

**MANGALORE UNIVERSITY**  
**CENTRE FOR DISTANCE EDUCATION**  
**MANGALAGANGOTHRI - 574 199**  
**DAKSHINA KANNADA DISTRICT, KARNATAKA STATE**

**COURSE 8**  
**Pedagogy of School Subject - II (b)**

**MATHEMATICS**  
**(Curriculum and Pedagogic Studies)**  
**BLOCKS 3 & 4**  
**(PART - 2)**

**B.Ed. DEGREE PROGRAMME**  
**(OPEN AND DISTANCE LEARNING)**

**SECOND YEAR B.Ed.**

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## **Overview of the Course**

Mathematics is a skill-oriented subject. Unlike the social sciences this subject needs to be addressed in parts giving equal importance to each of the topics it consists of. This paper tries to acquaint the student teacher with the idea of mathematics and the strategies of teaching this subject.

The first block nature, aims and objectives of Mathematics gives the glimpses of the important working terms in mathematics and tries to introduce the subject's underlying. The objectives of mathematics are discussed giving separate importance to writing objectives in Arithmetic, Algebra, Geometry and Trigonometry. The second block focusses on Curriculum and instruction. Principles and Approaches to Curriculum construction, along with the approaches to teaching-learning mathematics, as well as Strategies of teaching-learning mathematics are discussed in detail in this block. The third block is allotted for discussing the planning in teaching and learning mathematics. A fair amount of importance is given to ICT during the discussion of Learning Resources as it is the need of the hour. The fourth and the final block is kept aside for evaluation in mathematics. Evaluation forms an important part of teaching-learning and hence it is discussed in detail in this block. Diagnostic Testing is another important topic that is discussed in this block which will form an extra aid for a teacher in diagnosing the learning problems of students.

This paper covers all the essential knowledge for student teachers to teach Mathematics effectively.

## **Block 3 : Planning in Teaching and Learning Mathematics**

### **Unit 1 : Planning for Teaching and Learning of Mathematics-General Issues**

#### **Unit Structure**

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#### **3.1.1. Learning Objectives**

After completing this Unit, the student teachers will be able to

- Mention the various issues related to planning of math lesson;
- Discuss each of the issues in the light of recommendations of NCF-2005; and
- Cite examples to describe various general issues of planning to teach mathematics.

#### **3.1.2. Introduction**

Dear student you are aware that, to successfully perform any work, it should be planned well. Meticulous planning will ensure 50% success of the work to be performed. Teaching of mathematics is considered a challenging task ever since the formal schooling has begun. Mathematics as a subject has immense value in human life. It has been considered as one of the central components of human thought. Although people debate whether it is science or arts or language, it is a category by itself in spite of possessing components of all those three. When it is so much of significance, mathematics education should be given a priority. Quality mathematics education is possible only with committed and sincere teachers. Effective teachers all over the world agree on one thing that a reasonably good planning prior to teaching is a must. On the contrary, if you interact with practicing math teachers and dig little further to know the mechanics and dynamics of planning for a math class; one is forced to accept that there are a number of issues related to planning!

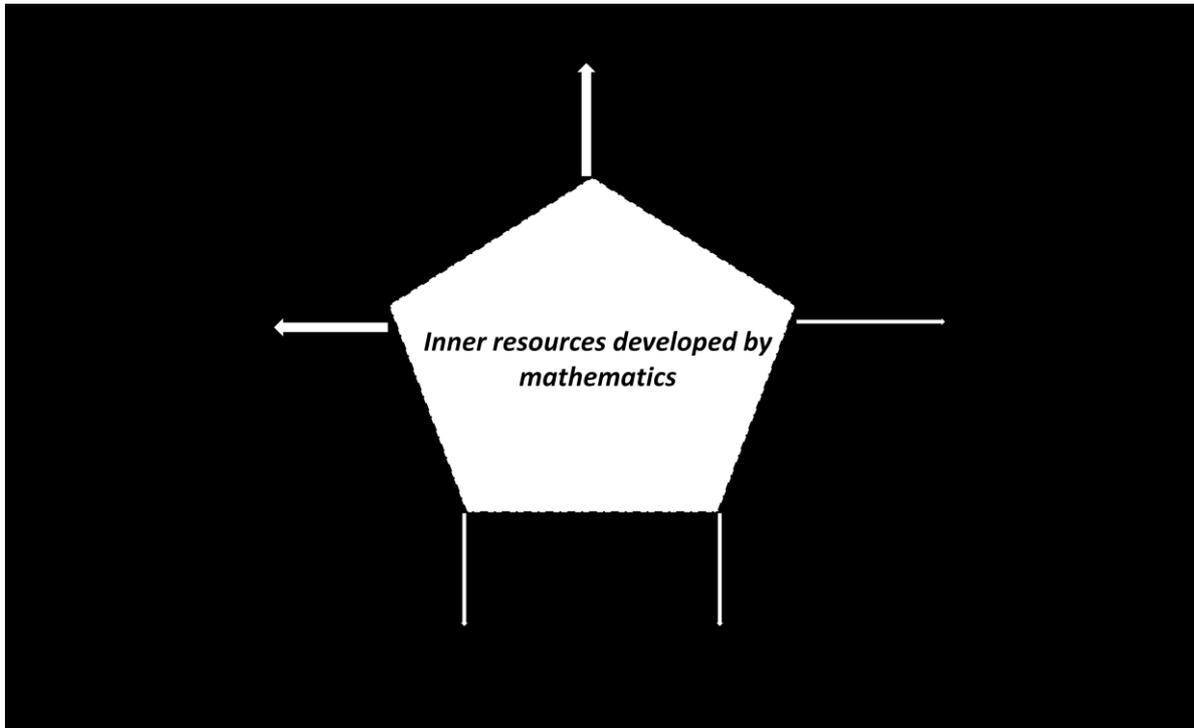
The main goal of Mathematics education according to NCF 2005 is to 'mathematize child's thinking'. This helps students to Think about the world in the language of mathematics & develop that kind of thinking which is special to mathematics. The kind of thinking one learns through mathematics is the ability to handle abstractions. Its process is an approach to problem solving. Thus, to plan to teach mathematics with such broad-based objectives cannot be without any issues. Here are a few issues related to planning of teaching learning mathematics. An effort is made to analyze them for a better grasp. Let's now analyze these planning issues in the light of the recommendations of NCF-2005. They are as given below:

### 3.1.3. Learning Points and Learning Activities

#### 3.1.3.1. Planning issues identified against the recommendations of NCF-2005 Part-1

##### Exercise I

Dear students observe the fig. given below and analyze the meaning of this.



What is your observation dear student? Discuss with your friends regarding the significance of these resources. As a math teacher you agree that these are the skills which lead one to a contented life. Of course, yes! They are like the tools for a comfortable life in the society! Therefore the demand is not the ability to solve a few numerical problems but ability to think mathematically! Without proper planning in this regard, it becomes difficult to accomplish. This poses challenge to teachers for successful planning. Teachers cannot be contented anymore by planning to develop only skills to solve a few mundane math problems! Now let us see some of the aspects suggested by NCF-2005 to be kept in mind while planning Mathematics Lesson.

##### **a) Planning to teach mathematics to imbibe its tools for a successful life**

We are aware of the two aims of teaching mathematics,

- Good and narrow aims: The schools should turn out employable adults - adults who can fill a job. The objective is to make the students employable.
- Higher aim: To develop all the inner resources of the growing child. Higher order of thinking viz., reasoning; critical thinking; logical thinking and problem-solving skills etc. should be imbibed by learning mathematics.

The narrow aim is more often easily achieved and teachers usually plan their class that gears them to achieve this aim.

Dear student just a few years ago, teachers would plan to teach mathematics keeping a single objective of developing the skill of numeracy. A student who masters this would be considered great! Now there is a gradual shift in planning math lesson from developing numeracy skills to various types of thinking!

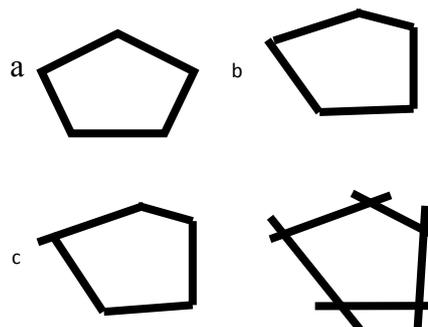
Yes! Mathematization of child's thinking is the higher aim which promises to develop the inner resources of a growing child.

Mathematics has its own tools in the form of various thinking skills. They are the inner resources to be imbibed by students through the process of learning mathematics. Just imagine as a teacher, if your plan focuses for numeracy skills, how can they develop these inner resources? Are the above-mentioned inner resources not needed to students? Don't these make an individual's life easy? The issue is not that the teachers are ignorant of their role in accomplishing this. They are aware that this is significant and should get prioritized first in their planning. **As there is no one approach to achieve this, planning to achieve higher aims has become an issue leaving it to the hands of individual math teachers.**

### **b) Formulating relevant learning experiences while planning in order to facilitate learning**

Earlier the teacher had tremendous belief that teachers' teaching alone can bring the learning among students! But now the present theories of learning such as Constructivists' approach convinces beyond reasonable doubts that students cannot be made to learn by anybody, unless they themselves desire to do so. That means students create knowledge themselves by participating in the learning experiences provided by the teacher. Dear student, observe the following situation for a better understanding of this:

Stella Mary, teacher of a local secondary school in Chamarajanagar near Mysuru is trying to cultivate the habit of thinking among her 9<sup>th</sup> graders. She challenges them "dear students just now you all have understood the definition of polygon...now here we have a set of 4 figures. All you need to do is just figure out which one represents a polygon and why are the others not?"

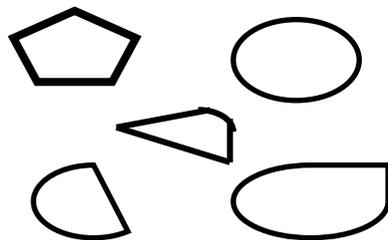


In the above situation the teacher has provided learning experience which if the students participate with involvement ensures deeper understanding of the concept polygon. Dear student can you help them answer the teacher's question? The students have ample opportunity here to think a lot and answer. The teacher has formulated apt learning experience which ensures deeper understanding of the concept. So what did you gather from the above? Instead of doing rituals under the illusion of teaching, the teacher can plan to provide suitable and relevant learning experience (may be in the form of activity) and encourage the student to involve and absorb the idea of the content. Here the teacher is not teaching but facilitating the learning by formulating relevant learning experience. She is

indeed a facilitator. Constructing knowledge by students themselves is not any insignificant aspect! This demand, for a committed facilitator more than a teacher! Effective facilitators formulate relevant learning experiences while planning, which motivates the students to participate with total involvement. Facilitators make effort to cultivate among students a habit of thinking. Are all teachers facilitators? Just think..., you cannot become a facilitator in the classroom when you are teaching. **A teacher's planned learning experiences if facilitates construction of knowledge/learning among students, only then the teacher becomes a facilitator!** It is indeed need of the hour that all teachers become facilitators. But are they in reality? Then what could be the issue here? In the above example the teacher has planned a relevant chart which has the potential to facilitate better learning. Now observe the chart planned by her friend Ganesha for the same topic. Make a comparison and discuss with friends and find out why one is better over the other.

