the number 13 appears in a lot of Biblical traditions. The number 13 is considered as the unlucky number in that religion. Even today, many hotels in the western society omit the 13th floor and room number with the fear of the number 13. In the same way, the number 666 is another number that's widely feared in western cultures. It is said to be the "number of the beast" as translated into English versions of the Book of Revelation verse 18. The number 4 is considered as an unlucky number in Asia countries like China, Vietnam, and Japan because it is something of a

homophone for the word "death" in the local languages. Just like in the west, hotels are prone to omitting the number 4 out of their floors and room numbers, and corporations have even followed suit, the serial numbers of Canon cameras don't include the number 4, and Samsung phones no longer use model codes with 4 either.

Many people of all over the world fear with numbers. Some might fear from one number and other fears from another number considering their culture, religion, place of birth and region. Country like Nepal, India, Bhutan and Myanmar, people who follows Hindureligion, they consider the numbers 0, 1, 8, 10, 12, 19 and 28 as unlucky numbers, bad luck or evil spirits etc. These numbers are called oudeno-phobia, heno-phobia, octo-phobia, deca-phobia, dodeca-phobia, enneadeca-phobia and eikosiocto-phobia respectively. They always fear from these numbers. In contrary to the above, especially the people from Nepal and India assume the number 7 as the lucky number and they like to choose this number and they don't fear. In China, the number 8 and multiples of 8 are considered as the luckiest number and they believe that the number brings wealth and good luck. Similarly, Chinese young people in slang word use 520 as the symbol of conveying love (I love you) to their best friend. However, especially in Nepal and India, people used 420 to convey as the bad character. Thus, due to different religious and cultural superstition, people surrounding these places may have different understanding about the number. The understanding may be positive or negative depending on their religious and cultural superstations. Such irrational beliefs about number create fear to the each and every learner.

4.2.2 Causes of Mathematics Phobia

Mathematics phobia can be occurred due to different causes. As concluded by Ihechukwu, &Ugwuegbulam (2016), lack ofdifferent aspects related to teaching learning like: good teacher-student relationship, use of students-centered/innovative approach of teaching, counseling, positive attitude towards mathematics, improved mathematics curriculum, breaking down topics into units, application of ICTs in teaching mathematics etc. can cause mathematics phobia. According to Foley, et al., (2017), mathematics anxiety is learned not from personal experience but from parents and teachers. As reported by Foley and colleagues, a study done in India found out that, parents with high mathematics anxiety unintentionally convey the idea that mathematics is difficult and anxious while helping their children's homework. In the same way, the study done in America found out that the level of mathematics anxiety depends on their teacher. The children read the subtle body cues of their elders to determine whether mathematics is something to fear or to feel good about. The students who get nervous on any occasion in the case of mathematics are caused by mathematics phobia. Thus mathematics phobia is

mainly caused by the test and examination(due to the pressure to perform well), people (individual, parents, teachers and peers)due to individual low proficiency, parents concept of difficulty, teacher poor knowledge delivery and peers negative feeling toward mathematics and nature of mathematics (due to abstract nature and not to relate all aspects in real life). The following points may be the causes of mathematics phobia:

i) Weak teaching method and weak mathematics background
ii) Teachers' aggressive, stressful and irritating characteristics
iii) Inability to solve mathematics problems
iv) Bad relationships between a teacher and a student
v) Inability to solve too much home assignment
vi) Not to understand mathematics in class
vii) Unable to solve mathematical tasks
viii) Use of abusive words by teacher
ix) Negative attitude towards mathematics
x) Not able to solve mathematics problem in time
xi) Not to be child-friendly teaching environment
xii) Mathematics learning difficulty (dyscalculia)
xiii) Community Influence (negative perception)
xiv) Low self esteem
xv) Lack of analogies

4.2.3 Symptoms of Mathematics Phobia

Mathematics phobia is a feeling of anxiety that appears due to the fears of solving different mathematical problems. Some people call mathematics phobia as a tension, panic, helplessness, and mental disorganization. The feeling of phobia in long term can have a negative impact on health of the person and also lose the desire to learn the subject further. Hence, any types of phobia should be eliminated at the very beginning stage not to evolve into more serious problems. In the same way, mathematics phobia has the following symptoms:

i) Try to avoid numbers
ii) Getting confused and disorganized
iii) Apparent choking sensation
iv) Anxiety, depression, and panic
v) Fear of doing anything else
vi) Sweating, trembling or getting hot flushes
vii) Problems with breathing

viii) Breathing rapidly and tightness in the chest
ix) Nausea, headache and fainting
x) Unable to express one's thoughts clearly
xi) Immediate desire to leave classroom
xii) Get detached from reality
xiii) Shows avoidance behaviour
xiv) Getting nervous and stressed when assigned to solve mathematical problems
xv) Skips classes and irrational thinking.

4.2.3 Way to Overcome Mathematics Phobia

It is fair to say that mathematics is not everyone's favorite subject. Some students have the feelings of tension and anxiety or fear toward mathematics. Such negative feeling towards mathematics suffers them day by day and it can be difficult to shift from a mindset of failure to a more positive attitude. Different research shows that if teachers as well as the parents deal with the mathematics phobic student in time by different way to shift into positive mindset, it is not impossible. So many students may have suffered from mathematics phobia due to the result of several negative experiences and perception in the past. It can be overcome by controlling anxiety, improving mathematics skills and developing positive attitude towards mathematics. The following steps are the main way forward from mathematics phobia and perhaps find a way to view mathematics in a more positive light.

i) Reinforce the child's sense of intelligence and skill in mathematics learning
ii) Create a supportive environment for learning mathematics
iii) Encourage the child to tackle in mathematics
iv) Explain the child about positive uses of mathematics
v) Familiarize the child into mathematics teaching aids
vi) Make mathematics teaching fun with games and puzzles
vii) Avoid to compare the child's abilities to others
viii) Increase the use of instructional materials in teaching
ix) Use of innovative and contemporary teaching approaches
x) Develop and maintain close student-teacher relationship
xi) Motivate students to treat mathematics positively
xii) Provide access of reference material
xiii) Use of modern facilities, devices, and tools
xiv) Use of ICT in teaching learning situation
xv) Make enough and effective practice of mathematics.