Ganesha's chart contains the following question:

Which of the following represents a polygon and why the others are not?



The above chart is no doubt relevant but this experience only superficially develops the knowledge of the concept without giving opportunity to develop deeper understanding. The chart contains only one relevant fig. and others are totally different. Even a student having superficial knowledge of polygon can successfully answer this. This cannot guarantee the meaningful understanding of the concept! Again, look at Stella's chart on the same theme. There are, more than one seemingly correct response, which encourages them to think and get the clear concept of polygon. The issue here is again not planning for relevant learning experiences but planning the most relevant ones! Now it may be possible for you to agree why this has become a planning issue. Teachers more often fail in deciding the experiences that are most relevant in the sense, which facilitate deeper level learning.

**c) Planning to teach important math and not confined to formula**

The NCF-2005 recommends that children should learn important mathematics! Then important math is what the teachers should plan for? This naturally should reflect in the teacher's planning. But the question arises, are there important math and unimportant math? This sound strange and surely there is an issue related to this. Discuss among your friends and find out when does any math content become important to learn?

Any content of math becomes important if the students find meaning in solving them! Let's understand this by considering the following examples:

Example-1:

Just imagine in a geometry class, you are working on a complex rider sum on some theorem. Your teacher has given a solution already and you are taking little longer... but sooner you will arrive at a more exciting solution to it. When you did come out with an

alternative solution to the same problem, you find yourself exclaiming: “wow! This is the beauty of math; I simply love solving such challenging tasks”.

Consider another example on application of mathematics in daily life:

Example-2:

Raghu was not at all interested to participate in the orientation cum demo organized by the school authorities. He did not even focus on the theme that read: ‘**Significance and role of Mathematics in Advancing Science Forward**’. But the teacher did not permit him to skip and there he is in the second line of seating arrangement forcing him-self to concentrate. To his surprise the demo and the running- commentary by the resource person was so effective... that he did not realize how the time was spent. He kept thinking ‘wow! For the rocket to go to outer spaces the whole lot of mathematics involved! Ignorance of this would be at the cost of the very invention of rockets themselves!’ What he thought as **mundane numerical calculations** are so significant and push ahead the scientific advancement! Next morning he found himself to be taking extra interest in solving math problems with enthusiasm! Math was no more a dry and drudgery...he was convinced.

Dear student you must have observed the above citations. Do you agree that both are important mathematics? Why? Discuss with your peers and find out. Yes! Your discussion might have furnished the information that important math is that which gives meaning in the sense ‘**a purpose is served**’ feeling! In both the examples cited above, some purpose is served (in the first case the student is enjoying the beauty of math and finding happiness greatly, serving the self of the individual! whereas, in the second case the student finds some use of math-learning in his daily life!) Thus in both cases they are learning important mathematics. Observe the following picture which is the fate of math students in many schools.



Do you think they are learning important mathematics? Why is it so? May be because to plan to teach ‘important’ math is not every teacher’s cup of tea! There are two aspects to this viz.

- teachers identify and feel the importance of math content themselves and
- teachers while planning formulate such learning experiences that leaves behind a feeling of ‘**purpose served**’ among student.
- 

In most cases the first aspect is itself not taken care off! Such teachers who are not keen in identifying and get the feel of importance by themselves, how can they plan to teach important math?

### Check Your Progress - 1

1. What is mathematization of child’s thinking?
2. What makes planning for mathematization an issue?

### 3.1.3.2. Planning issues identified against the recommendations of NCF-2005 Part-2

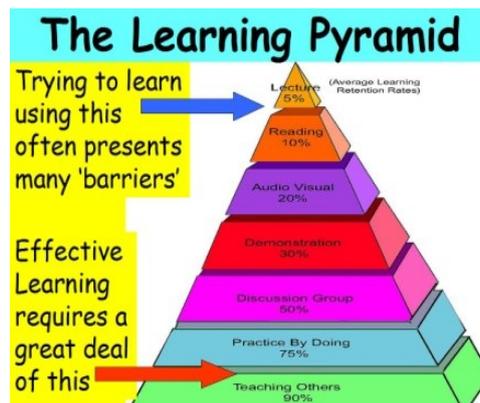
#### Exercise II

Imagine the activity Fun Fair. Below indicated are some of the math skills used in its organization and execution. Read through the skills and answer questions given below.

- Fun fair activities
  - Method and Skill from commercial method.
  - Skill of making graphical represents.
  - Estimating budget.
  - Making cubicles for each stall using space geometry.
  - Creating math games using syllogism.
1. Who is facilitator of learning?
  2. Formulating most relevant learning experiences has become an issue-why?
  3. What are the two aspects of planning for teaching important mathematics?

As you went through the activities several thoughts might have come to your mind regarding how mathematics lesson should be planned in order to develop the skills that are necessary. Now let us discuss them

#### a. Planning to pose and solve meaningful problems to develop problem solving skills



The diagram provided here displays a number of methods and techniques moving from teacher dominated to students dominated ones.

Math teachers find it harder to plan to use the above techniques to teach math. Somehow most math teachers are comfortable in **teacher dominant** techniques only. This may be due to various reasons such as lack of attitude, lack of competence, false rationale (for eg; math classrooms should not be noisy and it's beyond students to participate on their own and understand the ideas. Therefore, teacher dominated plans are practically feasible and are of less risk) setting etc. Whatever is the reason it all ends up with math teachers to plan only to equip them with some cheap tricks of solving a few problems instead of learning the problem-solving skills.

Dear student you should understand that solving math problems should develop problem solving skill among students and thereby make them equipped to solve their daily life problems. For this to happen, the teacher should plan to develop the ability of students to

visualize and pose real life situations as problems and find its solution. This enhances their problem-solving ability.

For example: Here is situation that reflects vegetable vendor's routine. Read it for understanding.

Nagalakshmi is a vegetable vendor. She has purchased 20kgs of Tomatoes at the rate of Rs 40/-. She managed to sell 6kgs of tomatoes at the same rate. Due to the excess heat, half of the remaining tomatoes got rotten. It's indeed a loss to her! She opined if she does not sell the remaining (those which are not rotten yet!) soon, they may also get rotten! She wants to make profit on loss now.

After reading the situation answer the following questions:

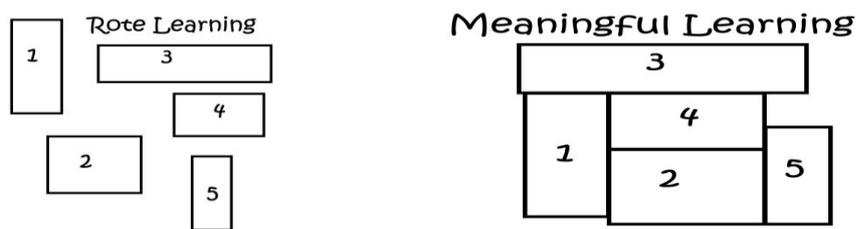
1. How many math problems can be posed from this situation? Which are they?
2. How can she make profit on loss?

Dear student, you might have successfully identified the uniqueness of the learning experience provided here! Such teachers actually help students learn to pose daily life situations as problems and show inclination to find solution. But how can this be a planning issue? The planning issue here is, the lack of the following aspects among teachers:

- Proactive attitude among teachers.
- Ability to identify and pose real life situations as problems.
- Ability to plan and ask questions, which motivate students to think about the various perspectives of the real-life situation that is posed.

**b). Planning to highlight the inter-linkages between the concepts for a meaningful understanding**

Observe the following pictures and analyze the differences between the two:



Courtesy: aha! Unfolding constructivism-a handbook for teachers published by Agastya international foundations

Your observation of the above picture might have provided insight that if teacher plans to teach the content as isolated bits they get compartmentalized and results in similar type of learning. For meaningful and holistic learning they have to be taught highlighting the inter-linkages between the concepts.

Dear student try to help Chithra, an 8<sup>th</sup> grade math teacher from government school Puttur, in finding some examples to demonstrate the inner linkages between math concepts in the following example:

An effective teacher deliberately formulates learning experiences with a view to make the students identify the internal linkages between various math concepts. For example, to highlight the inter-linkages a teacher teaches **division of numerals** not simply as yet another concept for them to learn, but a concept which involves other concepts which already they are aware of viz., subtraction, multiplication, place value etc.

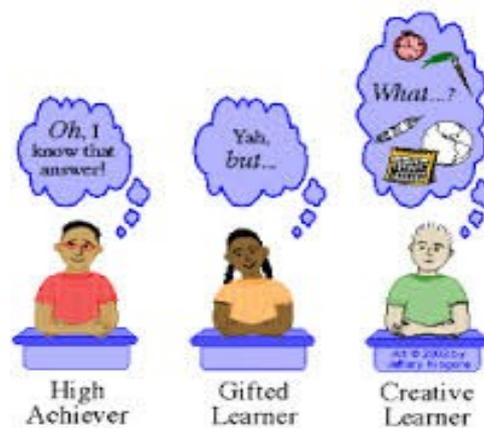
### Check Your Progress -2

1. What could be the reasons for teachers to plan teacher dominated math lessons?
2. Visualize and pose any two real life situations as problems.
3. How can a teacher avoid teaching math as isolated bits?
4. Give an example from math content showing the inter-linkages between the concepts

### 3.1.3.3. Planning issues identified against the recommendations of NCF-2005 Part-3

#### Exercise III

Observe the following figure which depicts the scenario in most schools. What do you conclude about the planning of the lesson?



Response to a Question

**Courtesy: aha! Unfolding constructivism-a handbook for teachers published by Agastya International foundations**

Lack of effective planning with conviction to make every child learn math disappoints both a talented minority as well as the non-participating majority at the same time. Now let us see the important aspects that need to be kept in mind while planning mathematics lessons.

#### a) Teachers are expected to plan meticulously to engage every child in class with the conviction that everyone can learn Mathematics

Every child in the class should be made to learn mathematics. This is vision of NCF 2005! When most teachers lack positive attitude towards teaching mathematics, they collectively feel that it is indeed a reality that Mathematics is a dry and drudgery subject. Society is no exception this notion. Whenever parents, exclaim “Wow! You are a math teacher! Great?!” they really are expressing their fear about the subject mathematics and thus respect the one who teaches that subject!! Teachers proudly accept this! When this is the attitude of both society and teachers teaching mathematics, it becomes an issue in planning their lessons with the conviction that everyone can learn Mathematics.

**b). Planning modern assessment techniques to test students' mathematized abilities rather than the procedural knowledge**

Dear student, observe the following example to know how mechanized teachers are in their expectations of students.

It so happened once in Shankar's math class, he had given the scored test paper to students and told he is ready to clarify any doubt with regard to the scoring that he has done. Shwetha politely came near him and in a low voice showing her paper said, "sir, you have not given me the full marks for this response". Shankar looked at the paper and got annoyed and shouted, "How can I give you full marks? You have gone wrong in the second step itself!" Shwetha with all humility confessed, "Oh Sir! Its only that I have skipped one step and gone ahead!" Shankar felt ashamed for blindly looking at the stepwise answers without realizing that some students are slowly developing the skill of mathematization.

The above example might have conveyed the importance of using better and modern assessment techniques which go a longway to assess the deeper understanding of math content. This becomes an issue for the following reasons:

1. Ignorance of teachers regarding the newer techniques, which are cleaner and better
2. Negligence and lack of positive attitude in this regard, on the part of the teacher to use the modern assessment technologies
3. Ignorance of finding such assessment techniques

**c) Attitude of math teachers regarding their professional growth**

When teachers are not prepared and updated to teach mathematics, they do the rituals in teaching but at the same time they expect to achieve great!?

Most teachers do not understand the need to update themselves as mathematics teacher. If they are well-worsted with the capacity to solve all the problems of the unit end exercise, it is natural for them to think that they are the best teachers. Teachers seem to believe that it is sufficient for teacher only to able to solve all the exercise problems. This attitude holds them back from updating themselves regarding modern teaching and assessment techniques. Once they are ignorant of the significance of their professional growth, their attitude holds them stagnant and planning of math lessons get affected. Even if they are skilled and effective communicators, they will not be effective if their attitude is not positive towards incorporating something new into their teaching of mathematics.

There will be no question of achieving higher aim of math education, as equipping in numeracy is what such teachers plan for!

**d). Inhibitions among teachers to develop awareness and enrich themselves with a variety of mathematical resources, to teach math with well planned lessons**

The major issue is the lack of awareness among teachers regarding resources available (in variety).

Teachers should seek for resources from all sources without any inhibitions. They should develop that type of bent of mind to seek for and share with resources from sources. Consulting various resources not only gives them professional growth but also results in more effective plans to teach mathematics.

### **e) Lack of teacher preparation and support in the teaching of mathematics leading to ineffective math lesson plan**

There exists a wide gap between how a math teacher is equipped during the training and the needed tools and competence to face the real class room situations. If the teacher preparation is only doing rituals then we cannot expect magic to happen when these teachers teach at schools! Planning involves both cognition and visualization of content on hand as well as the situation to be. The freshly trained math teachers are sometimes ridiculed by the senior teachers of the schools where the former opt to bring in some innovation in the teaching. Some schools believe that to teach mathematics there is hardly any need of learning aids, instead only work out more numerical problems.

### **Check your progress - 3**

1. What may be holding the teachers back to plan lessons to motivate all students that they all can learn math?
2. 4. Why should we mark the center first to draw a circle?
3. How can resources help teachers to plan math lesson in a better way?
4. What is the gap between the kind of training a teacher receives and the real classroom setting?

### **3.1.4. Let us Summarise**

This unit covers the following general issues related to planning for teaching and learning mathematics.

- Planning to teach mathematics to imbibe its tools for a successful life.
- Formulating relevant learning experiences while planning in order to facilitate learning.
- Planning to teach important math and not confined to formula.
- Planning to pose and solve meaningful problems to develop problem solving skills.
- Planning to highlight the inter-linkages between the concepts for a meaningful understanding.
- Teachers are expected to plan meticulously to engage every child in class with the conviction that everyone can learn Mathematics.
- Planning modern assessment techniques to test students' mathematized abilities rather than the procedural knowledge.
- Attitude of math teachers regarding their professional growth.
- Lack of teacher preparation and support in the teaching of mathematics leading to ineffective math lesson plan.

### **3.1.5. Answer to 'Check Your Progress - 1, 2 and 3'**

#### **Check Your progress -1**

1. Mathematization of child's thinking, is the higher aim which promises to develop the inner resources of a growing child.
2. Teachers are aware that mathematization is significant and should get prioritized first in their planning. As there is no one approach to achieve this, planning to achieve

#### **Check Your Progress - 2**

1. This may be due to various reasons such as lack of attitude, lack of competence, false rationale (for eg; math classrooms should not be noisy and it's beyond students to participate on their own and understand the ideas. Therefore, teacher dominated plans are practically feasible and are of less risk) setting etc.

2. You can consider any real-life situation similar to what is cited in this unit.
3. For meaningful and holistic learning, the lessons have to be planned well highlighting the inter-linkages between the concepts.
4. You can give any example other than what is given in the unit.

### **Check Your Progress - 3**

1. When most teachers lack positive attitude towards teaching mathematics, they collectively feel that it is indeed a reality that Mathematics is dry and drudgery subject
2. According to the definition of the concept of circle, the points on the circle are at equidistant from a fixed point. That's the reason to mark the fixed point (center) first and then join all other points which are at equidistant from it.
3. Consulting various resources not only gives them professional growth but also results in equipping them with the ability to prepare more effective plans to teach mathematics and execute.
4. There exists a wide gap between how a math teacher is equipped during the training and the needed tools and competence to face the real class room situations. Planning involves both cognition and visualization of content on hand as well as the situation to be.

### **3.1.6. Unit end Exercises**

1. Presently the demand is not the ability to solve a few numerical problems but ability to think mathematically-discuss in the light of planning math lesson to mathematize students' thinking
2. Explain the meaning of 'important math' with an example
3. Explain the issues related to planning to pose and solve meaningful problems?
4. What are the issues related to problem solving skills? Explain with examples

### **3.1.7. References**

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## **Block 3 : Planning in Teaching and Learning Mathematics**

### **Unit 2 : Structure and Importance of Unit Plan and Lesson Plan**

#### **Unit Structure**

- 3.2.1. Learning Objectives
- 3.2.2. Introduction
- 3.2.3. Learning Points and Learning Activities
  - 3.2.3.1. A general frame work and significant considerations of Planning  
Check Your Progress - 1
  - 3.2.3.2. Preparation of Unit Plan  
Check Your Progress - 2
  - 3.2.3.3. Preparation of Lesson Plan  
Check Your Progress - 3
- 3.2.4. Let us Summarize
- 3.2.5. Answer to ‘Check Your Progress - 1, 2 and 3’
- 3.2.6. Unit end Exercises
- 3.2.7. References

#### **3.2.1. Learning Objectives**

After completing this Unit, the student teachers will be able to

- Define unit plan and lesson plan;
- Identify the general frame work of planning for math teaching;
- Explain the significant considerations of planning math lessons; and
- Mention the importance/uses of planning to teach mathematics.

#### **3.2.2. Introduction**

Dear student, you may be aware of the fact that in most cases the state/university/institution decides what the students should learn. But how the students learn is in the hand of the teachers! Yes! it is in the hands of teachers to structure the curriculum & transact meaningfully. This is no easy task. In order to be effective in the class room transaction the teacher needs to do some prior preparation. This calls for planning at various levels. The significance of planning is better understood by analyzing the words of Spencer who opines, ‘One of the most important (principles of good teaching) is the need for planning. Far from compromising spontaneity, planning provides a structure and context for both, teacher and students, as well as a framework for reflection and evaluation’ (Spencer, 2003, p. 25).

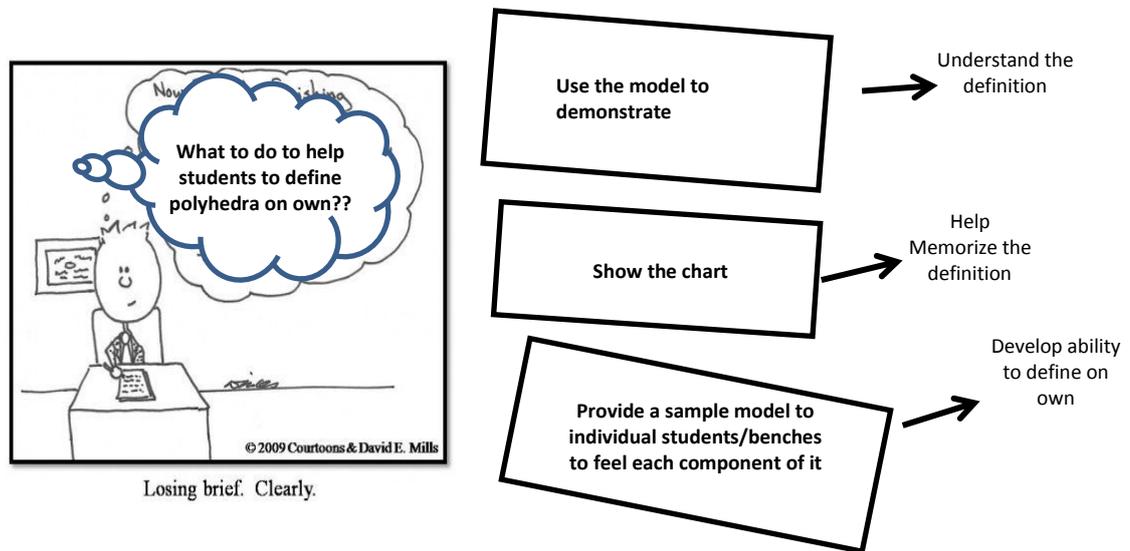
For a novice mathematics teacher, planning for effective teaching can be both challenging and difficult exercise with many different angles and perspectives. Planning for teaching mathematics enhances teachers’ confidence and directs the teachers as to what, why and how to teach mathematics content. This certainly ensures effective teaching and learning experience. Planning serves as the best medicine for the nerves for a teacher when teaching a subject. Planning is the only way to ensure that your educational objectives are achieved. Let’s try to understand the mechanics and dynamics of planning for teaching and learning Mathematics.

### 3.2.3. Learning Points and Learning Activities

#### 3.2.3.1. A general frame work and significant considerations of Planning

##### Exercise I

Go through the following and realize the importance of planning for teaching learning mathematics and note down in your books in the importance of planning.



This citation helps you to understand how planning directs a teacher towards the goal. Yes Planning to teach provides the road map throughout the teaching period, and helps the teacher to manage successfully. It also helps teachers achieve the learning outcomes by making the teachers stay without deviation, on course. Planning helps teacher realize what content is to be learned by students after a particular class.

#### A. Importance of Planning in Mathematics

- Planning to teach provides the road map throughout the teaching period, and helps the teacher to manage successfully
- A good plan not only answers teachers' questions but also provide sufficient support to the teacher so that the teaching becomes smooth and easy
- Sincere planning avoids aimless teaching and leads to successful instruction.
- Planning saves a lot of time and energy
- Boosts teachers' confidence and makes the teacher better equipped
- Intrinsically flexible in nature facilitating multiple users of a plan

#### B. Planning for teaching mathematics

There can be levels of planning. As you know already, teacher should plan for the whole of academic year by spreading the various units of content over time maintaining the sequence. Semester-wise Planning or annual planning can solve this problem.