5. Theories on Attitude:

Attitude is a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour (Eagly&Chaiken, 1993). It is a predisposition or a tendency to respond positively or negatively towards a certain idea, object, person, or situation or an attitude object. Attitude influences an individual's choice of action, and responses to challenges, incentives, and rewards (Business Dictionary). Zelley, Marianne and Elaine (2005) postulate that attitudes are generally positive or negative views about a person, place, thing or event which are often referred to as the attitude object. Arul (1995) quotes Allport's definition of attitude as a mental and neural state of readiness organised through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related. Implicit in the various definitions is that attitude is a psychological orientation developed as a result of one's experiences, which influences how a person views situations, objects or people, and how she appropriately responds to them. The response may be positive or negative; favourable or unfavourable; neutral or ambivalent.

5.1 Components of Attitude:

Research suggests that there are three different components of attitude. These are the cognitive component, the affective component, and the behavioural component (Eagly&Chaiken, 1993; Maio& Haddock, 2010). The cognitive component of attitude is what the individual thinks or believes about the attitude object. An example is that a person might think that a snake is a dangerous reptile. The affective aspect of attitude is the feelings or emotions of the individual associated with the attitude object. For example, the sight of a snake may evoke the feeling of fear in the individual. The behavioural component is the tendency to respond in a certain way to the attitude object. An example is a person choosing to run away or scream upon seeing a snake. Hence the cognitive, affective and behavioural components of attitude are interrelated and interconnected.

5.2 Formation of Attitude:

Research has shown that formation of attitude is experiential. People form attitudes through their experiences in life. Social psychology explains how attitudes are formed using three major learning theories which are classical conditioning, operant conditioning and observational learning. Propounded by Ivan Pavlov, classical conditioning is a procedure for modifying behaviour in which repeated pairing of conditioned stimulus

with an unconditioned stimulus leads to the development of a conditioned response (Ntim, 2010, Linero& Hinojosa, 2012). Classical conditioning entails neutral stimuli that naturally elicit a response. Children, for instance, become fans of football clubs of their fathers. They grow up believing that those particular football clubs are the best and develop the same passion for the clubs. Hence, we form attitudes according to how we are conditioned or how our experiences condition us.

B.F. Skinner's Operant Conditioning theory is a form of learning in which a response is made in anticipation of a stimulus. In operant conditioning, reinforcement increases the likelihood that behaviour will be repeated (Ntim, 2010). Behaviours that are followed by positive consequences are reinforced and are more likely to be repeated than are behaviours and attitudes that are followed by negative consequences (Moris&Maisto, 2001). Operant conditioning requires the use of reinforcement and punishment. A case in point is if a child's mother smiles at her anytime she picks something up for her, the child begins to realise that it is good to be helpful and she is likely to repeat the behaviour. Conversely, if a mother screams at a child for picking up a puff of a piece of cigarette, the child will grow up having an unfavourable attitude towards smoking and probably those who smoke. This is due to the negative consequence of her action.

Finally, people also learn attitude through observation of people around them, especially if they are people they admire, respect or hold in high esteem. Children therefore invariably observe the attitude of parents and teachers and learn a lot from them. Observational learning theory propounded by Albert Bandura posits that behaviours are acquired by watching another or the model that performs the behaviour (Yara, 2009). The model displays thebehaviour and the learner observes and tries to imitate it. Teachers are, invariably, role models whose behaviours are easily copied by students.

5.3 Attitude towards Mathematics:

Some authorities regard attitude towards Mathematics as just a like or dislike for Mathematics, while others extend the meaning to embrace beliefs, ability, and usefulness of Mathematics. For Zan and Martino (2007), attitude towards Mathematics is just a positive or negative emotional disposition towards Mathematics. Neale (1969), however, defines attitude towards Mathematics as an aggregated measure of "a liking or disliking of Mathematics, a tendency to engage in or avoid Mathematical activities, a belief that one is good or bad at Mathematics, and a belief that Mathematics is useful or useless" (p. 632). Similarly, Hart (1989) considers attitude towards Mathematics from multidimensional perspectives and defined an individual's attitude towards Mathematics as a more complex phenomenon characterised by the emotions that he associates with

Mathematics, his beliefs about Mathematics and how he behaves towards Mathematics. Attitude towards Mathematics includes the tendency to be fearful of and anxious about Mathematics.

Attitude towards Mathematics has cognitive, affective and behavioural components; and like any other kind of attitude, it can be formed through any of the three processes described earlier. A student can develop positive attitude towards Mathematics because he or she learns to associate positive experiences or events with it. Also, positive reinforcement creates room for the formation of positive attitude for Mathematics. And by no means is students' observation of teachers and teachers' behaviour especially in relation to Mathematics among the least of the factors that influence their attitude towards Mathematics.

5.3.1 Student Attitude towards Mathematics:

The conceptions, attitudes, and expectations of students regarding Mathematics and Mathematics teaching have been considered to be very significant factors underlying their school experience and achievement (Borasi, 1990; Shoenfeld, 1985). In general, the concepts students hold about Mathematics determine how they approach the subject. In many cases, students have been found to approach Mathematics as procedural and rule oriented. This prevents them from experiencing the richness of Mathematics and the many approaches that could be used to develop competence in the subject.