It is to your knowledge that all mathematics content of a unit cannot be taught in one single class period. To have a hold on the unit as well as to move in a smooth & connected phase, a planning at the unit level can be made first. This is the **unit plan**.

- a) Unit Plan:** In this, a single unit is considered and the whole unit is divided into meaningful parts (sub units). Each subunit can be considered as a single lesson of a class period. A successful unit plan addresses and integrates the following key points:
- ✓ Objectives for the unit as a whole
  - ✓ Division of the unit into meaningful subunits that have the potential to become individual class lessons
  - ✓ Collection of various learning experiences (may be in duplicate/multiples) as well as assessment activities/tasks for various learning points of the unit
  - ✓ Platform in the form of ‘follow up activity’ for a coherent application of all the learning points of that unit.
- b) Lesson Plan:** Math content that is taught in a single class hour is called a lesson. Effective teachers plan to teach their lessons. A successful lesson plan addresses and integrates these key components:
- Objectives for the content chosen, for student learning
  - Identification of major learning points that can be covered in the class period
  - Teaching/learning activities relevant with respect to cost; content; stipulated time; and realization of objectives
  - Strategies to check student understanding-mostly formative which are feasible and relevant to the objective of assessment.

Important information related to the preparation of any lesson plan is that most of the fundamental ideas for planning can be borrowed from the unit plan, to which the lesson belongs to.

Before going deep into the structure, let us know unique aspects of planning for teaching with special stress on mathematics content

**C. A general frame work of planning (both unit and lesson plans) for teaching & learning Mathematics (applicable for planning of any subject) can be outlined: -**

Planning involve of three stages. Although these are true in planning for teaching of any subject, it is worth to develop the awareness for you as a mathematics teacher. The general frame work is discussed under the following questions:

**a) What to plan for?**

The following questions if you pose and find answer it may help you gather broader meaning of above question:

- Whom am I teaching?
- What am I teaching? The unit/topic or subject.
- What is the purpose of my teaching? What do I want to achieve (my objectives)?
- What information do I need regarding the content?
- What instructional resources/materials are available?

Now, how does this activity help you? Of course, your involvement in this helps you identify that this stage involves in,

- creating an overview of the mathematics curriculum, desirable math outcomes, learning objectives etc.
- preparing time-line for the execution of the plan and
- Gathering data and teaching/course materials.

## **b) What instructional decisions to make?**

Instructional decisions are those decisions you make in order to execute during your math lesson transaction. The following questions may help you simplify meaning of the above question further:

- How will I teach it?
- What Teaching and learning methods are most relevant?
- What is the length of time for each lesson, at my disposal?
- Which one/more of the available resources/materials is best suited to teach the topic/s?
- Whether to have small group activities or a teacher demonstration is sufficient?
- How will I know if the students understand?
- What are the informal and formal assessments techniques?
- What are the means of collecting feedback from learners?

You are right if you have understood that this stage involves ‘deciding on’ the ‘what’ and ‘how’ of the math teaching in order to incorporate them during transaction. Also it involves identification of work-flow of step by step implementation, delivery methods, assessment techniques, feedback options, etc.

## **c) Do the ‘transaction-decisions’ (instructional decisions) & objectives align (on par)?**

The following are the tips (in the form of questions), for the smooth grasping of the above:

- Whether the learning experiences provided communicate the content on hand?
- Do the teaching methods match the student age level?

In the above questions the learning experiences and the teaching methods indicate the instructional decisions made. Mismatch occurs if the learning experience decided by the teacher, fails to communicate the content teacher is teaching. Mismatch occurs if the teaching method decided by the teacher goes above their head! Teachers can match the instructional decisions made with the aspects you want to achieve and check for any mismatch. So dear student, look out for one-one relation between the two for alignment. If not, try to rethink your instructional decision in order to reform. Teachers should take care of this factor and try to eliminate the mismatch between the instructional decisions and the learning experiences formulated.

Till now you have understood the general framework for planning to teach mathematics.

## **D. Significant Considerations While Planning**

You may recollect that planning can be done at both ‘unit’ and ‘lesson’ level. The general frame work can be successfully used for both levels. However, dear student there are some significant considerations which you need to make for preparing effective plans at above mentioned levels. Let’s identify them now.

For an effective plan to prepare, there are some necessary considerations that is to be made. Let us discuss them one by one.

Concentrate on the following discussion and identify the various significant aspects of considerations for planning:

- State your objective at the **beginning** of the lesson plan. A teacher must know what he/she expects his/her students to learn after his/her teaching. Identify the learning points and then ask yourself as to what your students will be able to do at the end of

the lesson that they could not do at the beginning. Write them in the form of statements before you start planning your lesson. .

- Break big content down into small manageable pieces: any big area of content cannot be taught at once. In order to facilitate meaningful learning, the big area of content can be broken into smaller ones based on the number of learning points and their difficulty level. The productivity of teacher is also enhanced by this. Small tasks would seem easy job and will get you through doing a lot more than, within short time. This provides the teacher maintain a better control over the curriculum.
- Create a list of desired outcomes:-  
While deciding the outcomes, keep these questions in your mind.
  - ✓ What is the topic of the lesson?
  - ✓ What are the learning points in the topic?
  - ✓ What should the students be able to do after the lesson is taught?
- Decide which parts of the lesson will be teacher directed, and how the teacher's input will be presented. Take into account different learning methods and provide visual input in the way of pictures or diagrams and written directions or examples, as well as verbal direction. Effective teaching must take into account how students of all levels of ability will be helped to store the information in their long-term memory.
- Maximize student learning by planning tasks and activities. Plan for activities that help students to demonstrate understanding of the lesson and help them to apply critical or creative thinking.
- Collect teaching as well as assessment materials and supporting data. Besides the usual teaching materials, planning gives you time to gather enough data and resources to support your teaching. You could make use of reference books and documents other than your curriculum as well as new technologies to assist your instruction.
- Improvise on the way by making the plan flexible.
- Check upon students' entry behavior. For this try to collect the following information through your acquaintance:
  - Significant points about students' backgrounds and characteristics can be known by the teacher. Try to know if the students possess any background information related to the day's topic?
  - Review your understanding of your students when needed.

**Amount of content used for planning depends on the following aspects.**

1. Normal age-wise characteristics of students
  2. The subunits identified
  3. Size of the units (learning points) to divide into sub units
  4. The curriculum frame work of what to teach
  5. The approach one would like to select for students yours
- Plan a short review session at the end of the teaching period where the information and tasks of the lesson can be revised. As a whole group student can discuss with the teacher what they did, how they did it, and how it relates to the world outside.
  - Plan ways of collecting regular meaningful feedback from students of their progress, may be in the form of formative assessment tasks/activities.
  - Plan to relate your assessment tasks to your objectives. Just look at fig. given below and identify whether the two match or mismatch.
  - Provide opportunity to reflect upon the teaching, in the plan itself.

- Think about what sorts of physical resources you may need such as room furniture that can be altered to allow different discussion modes, access to computer labs, projection facilities etc.
- Teachers, who are sincere, ask plenty of questions about student learning while planning for math lessons.

While planning for a math lesson, these are the questions you ask:

- How do I monitor students' learning by sustaining their interest?
- How will students benefit from participating in the Sudoku or/any other activity?
- How are you going to ensure that they learn during and after the session (follow-up activity)?

### **Check Your Progress - 1**

1. Give any two importance of planning to teach mathematics
2. What are the key points (any two) addressed by a successful unit plan and lesson plan?
3. List any two questions that you can pose yourself to grasp the meaning of the content.

### **3.2.3.2. Preparation of Unit Plan**

#### **Exercise II**

Attentively discuss with your friends with what back ground information you already have on unit plan, and collect your query questions. The query may encompass the number of subunits; objectives; learning experiences; assessment tasks and any other. The answers to these questions may provide you with the structure itself! Now take out your notebook and start noting down and get going!

In a unit plan, the selected content is divided into meaningful subunits based on the learning points and difficulty level of learning points. Unit plans are made by teachers in order to plan out the lessons they need to teach to students. It should contain relevant content, the learning skills, objectives and the tools needed to be able to carry out the lesson. A unit plan is a road map that provides directions on how to reach the curriculum standards of the unit and contains checks (assessment) for understanding, quizzes or assessments that keep the teacher informed on the success of the students. A unit plan outlines the desired outcomes and lead toward the end. The purpose of unit planning is to connect the competencies, language standards, and skills together so that it creates a unified picture for students. Also, since it has the potential to work as a repository of learning experiences and assessment activities, it can be successfully used to prepare a lesson plan for a lesson on that unit. Let's know the finer details of the structure of a unit plan. By its definition it is evident that unit plan is to plan for the whole unit, which may comprise of more than two daily lessons.

Here is an opportunity for you to cross verify the outcomes of your discussion. It may contain some of the below questions for which the answer is also provided:

#### **1. Into how many subunits can I divide the unit on hand? What is the basis for this?**

There is no norm that a unit must contain a particular number of subunits. The number of subunits surely depends on, the following components:

- Students' entry behavior

- Number of learning points in a unit
- Level of abstractness of the learning points
- Available time on hand
- Average intelligence of the class

In any unit, identify the number of major learning points. For ex: Commercial Mathematics is a vast unit with more number of major learning points. This should be divided into more number of subunits compared to a unit on 'variables' (these examples do not belong to any class or grades but serve sheer purpose of an example). If a unit consists of some abstract learning points (say 'Hire purchase'), in such cases it can be further divided into some more subunits.

You are aware that each subunit is equivalent to one lesson of one-class period.

## **2. What objectives can I enlist to accomplish?**

Write instructional objectives to all major learning points encompassing the major learning points of all its subunits. You may enlist the specific objectives for each of them during planning lesson on that (lesson plan).

## **3. How many learning experiences do I need to plan for?**

You are aware that all objectives listed are to be achieved. To achieve any objective is to say that the students are able to learn that aspect. This means each objective can be accomplished through a suitable learning experience. Constructivists approach to learning suggests that students have the potential to construct the knowledge by themselves. Teachers have to only facilitate learning. So your plan can provide learning experiences in the form of 5Es i.e., activities that make students, **Engage; Explore; Explain; Elaborate/Extend** and finally activities that **Evaluate** students' learning.

One very important aspect is the fact that a unit plan can be a repository of learning experiences and assessment tasks. Yes! In case you realize that more than one learning experience is possible for a particular math concept, to achieve a particular objective, you can store them in the unit plan. It is also much recommended to consider it as significant since unit plan serves as a resource (or a store house) which can be later on consulted for, while planning for a lesson.

## **4. How to plan for acknowledging learning by students?**

After transaction of each learning point, it is not possible to proceed unless you are convinced that they have learnt the earlier content. So plan for some assessment tasks which is formative in nature. Also, as said earlier, to make unit plan serve like a storehouse, plan for a number of assessment tasks/activities under each learning point. Let your assessment tasks not confine only to paper pencil tests. Instead formulate activities, mini projects etc.

## **5. How do I give a holistic approach to unit learnt?**

Provide follow up activity. Any follow up activity should have the potential to make provision for students to use all major learning points of that unit, in one or the other way to successfully accomplish it.

Now let's incorporate all the above aspects and give it a structure as below. Here is a suggested format of a unit plan for teaching mathematics:

### Unit Plan Format

Sub Unit No	Learning Points	Instructional objectives to be focused	5Es activities to facilitate Learning	Evaluation (Tools & Techniques)
<b>Follow up activities (For the whole unit)</b>				

### Check Your Progress - 2

Mention any two questions that can be posed to get an idea of the structure of a unit plan?

### 3.2.3.3. Preparation of Lesson Plan

#### Exercise III

Plan a lesson to teach the topic 'Polygons'. What aspects do you think need to be considered while teaching this lesson? List in the space provided the different aspects that you think are necessary to be considered while planning a lesson.

As you answered the above question you surely would have thought of several aspects that are necessary for a lesson plan since you have already learnt about the Unit Plan. Lesson Plan is a plan for transacting a small content relevant to teach within 45minutes of time. The key component for the successful lesson planning is the alignment of learning objectives, learning experiences planned and assessment. These three elements address the same agenda and support each other. This is how they are related:

- **Learning objectives** are the key to the teaching and learning process. They define what is taught and what students should learn. Knowing the learning objectives, the students are able to focus their learning process on the objectives. Therefore, the objectives should be described openly for the students from the beginning.
- **Learning experiences (LE):** *teaching is nothing but what experiences a teacher provides to make learning happen in students. Therefore, learning experiences should be planned to accomplish the learning objectives. So decision about learning experiences becomes very significant while planning.* This means LEs should be in accordance with the learning objectives. Since teaching and learning are interactive processes, the students should be encouraged to participate actively in all the learning experiences provided for the desirable learning to occur.
- **Assessment** gives us information on how well the students have reached the learning objectives. Nevertheless, the assessment should measure not only the learning outcomes but also the learning process, motivation and personal development. The successful assessment takes into consideration the suitability of each assessment method for every student.

A lesson plan can borrow inputs from a unit plan. You may recall that a unit comprises of a number of subunits which are potential daily lessons. With this back ground, let's understand how a lesson plan can be prepared.

Let's repeat the activity of **query questions** here also in order to get a vague idea about its structure. You can consult with your friends and list the questions for clarification. The list may be as big as given below (the clarifications are provided inside the brackets):

- **What do you expect your students to be able to perform, after your teaching?**  
(Your expectations are written in the form of instructional/specific objectives in the plan)
- **Why to plan for learning experiences?**

(Learning experiences are to be planned in advance so that all of the listed major learning points are learnt and our objectives are achieved. When the students participate in these learning experiences their sense organs involve actively in the experience provided and absorb the idea related to the content to be learned). Also if the selected learning experience for its execution requires any aid or material, teacher can arrange for them well in advance.

- **Should the lesson plan indicate resources you have decided to use for transaction? (yes, this makes the plan flexible and facilitates for multi-users' benefit).**
- **How would you plan to activate (motivate) your students for the day's lesson? (elicit related previous knowledge simultaneously warm up them. Later on this relevant previous knowledge will be linked to the day's lesson).**
- **How do you plan for learning experiences?**  
(As suggested in the unit plan, use 5Es approach to provide learning experiences.).
- **How do you develop awareness about the clarity of learning by students?**  
(Plan for interaction, bringing conducive atmosphere so that they fearlessly seek for clarification unhesitant; use different evaluation techniques –formative testing activities/tasks; pose questions that help ensure student learning.).
- **How do you let them practice what is learnt?**  
Plan for after teaching activities to ensure student learning; provide problematic situations that use the content learnt for its solution.
- **How do you give them a holistic picture of day's lesson?**  
(All learning points of a lesson are sequentially connected. If this aspect is kept in mind while planning, there will be continuity between and among the learning points to give a meaningful whole.).
- **How do you end the session constructively?**  
(By providing reinforcement activities)

Now let's have a look at the format which incorporates all the above mentioned ideas.

### Lesson Plan Format

Name of the Teacher : xxxxx

Date : XXX

Class : XXX

Section : xxx

Period : XXX

Medium : XXX

Phases	Details of Phases	Specifications of Students' behaviour in the Learning Process
Phase One	<p><b>Creating appropriate Learning Environment/Stimulation of Previous Experiences related to the present topic.</b>            Set a purpose.            Check on previous learning. Identify where you need to start. Give activities to find out their knowledge about the topic.            Use questions, quiz activity, brain storming etc to know what they already know about the topic.            (Can also use pictures, visuals, Stories, Personal experience)</p>	
Phase Two	<p><b>Presentation of Learning Points</b>            Present the learning points, to be learnt on the day. Develop the lesson linking it to their previous knowledge.</p> <p>Build background knowledge, lecture and introduce key new points of understanding, correcting, misconceptions, Develop the learning points using appropriate approaches/ Strategies/ Techniques, Learning Aids, Experiments, Anecdotes, Analogies, Illustrations, Examples.</p>	
Phase Three	<p><b>Clarification</b>            Restate, reemphasize, add examples, illustrations about the points already discussed to strengthen their understanding.            Provide additional details,/examples/illustrations/experiments/sample problems/and situations. Pose questions to move students toward independent work.</p>	
Phase four	<p><b>Practice/Review and Independent Practice</b>            See that student work with you, and whole class, in small groups, or with a partner to clarify learning. Plan activities for the same.</p> <p><b>Independent Practice</b>            Students practice on their own. Begin homework. Struggling students get additional practice.</p>	
Phase Five	<p><b>Closure</b>            Motivate students to consolidate the points learnt in the class. Connect the lesson details together. Answer questions and respond to whole class difficulties.</p>	
Phase Six	<p>Assign follow up activities that strengthen the learning of students.</p>	

Now dear student it is not sufficient if you learn to plan for both unit and a lesson in mathematics, but knowing its worth is very important.

### **How to assess your plan?**

It becomes teacher's responsibility to ensure the effectiveness of his / her plan. Following are a few suggested techniques that you can try to know the quality of your plan:

#### **1. Use Students' performance /results as the evidence**

Obviously, you can consult with the evidence of outcomes which is in the form of students' performance (results/grades). This gives you solid feedback on quality of the plan and how effectively it has worked. You are advised to reflect on it and accordingly make improvements and improvisations in your plan.

#### **2. Guard and be vigilant so that the insight provided by an effective plan is not out of sight!**

An effective plan should ultimately provide some insights to you. It provides valid information regarding your time management skills, teaching skills etc. Situations that may provide insight:

- a) While planning for a concept or a learning point, you may suddenly sense the need to introduce a sub concept for a deeper understanding of the learning point (which is not mentioned in the curriculum).
- b) After the execution of an activity in one of the math classes, a teacher might develop insight that the activity demanded specific arrangement of the class for its effectiveness. While planning this forethought was not done. Such insights should not be out of sight!

#### **3. Look out for any shift in the Perception of math curriculum**

An effective plan can go a long way to modify how a teacher and the students perceive the curriculum. It gets things organised and accessible.

#### **4. Check if your productivity to plan more efficiently and constructively has enhanced.**

Obviously as you develop experience in the lesson plan preparation, all issues related to its preparation automatically gets resolved. You will be better equipped to complete tasks and evaluate outcomes faster.

**5. Feedback: Gather feedback from various sources.** This is the most significant as well as easiest way to know if the plan is working.

Finally keep in mind the words of Jim Scrivener who says "Prepare thoroughly. But, in class, teach the learners, not the plan."

### **Check Your Progress - 3**

1. Mention any two factors that help a teacher to assess his/her lesson plan

#### **3.2.4. Let us Summarise**

This unit covers the following aspects related to planning in teaching and learning mathematics.

- General frame work of planning
- Significant consideration while planning
- Preparation of unit plan and lesson plan.

- Format for writing the following:
  - ✓ Reflective teaching and learning
  - ✓ Unit plan
  - ✓ Lesson plan
- Assessing the lesson and unit plan

### 3.2.5. Answer to ‘Check Your Progress - 1, 2 and 3’

#### Check Your Progress - 1

1. Planning to teach provides the road map throughout the teaching period, and helps the teacher to manage successfully.
  - a. Planning trains the teachers to visualize through the process of planning and forecast consequences of the learning experiences that are decided to provide to the class.
2. A successful unit plan addresses and integrates the following key points:
  - a. Objectives for the unit as a whole
  - b. Division of the unit into meaningful subunits that have the potential to become individual class lessons
3. Some questions are:
  - a. What am I teaching? the unit topic or subject
  - b. What is the purpose of my teaching?
4. It speaks of the significance of consideration of identifying the learning points as well as listing of objectives prior to planning.

#### Check Your Progress - 2

1. Some questions are:
  - Into how many subunits can I divide the unit on hand? What is the basis for this?
  - What objectives can I enlist to accomplish?

#### Check Your Progress - 3

Use Students’ performance /results as the evidence and Gather feedback from various sources

### 3.2.6. Unit end Exercises

1. Are the three stages mentioned under general frame work sequential? Substantiate this with an illustration from mathematics content.
2. Use the format of unit plan and lesson plan to plan for a unit as well as a lesson of your choice, in mathematics
3. Prepare unit plan for a unit of your choice. Use this to prepare a lesson plan from the same unit.

### 3.2.7. References

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## **Block 3 : Planning in Teaching and Learning Mathematics**

### **Unit 3 : ICT Applications in Teaching and Learning of Mathematics**

#### **Unit Structure**

- 3.3.1. Learning Objectives
- 3.3.2. Introduction
- 3.3.3. Learning Points and Learning Activities
  - 3.3.3.1 Factors influencing the integration of ICT in the classroom  
Check Your Progress - 1
  - 3.3.3.2. Benefits of integrate ICT to the teaching and learning of mathematics  
Check Your Progress - 2
  - 3.3.3.3. Strength and Weakness of ICT application in the teaching and learning of mathematics classes  
Check Your Progress - 3
- 3.3.4. Let us Summarise
- 3.3.5. Answer to ‘Check Your Progress - 1, 2 and 3’
- 3.3.6. Unit end exercises
- 3.3.7. References

#### **3.3.1. Learning Objectives**

After completing this Unit, the student teachers will be able to

- Give the meaning of ICT applications;
- Identify the factors that are affecting the use of ICT in math instruction;
- Identify the changed roles of math teachers by observing the linkages between Aims of Education; pedagogy and role of teacher in the light of technological advancement;
- Cite math illustration to show the relationship between content, technology and pedagogy;
- Mention the benefits of ICT application in math instruction; and
- Mention four sequential aspects of ICT application that yield enhanced quality in teaching.