Attitude can also be gender related. There are many who hold the view that boys do better in Mathematics than girls. This belief tends to affect the attitude of girls towards Mathematics. Farooq and Shah (2008) in a study of secondary school students in Pakistan found that there was no significant difference in confidence of male and female students towards Mathematics at secondary school level. They rather found that students' success in Mathematics depended on attitude towards the subject. Nonetheless, some studies have found gender difference in students' confidence in Mathematics. Compared to boys, girls lacked confidence, had debilitating causal attributional patterns, perceived Mathematics as a male domain and were anxious about Mathematics (Casey, Nuttal&Pezaris, 2001). In the study, girls were found to have lower self-confidence in Mathematics than boys.

Instructively, research on the relationship between student attitude and performance has also been inconclusive. Researches that have been conducted to determine the relationship between students' attitude towards Mathematics and achievement in Mathematics have yielded contradictory results. The findings have thus lacked consistency on the subject. Some studies have demonstrated a strong and significant

relationship between Mathematics attitude and Mathematics achievement (Minato &Yanase, 1984, Randhawa& Beamer, 1992, Schenkel, 2009). In the Schenkel's (2009) study of elementary school pupils, positive correlation between student attitude and student performance was found. Student beliefs and attitudes were found to have the potential to either facilitate or inhibit learning. In a comparative study of factors influencing Mathematics achievement, Burstein (1992) found that there is a direct link between students' attitudes towards Mathematics and student outcomes. Cheung (1998), in his study of 11-13 year olds, also discovered positive correlation between attitude and Mathematics achievement. The correlation showed that the more positive the attitude, the higher the level of achievement in the student.

Some researches have, however, demonstrated that the correlation between attitude towards Mathematics and achievement in Mathematics was rather weak and could not be considered to be of practical significance (Vachon, 1984; Wolf &Blixt, 1981). In a meta-analysis of 113 primary studies involving elementary and secondary school children, Ma and Kishor (1997) found that attitude towards Mathematics and achievement in Mathematics was positively and reliably correlated but not strong. The correlation was not statistically significant. Flowing from the preceding findings, studies in different cultural settings are eminent to realise the influence of student attitude towards Mathematics on student learning outcomes in the subject.

5.3.2 Teacher Attitude towards Mathematics:

An understanding of how attitudes are learned should establish a connection between teachers and students' attitudes, and attitudes and performance. Schofield (1981) reports that positive teacher attitude towards Mathematics was significantly related to high achievement in pupils. Bridget, Vemberg, Twemlow Fonag, and Dill (2008) studied how the teachers' attitude contributed to students' academic performance and behaviour. The study unveiled, among other things, that students with more devoted teachers were regarded by their peers as helpful to victims of bullying relative to students with less devoted teachers. The study also disclosed that students with the devoted teachers had the courage and determination to face difficulties in school life. Teachers were recognised as those who provided support, encouraged students and their value for love eradicated unwanted behaviour in students. Teachers are, invariably, role models whose behaviours are easily copied by students. What teachers like or dislike, appreciate and how they feel about their learning or studies could have a significant effect on their students. Unfortunately however, many teachers seldom realize that how they teach, how they behave and how they interact with students can be more paramount than what they teach (Yara, 2009).

Like all other kinds of attitude, a teacher's attitude towards Mathematics can be measured by the emotional response towards Mathematics (affective), beliefs about Mathematics (cognitive), as well as behaviour. Clarke, Thomas and Vidakovic (2009) postulate that attitudes and practices of teaching Mathematics are complexly affected by beliefs, emotions, social context and content knowledge. Studies confirm that emotional responses toward Mathematics that are found in teachers include like and dislike of Mathematics, anxiety associated with Mathematics and self-confidence in relation to Mathematics (Phillipou&Christou, 1998, Brady &Bowd, 2005, Henderson & Rodrigues, 2008). These emotional factors have been found to have an impact on student performance. In their study of teachers' self-esteem connected to Mathematics, Henderson and Rodrigues (2008) found that approximately half of the participating pre-service teachers, some of whom were highly qualified, lacked self-esteem in relation to Mathematics. Burks, Heidenburg, Leoni and Ratliff (2009) stipulate that teachers' exhibition of self-confidence when teaching Mathematics motivates student achievement in Mathematics. The learner draws from the teacher's disposition to form his own attitude which may affect her learning outcomes.

Teachers' beliefs about Mathematics such as the usefulness of Mathematics, the way Mathematics should be learned, the difficulty or ease of Mathematics, as well as gender ability and beliefs also affect their attitude towards the subject and impact on students' performance. According to Philippou and Christou (1998), teachers' beliefs about the utility of Mathematics are often found to correlate with either a more positive or negative attitude towards the subject. It is believed that a teacher who sees no usefulness of Mathematics in the real world and believes that Mathematics should be learnt as a set of rules and algorithms will require his students to memorise procedures and rules without meaning. This is a negative outlook that will make his students develop a negative attitude towards the subject. Also, a teacher who believes that girls are poor in Mathematics is likely to impact negatively on girls in his class who will begin to believe that they cannot do Mathematics.

Another aspect of the teacher's attitude towards Mathematics is the teacher's behaviour in relation to Mathematics. Such Mathematics-related behaviour as avoidance of Mathematics, pursuit of Mathematics and instructional behaviour in the classroom all affect student attitude and performance. Usually, the way that Mathematics is represented in the classroom and perceived by students, even when teachers believe they are presenting it in authentic and context dependent way stands to alienate many students from Mathematics (Barton, 2000, Furinghelti&Pekhoren, 2002). Ogunniyi, as cited in Yara, (2009) stipulates that students' positive attitude towards Mathematics is enhanced

by the following teacher-related factors: teachers' enthusiasm, teachers' resourcefulness and helpful behaviour and teachers' thorough knowledge of the subject-matter and their making Mathematics quite interesting. It is inferred that teachers can foster in students the positive attitudes about Mathematics that help to build confidence by: encouraging the belief that everyone can "do" Mathematics – emphasizing effort, not innate ability; modelling enthusiasm for teaching and learning Mathematics; addressing the learning styles of students by providing a variety of ways for students to gain an understanding of difficult concepts; helping students to appreciate the value of Mathematics in their lives; and choosing activities carefully (not too easy, not too hard), so that students can be both challenged and successful (Ministry of Education, Ontario (2004).

6. Factors related to mathematics learning

Factors or predictors in math achievement, are divided into sub factors: **Demographic Factors** (gender, socio-economic status, parent's educational level), **Instructional Factors** (teacher competency, instructional strategies and techniques, curriculum, school context and facilities), and **Individual Factors** (self-directed learning, arithmetic ability, motivation) and **Environmental Factors.**

6.1. Demographic Factors

Various demographic factors are known to be related to mathematics achievement. Gender, socio-economic status, and parents' educational level are factors that have been analyzed in this study as predictors of math achievement.

Gender

Many variables have long been studied as predictors of mathematics achievement. However, gender issues on math achievement are studied most frequently by researchers. For instance, a study through a meta-analysis reveals that males tend to do better on mathematics tests that involve problem-solving (Hyde, Fennema, and Lamon 1990). Females tend to do better in computation, and there is no significant gender difference in understanding math concepts. Another study shows that females tend to earn better grades than males in mathematics (Kimball, 1989).

Some recent studies have revealed that gender differences in mathematics education seem to be narrowing in many countries. However, studies indicate that as students reach higher grades, gender differences favor increase in math achievement by males (Campbell, 1995; Gray, 1996; Mullis, Martin, Fierros, Goldberg, &Stemler, 2000). For instance, the results from the Third International Mathematics and Science Study showed

that mathematics achievement scores of each gender group were close to each other at the primary and middle school years (Beaton et al., 1996; Mullis et al., 1997). However, in the final year of secondary school, evidence was found for gender differences in mathematics achievement. Another study, which was conducted to analyze factors that affect math achievement of 11th-graders in math classes with an identified gender gap, also showed that males scored higher than females on 11th grade math achievement test, but this difference decreased from 10th grade (Campbell &Beaudry, 1998).

In addition, gender differences in attitudes and perceptions of the usefulness of mathematics for middle school students were found statistically important (Lockheed, Thorpe, Brooks-Gunn, Casserly, and McAloon 1985; Oakes 1990). For example, female students show less interest in mathematics and have negative attitude toward mathematics. It is also reported that girls tend to learn mathematical concepts by means of rules or cooperative activities, while boys have a tendency to be in a competition to master mathematical concepts (Fennema& Peterson, 1985; Hopkins, McGillicuddy-De Lisi, & De Lisi, 1997).

The literature on gender differences provides evidences that gender issues impact achievement in mathematics. Hence, it is crucial for educators and researchers to pay attention to gender differences in the design of mathematics instruction.

Socio-Economic Status

Socio-economic status is determined to be a predictor of mathematics achievement. Studies repeatedly discovered that the parents' annual level of income is correlated with students' math achievement scores (Eamon, 2005; Jeynes, 2002; Hochschild, 2003; McNeal, 2001). Socio-economic status was found significant in primary math and science achievement scores (Ma & Klinger, 2000). Another study found poor academic achievement of Canadian students to be attributable to their low socio-economic status (Hull, 1990). Socio-economic status was examined and found to be one of the four most important predictors of discrepancy in academic achievement of Canadian students (aged 15) in reading, mathematics, and science by the Program for International Student Assessment (Human Resources Development Canada, Statistics Canada, & Council of Ministers of Education Canada, 2001).

A number of studies showed that parents with higher socio-economic status are more involved in their children's education than parents of lower socio-economic status. This greater involvement results in development of positive attitudes of children toward school, classes, and enhancement of academic achievement (Epstein, 1987; Lareau, 1987;

Stevenson & Baker, 1987). It is believed that low socio-economic status negatively influences academic achievement, in part, because it prevents students from accessing various educational materials and resources, and creates a distressing atmosphere at home (possible disruptions in parenting or an increased likelihood family conflicts) (Majoribank, 1996; Jeynes, 2002). For these reasons, socio-economic status of a student is a common factor that determines academic achievement.

Parents' Educational Level

Parents' educational level has been shown to be a factor in academic achievement. Parents serve as a role model and a guide in encouraging their children to pursue high educational goals and desires by establishing the educational resources on hand in the home and holding particular attitudes and values towards their children's learning. In this case, the educational attainment of parents serve as an indicator of attitudes and values which parents use to create a home environment that can affect children's learning and achievement.

A number of studies indicated that student achievement is correlated highly with the educational attainment of parents (Coleman, 1966). For instance, students whose parents had less than high school education obtained lower grades in mathematics than those whose parents had higher levels of education (Campbell, Hombo, &Mazzeo, 2000). Research has shown that parents' educational level not only impact student attitudes toward learning but also impact their math achievement scores.

6.2. Instructional Factors

Curriculum

Many concerns have been emphasized in the literature about the existing math curricula that emphasize. . . not so much a form of thinking as a substitute for thinking. The process of calculation or computation only involves the deployment of a set routine with no room for ingenuity or flair, no place for guess work or surprise, no chance for discovery, no need for the human being, in fact (Scheffler, 1975, p.184).