#### **3.3.2. Introduction**

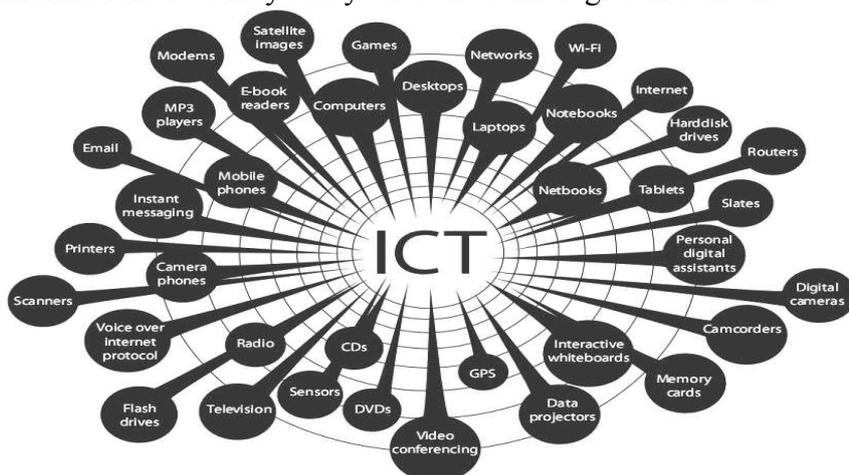
Advancement in Science and Technology altogether opened a horizon of new educational technologies. Information and communication technology is indeed a tremendous gift in the field of education. This witnessed the most advanced and user-friendly tools to be used by both the teachers (for effective transaction/delivery of the content) and the pupils (for deeper understanding of the content). This pushes us to inquire what actually ICT is. There appears to be a misconception regarding ICTs as to be dealing with only computers and computing related activities. ICT application in education is the mode of education that uses information and communication technology to **support, enhance and optimize** the delivery of information. Worldwide research has shown that ICT can lead to an improved student learning and better teaching method. Our understanding of ICT application in mathematics refers to the application of information, communication and technology towards supporting, enhancing and optimizing the effective delivery of mathematics resulting in deeper understanding by students.

### 3.3.3. Learning Points and Learning Activities

#### 3.3.3.1. Factors influencing the integration of ICT in the classroom

##### Exercise I

ICT comprise many technologies for capturing, interpreting, storing and transmitting information. Observe the figure and list the technologies that ICT encompasses. In the space provided classify them into the technologies for capturing, interpreting, storing and transmitting information. You may add your own technologies into the list.



courtesy: ICT (I see it) in Math education, Inder K. Rana [ikrana@gmail.com](mailto:ikrana@gmail.com), Department of Mathematics Indian Institute of Technology Bombay Powai, Mumbai, India

Technology used for			
Capturing	Interpreting	Storing	Transmitting

You have identified and classified the technologies which are used for capturing, interpreting, storing and transmitting information. Further, these technologies enable teachers to voluntarily work collaboratively with students and motivate the students to become deeply involved in their own learning. Dear student, you may be wondering about the potentialities of ICT application in class rooms! ICT application supplements strongly the teachers' effort and can facilitate and encourage students' active roles and independence, consequently developing deeper understanding of the content.

With this in mind probably you will accept ICT application in mathematics classroom to be a promising practice. Although it is true that these potentialities do exist within ICT usage, we do not get to see or experience in reality! Of course, the success of this depends on various factors related to teachers and school atmosphere etc. The following citations develop awareness regarding some of such factors. Dear student observes carefully the below

citations and identify in each case those factors that obstructing/promoting us from benefiting ICTs potentialities.

### Citation 1

Sameer appreciating the ICT preparation done by his fellow teacher Goutham, says, “...hm... yours is science and plenty of opportunities can be identified to use ICT, mine is not so it is mathematics dealing with non-living things?! It is not in most of the times possible to apply ICT?!”

### Citation 2

In a staff meeting the Principal identifies, “wonderful results of students in the board exams!..yes! After we implemented ICTs in classrooms... it’s commendable to see the achievement of students in Science and English. No doubt they have gained more competence!” Immediately the Mathematics teacher nods her head horizontally expressing her displeasure and reacts “I don’t think my students are of any less competence??!! I never use any ICT in my class, for your information?!”

### Citation 3

Observe the following and identify the factor which is affecting the use of ICT in classroom



### Citation 4

After participating in an orientation program on “**ICT application in the teaching of mathematics-a possibility**”, Shwetha- a local school mathematics teacher tells her husband over the phone “my god! ICT is a magic technology and of tremendous help to both teachers and learners. No matter whether I like to use it or not...I need to integrate it in my class. This surely helps my students in their learning....after all more than my likings it’s important to me that my purposes are fulfilled.”

### Citation 5

Girish gave his first ever demo lesson in mathematics using ICT for his 8<sup>th</sup> graders that too in the presence of his Principal. Of course he had planned his presentation by using ICT the way he desired! The feedback received made him fly in the 9<sup>th</sup> cloud! He exploded with a feeling of proud! Yes he proved himself capable of using ICT, **the way he desired to!**”

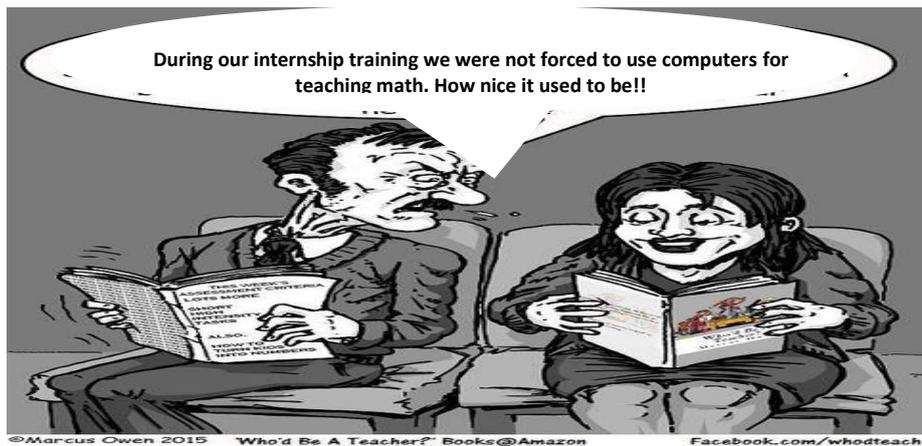
### Citation 6

Dileep and Tabassum, fellow mathematics teachers of local schools are sharing their experience with each other...Dileep is confiding “oh yes! Your painstaking is really

appreciable for ICT application in your class. But you know yaar sometimes it's also risky..in the sense, you know once it so happened I prepared my slides meticulously taking inputs from various sources including internet. When I was through it in my class teaching **Linear Equation**, using a simulation from my power point presentation...suddenly the computer became so stubborn that nothing on the monitor moved let alone my simulation! My class became a flop and of course I could not save my face in front of my students. Since then the 'demotivated me'... am not very confident in using ICT classes.

### Citation 7

Observe the cartoon and identify the factor



After this exercise probably a check on your identified list of factors need be done. Check whether your list includes all that is given below:

#### A. Factors influencing the integration of ICT in the classroom

- Teachers' attitudes towards ICT contribution to mathematics teaching. (citation 1)
- teachers' attitudes towards ICT contribution to students' mathematics learning,(citation 2)
- teachers' perceptions of their ability in ICT, (citation 3)
- Teachers' intentions to actually integrate ICT in their teaching. (citation 4)
- teachers' feelings of self-esteem and control in the presence of ICT in the mathematics classroom, (citation 5)
- Factors regarding ICT use in the classroom and related to tools, which could be: tools' operational technical problems, where they could decrease the use of the tools as personal tools, and, as a consequence, their general use in the classrooms. (citation 6)
- Factors regarding ICT use in the classroom and related to the system could be: teachers' training programs at colleges and universities, where ICT related training programs develop teachers' competences in computer use and affects positively their attitudes towards computers. (citation 7)

## **B. Need to integrate ICT in mathematics instruction**

Educational councils, such as the British Educational Communications and Technology Agency along with mathematics education researchers pointed out certain factors similar to each other's research.

The inbuilt features of ICT applications are supposed to encourage teachers in general and mathematics teachers in particular (because technological tools can provide multiple mathematical representations that facilitate easy grasping of mathematical concepts, procedures and topics) to use ICT in their teaching.

Dear students before knowing how ICT can help, it is crucial first to know why ICT? To understand this it is important for you to develop awareness regarding **Aims and objectives of Education; meaning of pedagogy and role of teacher** and its shift in the present scenery

**Aim of education:** George Polya (1887 – 1985) a Hungarian mathematician, who is the “The Father of Problem Solving in Mathematics Education”, identifies two kinds of aims of education:

1. Good and narrow aims: The schools should turn out employable adults - adults who can fill a job. The objective is to make the students employable.
2. Higher aim: To develop all the inner resources of the growing child. Higher order of thinking viz., reasoning; critical thinking; logical thinking and problem solving skills etc. should be imbibed by learning mathematics.

Mathematicians agree that Mathematics plays an important role in achieving both of the above aims.

**Pedagogy:** Oxford English Dictionary defines Pedagogy as “The science of teaching”. However, the following questions are answered in Pedagogy:

1. What is taught/learned - the content.
2. How it is taught or learned - approaches to teaching and learning.
3. Why it is taught or learned - the underpinning values, philosophy or rationale.

## **C. ICT contribution to teaching and learning of mathematics**

In olden days the teachers did occupy the central position in leaning process. As the technological advancement was witnessed, technology added a new dimension to the teaching-learning process. With this background let us now try to understand ICT contribution to teaching and learning of mathematics:

ICT application in mathematics education provides mathematics teachers with integrative teaching methods that motivate students learning, support their independent learning and active participation in the discovery of mathematics concepts and topics. This helps them have deeper understanding of the mathematical ideas accomplishing the higher aims of math instruction. So, the ICT application in the teaching and learning of mathematics helps students have better achievement in mathematics.

You can take up an activity of availing the results of some researches undertaken (in and around the world), in the area of ICT in education (of course you can use ICT to this!). You will be convinced that most researches indicate positive influence of ICT use in the field of education. Thus, information and communication technology is an important instrument. It

transfers the present isolated, teacher- centered and book-centred learning environment into a student - centered environment and has the potential to change the traditional concept of learning process.