The concerns here are not that students should never learn to compute, but that students must learn how to critically analyze mathematical problems and produce effective solutions. This requires them to learn, how to make sense of complex math concepts and how to think mathematically (Cobb et al., 1992). Many mathematics curricula overemphasize memorization of facts and underemphasize understanding and application of these facts to discover, make connections, and test math concepts. Memorization must

be raised to conceptualization, application and problem-solving for students to successfully apply what they learn. An impressive body of research suggests that curriculum that considers students to be incapable of metacognitive actions (e.g., complex reasoning) should be replaced with the one that sees students who are capable of higher-order thinking and reasoning when supported with necessary and relevant knowledge and activities (Bransford et al., 1994; Schauble et al., 1995; Warren &Rosebery, 1996). Research has also revealed evidence that curricula in which students' knowledge and skills grow is significantly connected to their learning, and therefore their achievement (Brown &Campione, 1994; Lehrer &Chazan, 1998).

Instructional Strategies and Methods

Being successful in math involves the ability to understanding one's current state of knowledge, build on it, improve it, and make changes or decisions in the face of conflicts. To do this requires problem solving, abstracting, inventing, and proving (Romberg, 1983). These are fundamental cognitive operations that students need to develop and use it in math classes. Therefore, instructional strategies and methods that provide students with learning situations where they can develop and apply higher-order operations are critical for mathematics achievement.

In the literature, it is pointed out that for students to accomplish learning, teachers should provide meaningful and authentic learning activities to enable students to construct their understanding and knowledge of this subject domain (Wilson, 1996). In addition, it is emphasized that instructional strategies where students actively participate in their own learning is critical for success (Bloom, B. 1976). Instructional strategies shape the progress of students' learning and accomplishment.

Teacher Competency in Math Education

Many studies report that what teachers know and believe about mathematics is directly connected to their instructional choices and procedures (Brophy, 1990; Brown, 1985; National Council of Teachers of Mathematics, 1989; Thompson, 1992; Wilson, 1990a, b). Geliert (1999) also reported that "in mathematics education research, it seems to be undisputed that the teacher's philosophy of mathematics has a significant influence on the structure of mathematics classes" (p. 24). Teachers need to have skills and knowledge to apply their philosophy of teaching and instructional decisions.

In the 21st century, one shifting paradigm in education is about teachers' roles and competencies. Findings from research on teacher competency point out that

If teachers are to prepare an ever more diverse group of students for much more challenging work--for framing problems; finding, integrating and synthesizing information; creating new solutions; learning on their own; and working cooperatively--they will need substantially more knowledge and radically different skills than most now have and most schools of education now develop (Darling-Hammond, 1997, p. 154).

Teachers not only need knowledge of a particular subject matter but also need to have pedagogical knowledge and knowledge of their students (Bransford et al., 2000). Teacher competency in these areas is closely linked to student thinking, understanding and learning in math education. There is no doubt that student achievement in math education requires teachers to have a firm understanding of the subject domain and the epistemology that guides math education (Ball, 1993; Grossman et al., 1989; Rosebery et al., 1992) as well as an equally meticulous understanding of different kinds of instructional activities that promote student achievement. Competent math teachers provide a roadmap to guide students to an organized understanding of mathematical concepts, to reflective learning, to critical thinking, and ultimately to mathematical achievement.

School Context and Facilities

School context and its facilities could be an important factor in student achievement. In fact, identifying factors related to the school environment has become a research focus among educational practitioners. For instance, research suggests that student achievement is associated with a safe and orderly school climate (Reyonds et al., 1996). Researchers also found a negative impact on student achievement where deficiencies of school features or components such as temperature, lighting, and age exist. In a study by Harner (1974), temperatures above 23° C (74° F) adversely affected mathematics skills. In terms of the condition of school building, Cash (1993) found student achievement scores in standard buildings to be lower than the scores of students in above standard buildings. In addition, Rivera-Batiz and Marti (1995) conducted multiple regression statistical analysis to examine the relationship between overcrowded school buildings and student achievement. The findings indicated that a high population of students had a negative effect on student achievement.

6.3. Individual Factors

Self-Directed Learning

Self-directed learning could be a factor in students' math achievement. Mathematics learning requires a deep understanding of mathematical concepts, the ability to make

connections between them, and produce effective solutions to ill-structured domains. There is no perfect, well-structured, planned or prescribed system that lets students think and act mathematically. This can be done if, and only if, students play their assigned roles in their learning progress. Self-directed learning has an important place in successful math learning. Self-directed students can take the initiative in their learning by diagnosing their needs, formulating goals, identifying resources for learning, and evaluating or monitoring learning outcomes (Knowles 1975). The teacher's role is to engage students by helping to organize and assist them as they take the initiative in their own self-directed explorations, instead of directing their learning autocratically (Strommen& Lincoln, 1992).

Arithmetic Ability

Arithmetic ability could also be another predictor of math achievement. Arithmetic ability includes the skills such as manipulating mathematical knowledge and concepts in ways that transform their meaning and implications. It allows students to interpret, analyze, synthesize, generalize, or hypothesize the facts and ideas of mathematics. Students with high arithmetic ability or mathematical reasoning can engage in tasks such as solving complex problems, discovering new meanings and understanding, and arriving at logical conclusions.

Arithmetic ability was determined by various studies as a critical factor on students' math achievement. For instance, in a study by Kaeley (1993), arithmetic ability gave the highest correlation coefficient with mathematics achievement. Similarly, student achievement scores were found to be most strongly predicted by level of ability (Schiefele&Csikszentmihalyi, 1995). Some other researchers have also investigated the relationship of gender issues and arithmetic ability on math achievement. For instance, Mills (1997) conducted a study to investigate longitudinal data gathered over 10 years with an aim at asking whether personality traits were related to gender differences in long-term achievement in mathematics and the sciences. The study revealed that math ability was the most significant predictor of long-term achievement in math for young women. However, the level of math ability did not seem to be a factor of long-term math achievement for young men.

Motivation or Concentration

Mathematics education requires highly motivated students because it requires reasoning, making interpretations, and solving problems, mathematical issues, and concepts. The challenges of mathematics learning for today's education are that it requires disciplined

study, concentration and motivation. To meet these challenges, learners must be focused and motivated to progress. Broussard and Garrison (2004) examined the relationship between classroom motivation and academic achievement in elementary-school-aged children (122-first grade and 129-third grade participants). Consistent with previous studies, they found that for a higher level of mastery, motivation was related to higher math grades.

The teacher's role in students' motivation to learn should not be underestimated. In helping students become motivated learners and producers of mathematical knowledge successfully, the teacher's main instructional task is to create a learning environment where students can engage in mathematical thinking activities and see mathematics as something requiring "exploration, conjecture, representation, generalization, verification, and reflection" (Carr, 1996, p.58).

As you know Mathematics is considered to be a nightmare for many students out there and this is because students find mathematics as one of the toughest and difficult subjects that twist your mind and sometimes gives you stress too. Parents of these kids try to find the best tutor who can assist their children in order to complete Mathematics Assignments and also guide their children in Mathematics so that they can score good grades. As you know mathematics can not only be studied for getting good grades and this subject cannot be learned by just mugging up because this subject needs concentration and Mathematics is the only subject that can be initially used for a lifetime. The importance of learning in a subject like Mathematics cannot be explained because it is studied in different ways. You can only master this subject by doing practice and a lot of hard work too. Apart from these qualities if you apply certain tips in order to learn Mathematics it will become an Advantage for all the students too.

Locus of Control: There are some students who initially believe that the mathematical achievement is basically attributable to the factors that are initially beyond their control and this can be called as luck. These students initially think that if they scored well on the mathematics assignment then they only did this because it was easy but what about the knowledge you get if you didn't understand the concept. Their locus is usually external and this is because they actually believe achievement is actually due to factors that are beyond their control and also do not generally acknowledge the diligence it requires and also a positive attitude it generally plays because it does play the most important role in the accomplishment. Sometimes, students also believe that failure is basically related to either the lack of innate mathematical inability and level of intelligence at the same time as they initially view their achievement as an accidental and poor progress to be inevitable.

Memory Ability: Generally, there are some students who initially lack in well developed mental strategies in order to remember how to complete the algorithmic process and also the combinations of basic facts. However, this essentially involves strategies in order to improve the capacities so that one can remember the formulas, process and the facts that have been taught to them. It is important to keep a check on one's ability as it helps in organizing the thinking and then use it accordingly to recall the data that will initially affect the success throughout the curriculum.

Attention Span: There are some students who are mentally distracted and sometimes find tough in order to focus on the multistep problems and process. So, it sometimes becomes difficult to deal with the long-term projects or a number of variable or pieces of Information at one time as it can interfere the achievement. There are effective teachers that initially use attention seekers such as learning aids or drawings and students who generally work in groups can help each other at the same time.

Understanding the Language of Mathematics: There are some students who generally are confused by words that contain special mathematical meaning for ex: area, yard, power and volume. It does require a lot of understanding. So, lack of understanding for the mathematical terms like Divisor, multiple, factor and denominator generally hamper one's abilities in order to focus on and at the same time understanding the terms and the operations only for problem solving and algorithms. It is of no use if you don't memorize these terms without meaning or context.

There are numerous reasons why students fall below their expected level of Mathematics achievement. Some most common reasons are "never likes this subject or never understood maths". These reasons can be further classified as the environment, personal or individualized factors.

6.4. Environmental Factors

Instruction: Generally, Mathematics Instruction duly offers many opportunities in order to build concept for relevant challenging questions, reasoning, problem-solving and connections related questions that are included in the curriculum and is also based on the real world situations. So, students are generally taught in a different and in a better way that makes them understand the meaning and question better in order to retain the maths concepts and all the generalizations.

Curricular Materials: Curriculum initially offers opportunities for all the learners so that they can deal with the content development in the meantime. The concepts are basically built upon various topics and are generally related to previous learning

throughout the session. Sometimes for a student becomes very proficient and experienced in Maths. Hence, it is quite frustrating for the fact that these containers will not repeat again and it will become difficult for those students who didn't get to learn first time as they won't get any second chances as well. Therefore, this kind of work generally presents a broad way of mathematical foundations and also a low level of expectation in order to understand the student's abilities because it generally limits the opportunities.

The Gap between the subject matter and the learner: When the tough or difficult mathematics content is being taught to the students and they do not understand the subject taught to them and goes out of their mind, serious achievement gaps duly occur and this situation only occurs if the students are not regular or transfer to another school during the academic session. Sometimes, a student might find the subject more advanced and different from what was being taught in the previous school and this is the reason why students remain lost most of the time during their education.

ACTION RESEARCH

The pupil-teacher can make use of these concepts in planning and organizing effective teaching and realizing the objectives of teaching. A teacher has to face many problems in his presentation or teaching to achieving the learner objectives. The classroom problems can be solved by employing the action research device. It is a best method for solving the problems of teaching objectively and systematically. Action research is useful for improving and modifying the teaching process.

Meaning and Definitions of Research

Research word is made up of two words–**'Re'** and **'Search'**. Where **'Re'** means **'again'** and **'search'** means **'find out something'**. Hence, research means, A process in which a person observes the phenomena again and again and collects data. Research is a process to study the basic problems which contribute in the edifice of human knowledge. The research process establishes new truth, finds, out new facts, formulates new theory and suggestion for new applications.