Also, the use of technology should develop sensitivity to the dynamic, transactional relationship between the three components of knowledge: Content, Technology and Pedagogy. This is very important. At present technology training appears to focus mainly on technology knowledge and skills while overlooking the relationships between technology, pedagogy, and content. ICT is often used simply as a supplement for existing pedagogical practices. However, in order to fulfil the potential of ICT as a tool for enhancing teaching and learning, ICT must be fully integrated into pedagogical processes, which requires a cognitive shift on the part of educators, curriculum developers, administrators and policy-makers. The relationship between the three components is indicated through the diagram given below:

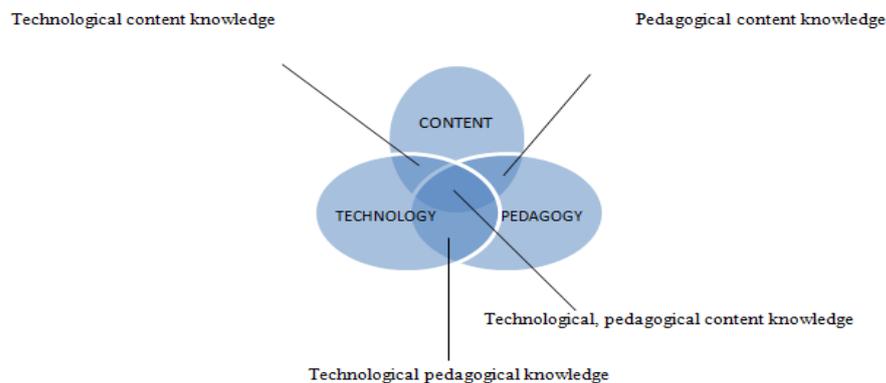


fig: Relationship Between Content, Technology and Pedagogy Knowledge  
 (Research Inveny: International Journal Of Engineering And Science Vol.2, Issue 12 (May 2013), Pp 51-54 Issn(e): 2278-4721, Issn(p):2319-483, Wwww.Researchinveny.Com )

**Check Your Progress - 1**

Mention any two factors effecting / influencing the integrating of ICT in the class the class room.

**3.3.3.2. Benefits of integrate ICT to the teaching and learning of mathematics**

**Exercise II**

Since you have already encountered technological use in your day-to-day life, list in the space provided below, the use of ICT that will be beneficial in the classroom teaching.

I am sure you have listed several benefits of ICT as understood by you. Let us discuss some more.

The British Educational Communications and Technology Agency summarized the main benefits of this use as:

- it allows the pupils to focus on strategies and interpretations of answers instead of wasting valuable time on unnecessary computations;
- it enables quick and accurate feedback for the pupils which consequently leads for positive motivation;

- It increases the collaboration among pupils and encourages communication and knowledge sharing;
- it supports constructive pedagogy, that is, the pupils use technology to discover mathematical ideas and deeply understand them.

#### A. Benefits of ICT application classes

Now let's understand some more benefits of using ICT application. The following are the benefits of conducting ICT application classes for mathematics education:

- **Organizing Activities in math class For Learners Through ICT** Through ICT students can experience various stages of learning, such as critical thinking, problem solving, guided instruction, extra connect, cooperative learning and group monitoring.
  - **Simulations-** ICT applications in teaching of Mathematics, facilitates the use of simulations. These provide excellent opportunities for teachers to create settings where students are led through critical thinking stages.
  - **Guided instructions-**allows students to submit pieces of a project step by step, allowing for a rich feedback interaction between students and instructor.
  - **Cooperative learning-**websites provide ready sites for discussions, cooperative groups are designed and assigned to do the activities by monitoring these groups, and the instructor can introduce timely prompts to redirect the conversation, posing problems that challenge the quo.
  - **Acceleration-**children can be accelerated within their own class working independently, often with some additional support.
  - **Extension-**moving outside the syllabus normally not covered in the curriculum.
  - **Enrichment-** extending students' understanding and applying them to other situations and problems to develop higher level problem solving and communication skills.
1. **Provides learner-friendly feedback mechanism.** Learning from feedback-the computer often provides fast and reliable feedback, which is non-judgmental and impartial. This can encourage students to make their own conjectures and to test out and modify their ideas.
  2. **Facilitates the identification of patterns which in turn lead to identification of solutions.** Observing patterns-the speed of computers and calculators enable student to produce many examples when exploring mathematical problems. This supports their observation of patterns and the making and justifying of generalizations.
  3. **Makes the learner easily identify the connections between two factors.** (For example: two graphs indicating how changes in one, leads to the change in other's shape of the graph). Seeing connections-the computer enables formulae, tables of numbers and graphs to be linked readily. Changing one representation and seeing changes in the other helps students to understand connections between them. It enhanced power to deal with multiple representations via ICT- Ex. Symbolic, numerical and graphical representations of functions in algebra.
  4. **Opportunity to work with 3D and dynamic images-**students can use computers to manipulate diagrams dynamically. This encourages them to visualize the geometry as they generate their own mental images. It enhances ability to visualize via ICT- Experience. Manipulations through software packages of 3-dimensional objects such as solids etc can be used by students as an aid in developing spatial visualization skills. Develops spatial knowledge.

5. **Accesses to Explore data**-computers enable students to work with real data, which can be represented in variety of ways. This supports interpretation and analysis.
6. **Enhanced opportunity to construct mathematics knowledge via individual and group investigation using technologies**-Ex. discovery of geometric properties by students via geometry software.

## **B. ICT-An Aid In to develop Mathematical Concept and Skill**

### **a. Mathematical problem-solving skill:**

You are aware that whenever any problem is made to solve the math teachers insist on the computational aspects predominantly. But use of ICT has enhanced the ability to focus on the process of problem solving instead of the computational aspect. It enhanced ability to solve realistic problems instead of being restricted to contrived problems having solutions-Ex. algebra students solving problem whose model is a cubic equation via the aid of graphing calculator.

### **b. Mathematical Reasoning:**

Thinking and **reasoning** mean more than simply using your mind to produce thoughts. But it is the ability to use your thought process to form conclusions, inferences, or judgments. Using simulations through computers, students can get insights about solving problems may be through the identification of number of patterns.

### **c. Mathematical Communication:**

Recent studies also have shown that there is consensus among teachers that effective communication is critical for more rigorous instruction and deeper mathematics learning. Use of ICT in math instruction makes the communication very effective. It enhances motivation to communicate mathematics precisely in order to perform a desired tasks-Ex. Algebra students programming a computer to estimate the probability that a quadratic equation has real roots under varying conditions on the coefficients.

All the above mentioned benefits no doubt take the process of teaching and learning of mathematics to a very high quality. ICT can enhance competence of students as well as teachers in four sequential areas resulting in enhanced quality of teaching. Let's see how it is possible:

## **C. Four Sequential aspects of ICT application**

The following four sequential aspects of ICT application yield the enhanced quality in teaching

- **Technology Literacy**

Frequent use of ICT makes the teachers and students' techno-literate and both will be in a position to use technology with the ability to select and use appropriate mathematics software available including internet usage. This not only helps develop mathematics teachers' professional development but also results in better class room teaching and learning process.

- **Knowledge Deepening**

Teachers who conduct ICT application in mathematics classes, deepen their knowledge related to all the three key components viz., content; pedagogy and technology

and develop the ability to solve complex real world problems. Such teacher can train their students in turn.

- **Knowledge Creation**

As the mathematics teachers become more experienced in the ICT application classes and acquire depth in knowledge, they develop ability to prepare ‘tailor-made resources’ (resources suitable for specific level of students). Thus teachers will be empowered to create a knowledge hub for them-selves, students and for the like-minded.

- **Impact in Classroom**

- Enable better management of classroom and students by deploying innovative teaching methodologies and more interesting material that create an interest in the students, thereby improving the productivity of the tutor as well as the taught,
- Enables the teacher to concentrate on other tasks such as research and consultancy,
- Enables optimum utilization and sharing of resources among institutions thereby, reducing the cost of implementing ICT solution.

**Check Your Progress - 2**

1. Google NCTM to find out what it views technology as.

**3.3.3.3. Strength and Weakness of ICT application in the teaching and learning of mathematics classes**

**Exercise III**

Let’s now try to analyze the strengths and challenges of ICT application in the teaching and learning of mathematics classes. List the space below the advantages and disadvantages of ICT.

<b>Advantages</b>	<b>Disadvantages</b>

Now that you have given a thought to how ICT can be beneficial and also to its advantages and disadvantages let us discuss some more of its strength and weaknesses.

**A. Strengths**

Some of the strengths of the ICTs (are applicable to all subjects, particularly so to the teaching of mathematics) are as follows:

1. Individualization of learning: This means that people learn as individuals and not as a homogenous group. ICTs allow each individual to relate to the medium and its content at his/her own time and own pace. Learner can access the content, go forward and backward in the content, start at any point depending upon prior knowledge instead of always in a sequential way.

2. Pedagogical gains: ICTs can help bringing interactivity, multiple representations, collaborative learning, independent thinking, bringing topic to real life context, and so on.
3. High speed delivery, wide-reach at low per unit cost: There is instant delivery of information. Further per person, ICTs reduce the cost of education from very high to very low.
4. Distance and climate insensitive: It does not matter where you are, or how the weather is, you can still access and learn from ICTs.
5. Can serve multiple teaching functions and diverse audiences: ICTs, especially the computer and Internet based can be useful in drill and practice; to help diagnose and solve problems, for accessing information and knowledge about various related themes.
6. Uniform quality: If content is well produced and is of good quality, the same quality can be delivered to the rich and the poor, the urban and the rural equally and at the same low cost.

### **B. Challenges**

1. Implementation of ICTs also poses challenges:
2. Demands High infrastructure and start-up costs for institution are heavy:
3. Problems of reach, access, remain: Not everyone has equal access; so not everyone benefits equally from the use of ICTs.
4. Tend to create new class of knowledge without distinguishing the quality of knowledge- rich/knowledge-poor:
5. Hard to assess impact: Learning from ICT delivered content is difficult to assess since it is of a multidimensional and long term kind.
6. Officers, trainers need reorientation and retraining for constant up gradation:

### **Check Your Progress - 3**

1. Mention any four strengths and challenges of using ICT in mathematics instruction

### **3.3.4. Let us Summarise**

This unit covers the following aspects

- Need to integrate ICT in Mathematics instruction
- Factors influencing the integration of ICT
- Benefits of integration of ICT
- Strength of challenges of ICT application in the teaching and learning of mathematics classes

### **3.3.5. Answer to ‘Check Your Progress - 1, 2 and 3’**

#### **Check Your Progress - 1**

Teachers’ attitudes towards ICT contribution to mathematics teaching: teachers towards ICT contribution to students’ mathematics learning.

#### **Check Your Progress - 2**

The National Council of Teachers of Mathematics (NCTM) points at technology as essential for the teaching and learning of mathematics because it affects the mathematics that the teacher teaches and the pupils learn, and it improves the pupils learning. The NCTM also declares that pupils, who use technology, learn mathematics in depth. It states, technology as

enabling, as well as encouraging the pupils to concentrate on reflection, verification, decisions making and problem solving. These are higher aims of mathematics education.

### **Check Your Progress - 3**

You can mention any 4 from the list given under strengths and challenges.