According to **Best (On the basis of education),** "Research is identified with a better understanding of the teaching-learning process and the conditions under which it is most successfully carried on."

According to **P. M. Cook's,** "Research is an honest, exhaustive, intelligent process searching for facts and their meaning or implication with reference to a given problem."

According to **Bernard Mehl,** "Research is perhaps the only assurance we have that a discipline or a profession will not decay into meaningless scraps of dogmatic utterances."

According to **W. S. Monroe,** "Research may be defined as a method of studying problems whose solutions are to be desired partly or fully. The final purpose of educational research is to ascertain principles and develop procedures for use in the field of education."

In brief, the significance of each letter of the word **'RESEARCH'** may be seen as under:

R = Rational way of thinking.

E = Expert and Exhaustive Treatment
S = Search for solution with scientific approach
E = Exactness
A = Analytical Analysis of Adequate Data
R = Relationships of Facts
C = Careful planning, recording, observation, attitude, condensed and compactly stated generalisations.
H = Honesty and Hard work in all aspects of the treatment of data.

Hence,
* Research is an intelligent process.
* The findings of research are valid.
* The facts are discovered in the light of freedom.
* The facts are studied with understanding.

EDUCATIONAL RESEARCH

Educational research is based on insight and imagination. It requires an inter-disciplinary approach and usually employs deductive reasoning process.

According to **W.M. Traverse,** "Educational research is that activity which is directed towards the development of sense of behaviour in education situation."

Educational Research are divided into two parts:

(i) Basic Research
(ii) Action Research

ACTION RESEARCH

Action research change and improve the problems of teacher's teaching. The process of action research is based on problem-centred. In recent years, **Dr. S.M. Corey** has applied the concept of 'Action Research'. The nature of action research is practical. The concept was put forward to improve school practices and is based upon the modern human organisation theory.

The word **'Action'** means **'To act'**. In wider sense **'Action'** means we are doing some thing in a concrete manner. Hence, it is a form of school research in which the teachers, principals and other administrators solve their problems using scientific steps of research.

Sometimes action researches are called on-the-job research. It involves the application of the steps of the scientific method to classroom problems. In action research in education, the researchers are usually teachers, curriculum workers, principal, supervisors or others whose main function is to help provide good learning experiences for pupils.

Definitions of Action Research :

According to **Stephen M. Corey,** "Action research is a process by which practitioners attempt to study their problems scientifically in order to guide, correct and evaluate their decisions and actions."

Again Stephen M. Corey describe the Action Research, "Action research is conducted in the heat of combat."

According to **Jane Franseth,** "Action research is a systematic examination conducted by individuals or groups studying their own practices in search of sound answers to unresolved problem in their work and aimed at improvement their own performance on their own jobs."

According to **Sara Blackwell,** "Action research is the research concerned with school problems carried on by school personal, to improve school practices."

According to **Best J. West,** "Action research is focused on the immediate application, not on the development of theory, it has placed emphasis on a real problem, here and now in a local setting."

According to **Megrath and Others,** "Action research is organised, investigative activity aimed towards the study and constructive change of a given Endeavour by individual or groups concerned with such change and improvement."

According to **Educational Dictionary, "**Research done with the limited objective of improving their own decisions and actions by teacher and administrators is called actions research."

In general language, "An experimental project is a kind of research work which a teacher performs in order to make a solution of the problems related with his subject, his class and his students."

Hence action research is the research a person conducts in order to enable him to achieve his purposes more effectively. A teacher conducts action research to improve his own teaching. A school administrator conducts action research to improve his administrative behaviour. It is more objective, more scientific.

Characteristics of Action Research

The main characteristics of action research are :

1. Action research is focused on the immediate problem.
2. It results in a more careful problem diagnosis and more objective evaluation of the consequences of action.
3. It solves the daily life problems.
4. It is conducted by the person himself working in the field.
5. The researcher and the practitioner is the one and the same person.

6. Action research is personal study of individuals and group problems.
7. The main aim of action research to improving classroom and school practices.
8. It involves very little finances.

Objectives of Action Research

The action research projects are conducted for achieving the following objectives :

1. To improves the working condition of school plant.
2. To develop democratic attitudes among students and teachers for understanding and solving their problems.
3. Helpful in the improving and modifying the class room teaching strategies.
4. To provide healthy environment for effective learning.
5. To stimulate the students to raise their standards of learning.

Scope of Action Research

The action research approach to deal with practical problems seems to be appropriate and promising for all kinds of professional workers in education so long as their desire is to improve their own professional behaviour. An administrator who is dissatisfied with his efforts to develop good morale in his staff could approach this problem with action research, for example : He would only do so, however if he accepted some responsibility for the morale situation and was willing to effect some changes in his own behaviour to improve it.

Advantages of Action Research

Advantages of Action research are :

1. A person improves if he remains active in the process and programme he is engaged in.
2. Action research helps the teacher acquire new interests, new motives and new insights.
3. Action research approach is experimental rather than dogmatic.
4. Facts and evidences are stressed which keep the changed process anchored more continuously to reality.
5. Action research has a great stimulating effect upon the teacher for finding better ways of doing things.
6. It introduces experimental outlook among teachers.
7. It enables the teacher to organise instructional procedures on a more reliable and sound basis.
8. Action research on the part of the teacher helps students acquire skill in problem-solving and scientific methods.

9. The entry of the teachers into the world of research will enable them to read reports of research findings more intelligently.
10. One's own findings are willingly implemented and in this context, action research is very useful.

Limitations of Action Research

1. The applicability of the findings to another school or class in the event of teacher transfer, is even questionable. Action research by and large, is a localised affair.
2. Action research is frequently added to the shoulders of already but busy teachers who have only limited freedom to say 'no'.
3. On account of several limitations, action research may result in unverifiable and deceptive conclusions.

Difference between Action Research and Basic Research

The difference between action research and basic research are as follows :

Action Research	Basic Research
1. The concept of action research is developed by basic research.	1. It is a old concept.
2. The main purpose of action research is to improve in school and classroom teaching process.	2. It contributes of new knowledge in the form of new theory, facts and truth.
3. Simple analysis procedures are usually sufficient.	3. Complex analysis is often called for.
4. Observation and teacher made tests are used for collecting data in action research. The standardized too may be used if it is available.	4. Usually standardized tests are used for collects of data.
5. It has no problem of sampling.	5. Sample is selected very carefully.
6. Result of action research can not be generalized.	6. The generaliztion of basic research is possible.
7. The teacher is invariably involved in the research problem.	7. The research worker is not usually involved in the problem he selects for research.
8. The design of action research is flexible.	8. The design is rigid and can not be changed.
9. The field of action research work is very narrow.	9. The field for basic research is
10. The major importance for	

solving the local problems of school and classroom teaching.	broad. 10. The major importance is to answer the basic questions and contribute in field of knowledge by solving the basic problems of education.
11. Evaluation is made by the teacher himself.	11. Evaluation is made by experts appointed by the university.
12. Action research requires no special training or expertise.	12. Basic research requires research scholar and research methodology.
13. To complete to the action research project, less money and less time is required.	13. To complete the fundamental research, more time and more money is required.

Need and Importance of Action Research in Indian Schools

According to **John W. Best,** "If classroom teachers are to make an active research contribution, it will probably be in the area of action research. Studies will be made for the purpose of improving school practices. Many educational observers see in action research one of the most promising avenues of teacher growth, professional improvement and the development of better curriculum."

The need and importance of action research in Indian schools is being felt by all concerned to keep pace with the latest developments in the field of education. A teacher while teaching his students comes across numerous problems. Sometimes he tries to tackle them with great patience and other time being in an angry mood, he scolds the students, turns them out of the class, gives punishment of one from or the other and still at some other times, be overlooks them.

If the teachers are encouraged to come out with their problems and are provided necessary facilities in the form of guidance and help in conducting action research, they can solve their problems themselves with great satisfaction to themselves and consequently leading to their professional growth and development.

Steps of Action Research

Action research following steps :

1. Identification of problem
2. Defining and delimiting the problem
3. Analyzing the causes of the problem
4. Formulation the action hypotheses
5. Design for testing the action hypothesis

6. Conclusion

1. Identification of Problem–A teacher should be sensitive towards job-activities. The problem is isolated from the broad fields. An investigator must realize the seriousness of the problem.

2. Defining and Delimiting the Problem–After identifying the problem it should be defined so that action and goal may be specified. The delimitation means to localize the problem in terms of class, subject, group and period in which a teacher perceives the problems.

3. Analysing the Causes of the Problems–It is useful to why the problems are occurring. It analysed with the help of some relevance. The nature of the causes is also analysed whether it is under the control of investigator. This helps in formulating the action hypotheses.

4. Formulating the Action Hypotheses–The basic for the formulation of action hypotheses are the causes of the problem which are under the approach of an investigator. The statement of action hypotheses consists of the two aspects : action and goal.

5. Design for Testing the Action Hypotheses–Whether the starting point for reasoning is right or wrong, it is also tested by investigator perfectly. If there is any short coming it is also removed. Hence an improved and moderated design is obtained through action research.

6. Conclusion of Action Research Project–After removing the short comings and making necessary improvement, conclusion is made. This conclusion helps in improving and modifying current practices of school and class room teaching.

8. IMPLICATION OF RESEARCH FINDINGS

Research implications suggest how the findings may be important for policy, practice, theory, and subsequent research. Research implications are basically the conclusions that you draw from your results and explain how the findings may be important for policy, practice, or theory. However, the implications need to be substantiated by evidence and the study's parameters need to be explained and the limitations taken into account to avoid over-generalization of results.

Recommendations urge specific actions to be taken with regard to policy, practice, theory, or subsequent research. They are specific suggestions that you make with regard to further research on the topic. For instance, you can make recommendations on subsequent research that can be conducted, especially, if there is an interest in generalizing the findings beyond the study's parameters. You may have identified gaps in

the literature that should be addressed, and to which your study may or may not have contributed.

Research implications basically refer to impact that your research might have on future research or policy decision or the relevant field of interest of your study. 'How will your research affect the targeted community or subject field' is the question that implications will answer. Recommendations are based on the results of your research and indicate the specific measures or directions that can be taken. For example, a clinical study might have implications for cancer research and might recommend against the use of a particular hazardous substance. Therefore, implications signify the impact of your research and recommendations might be concrete steps/actions that the research proposes.

Once you have conducted your study and drawn conclusions, you can state the “Research Implications”, which means that you are expressing how your study can affect future prospects in the subject area of your research, the policies or regulations that might be influenced because of your study or you can speculate how the outcomes of your study can have an impact in either hypothesizing a particular topic under consideration or the practical aspects of the same. The research implications are always supported by a strong statistical significance and correlations of results from your research keeping in view the shortcoming of the study. When you make a “Research recommendation”, you can emphatically state what are the next steps that need to be taken to address a problem, what are the immediate actions that need to be implemented to solve a particular question, what needs to be corrected & what needs to be avoided to solve a problem, what is the feasibility of your proposed policy, statements about the nature and timing of an evaluation plan that would be used to determine the effectiveness of the proposed policy. Again, these recommendations should be strongly supported by results of your study.