#### **3.3.6. Unit end exercises**

Divide your class into two groups and select a math topic and experiment teaching the same to both groups using different approaches suggested below and find out your exploration:

- Teach without using ICT
- Use ICT to intervene your teaching

#### **3.3.7. References**

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## **Block 3 : Planning in Teaching and Learning Mathematics**

### **Unit 4 : Preparation of Learning Materials in Mathematics instruction**

#### **Unit Structure**

- 3.4.1. Learning Objectives
- 3.4.2. Introduction
- 3.4.3. Learning Points and Learning Activities
  - 3.4.3.1. Types of Learning Materials  
Check Your Progress - 1
  - 3.4.3.2. Basic Consideration in the preparation/Improvisation of learning materials  
Check Your Progress - 2
- 3.4.4. Let us Summarise
- 3.4.5. Answer to 'Check Your Progress - 1 and 2'
- 3.4.6. Unit end Exercises
- 3.4.7. References

#### **3.4.1. Learning Objectives**

After completing this Unit, the student teachers will be able to

- Define learning materials;
- Mention various learning materials;
- Identify the need for preparation of learning materials;
- Identify the skills needed to prepare or improvise learning materials in math instruction;
- Identify the reasons behind the absence of the needed skills to prepare learning materials in most teachers;
- Mention the aspects to be considered while preparing/improvising a learning material
- Mention the qualities of improvised learning material; and
- Prepare leaning material using low cost materials.

#### **3.4.2. Introduction**

"Teaching materials" is a generic term used to describe the resources teachers use to deliver instruction. Teaching materials can support student learning and increase student success. Since teaching materials should result in students learning, their preparation should be done by keeping in mind the needs of students and their learning. Hence, they can be aptly called the learning materials. Instructional Materials, also known as Teaching/Learning Materials (TLM), are any collection of materials including animate and inanimate objects and human and non-human resources that a teacher may use in teaching and learning situations to help achieve desired learning objectives. Learning materials are important because they can significantly increase student achievement by supporting student learning. For example, a worksheet may provide a student with important opportunities to practice a new skill gained in class. Learning materials refer to resources available to, and used by, a teacher for facilitating learning among students. Such learning materials include charts, computers, and television, audio and visual materials. Learning materials also refer to resources obtained online, supplemental textbooks and activity books, and materials provided by colleagues or from other sources.

### 3.4.3. Learning Points and Learning Activities

#### 3.4.3.1. Types of Learning Materials

##### Exercise I

Write in the space below, in order to teach the topic ‘Pythagoras Theorem’ what Teaching - Learning Materials would you use in order to make your teaching effective?

There are many ways in which Pythagoras theorem could be taught effectively i.e. with the use of working models, technology etc. Learning materials play an important role in the effectiveness of teaching. Dear student now let us try to know the various learning materials that can be used by teachers. Such learning materials include charts, computers, and television, audio and visual materials.

When these materials are not available or inadequate, the teacher is expected to improvise. Use of Adequate and relevant learning materials in the math class makes it highly effective.

##### A. Types of Learning Materials

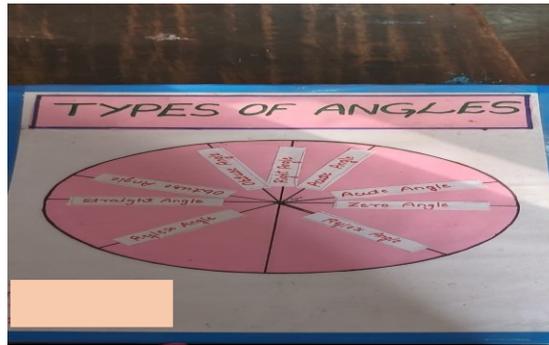
Some of the varieties of learning materials are as given below:

- **Audio materials:** It includes human voice, telephonic conversation, audio discs/tapes, gramophone records, Radio broadcast. Example: Teacher can record the voice of resource person or him-self can be the one who speaks on the daily life application aspect of graphs/ commercial math / trigonometry
- **Visual materials:** It includes Visual (Verbal) Print e.g. Textbook, Supplementary book.
- **Audio-visual materials:** This includes Preparation of a power point presentation, using, all available software including online resources.
- **Low-cost no-cost materials** are the learning aids which require no-cost or available cheaply, and developed by locally available resources and accelerate the process of learning in the classroom. Low cost no cost materials are developed from the waste and help the teachers in making their teaching interesting and concrete.

Let us discuss little more on this variety of learning materials. Actually, teachers get a number of learning materials to teach mathematics, in the market. But there are reasons why teachers need to prepare learning materials at times in the form of learning aids. This means teachers prepare the needed mathematical learning materials by themselves. Preparation can also be done by improvisation process too, which is a better idea.

**Improvisation / preparation** of learning materials for teaching mathematics is the ability of the mathematics teachers and students to create appropriate, adequate and relevant material resources by making use of the available materials. There are two types of such learning materials and they are:

- **Visual (Pictorial- Non Projected) :**Preparation of charts, activity charts, tables etc .below is given the picture of a chart on ‘Types of triangles’



- Models and working models:** These are useful to represent some mathematical concepts and how some math principle is applicable. For example: the teacher may have prepared a **graph board** where students can give various values to x & y axes to avail the corresponding graphs. In the coming pages you will know more about these two.

**B. Need for preparation or improvisation of learning materials**

Mathematics is a subject that has been considered as dry and drudgery subject. The performance of students in mathematics has persistently continued to be poor. Dear student observe the following citation and discuss with your friends and others to collect their view point in this regard. Also, what is your view point?

As usual my daughter scored above 75% in all subjects except in mathematics where it halts at only 30%! Oh God what to do?



Thus teaching-learning of mathematics should be taken more seriously to see that students do not fear math and fail, instead like it and are motivated to learn it. In this regard there is a need to use learning material to make the learning interesting and thus motivate them to learn.

Dear student, consider the statement **“straight line is nothing but the path of a moving point”**. The concept is not easy to teach the students! Imagine the fate of students to learn this just by the oral expression of the teacher! You agree that this concept is very

abstract. Yes! It is very abstract. Indeed mathematics is full of such abstractions. Why don't you list some more math concepts to ensure its abstract nature?

Your list may be not exhaustive! This implies that it will take a great deal for students to grasp such abstract concepts, when taught. It is therefore advocated that the teaching of such abstract mathematics concepts should be concretized. Concretization of mathematics concepts means teaching mathematics from concrete to abstract. Of course there are a number of market-available learning materials to teach such concepts. But there seems to be some problem with the market available learning materials. Some of them are listed below:

- They are very costly and not economically feasible for most schools.
- Math Teachers find it not much useful in spite of having such costly learning materials well within their reach! This is because most of such materials do not meet the specific needs of individual class. Thus, there is also a need for tailor-made learning materials. Therefore, it becomes imperative that the mathematics teacher makes an alternative move to locally produce learning materials to teach mathematics. This alternative move to produce learning materials using resources in the local environment is called improvisation.
- To substitute for the modern audio-visual materials in their non-availability. Audio and audio-visual and digital resources cannot be used by math teachers as all schools may not be having the facilities. Even if some school teachers are privileged to have advanced technology, it cannot provide hands on experience. At times there will be a need to prepare learning materials that suit the requirements of individual class of students in all respect.

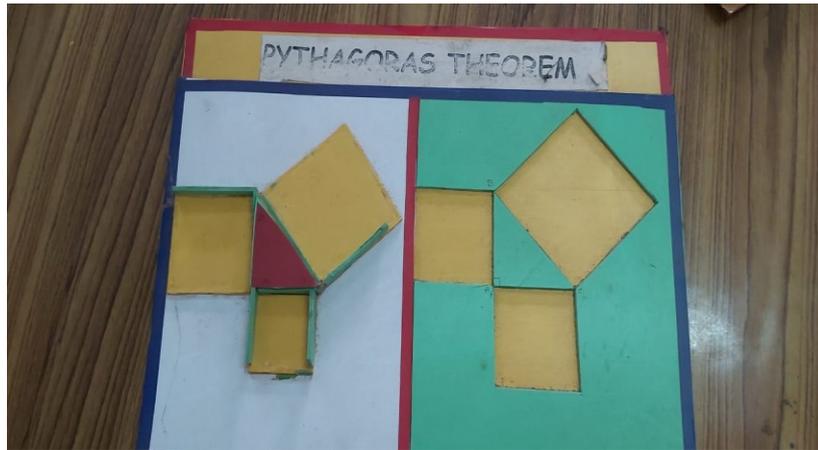
When the need is so, teachers have to develop the ability to prepare such learning materials. Dear student you can recollect that such an ability to collect available pieces of materials (low cost no cost) from our immediate vicinity and put them together in a new combination for a (different) purpose is nothing but improvisation.

Improvisation of learning materials for teaching mathematics is the ability of the mathematics teachers and students to produce tailor-made learning materials to suit and facilitate their students' learning

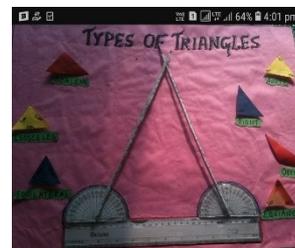
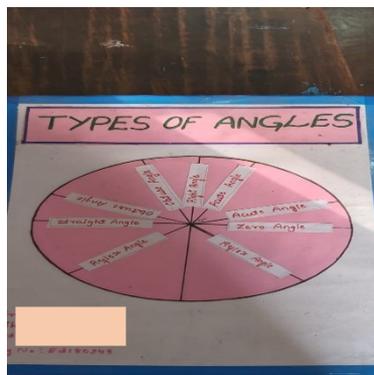
### **C. Skills needed to prepare or improvise learning materials**

There are prerequisite skills that mathematics teachers need for the effective improvisation of learning materials from the available materials.

Dear student below given is a learning material to teach a significant concept of mathematics. Observe carefully and identify the materials used and the skill required to produce this learning material. However the model given below does not indicate proficiency but surely goes a long way to help you identify the materials used and the needed skill as well. Remember the same material can be produced more efficiently by different teachers. This depends on the teachers' ingenuity and ability.



Some of the skills needed in production of learning materials are cutting, folding, painting, colouring, manipulating, sorting, dismantling, assembling and mounting of devices and measurement. These are mechanical skills. All these skills go in vain if the teachers lack professional commitment, competence, creativity, initiative, and resourcefulness. These differ among teachers even if all teachers are trained in mechanical skills in the same manner (even here the ability picked up differs). This implies that the level of improvisation skills possessed by teachers varies from one teacher to another. Observe the two learning materials on the same topic ‘Types of Angles’. Compare them and discuss about the quality of each one. Both teachers who prepared this to use in their class, are at different level. Also the leaning materials impact the students at different levels too!



The poorly improvised instructional materials will lead students to misconception. Thus, the professional commitment of math teachers guides and guards them against improvisation of substandard/poor leaning materials.

#### **D. Why most teachers do not possess the skill?**

You have witnessed that in spite of the awareness and necessity of improvised learning materials, teachers are not coming forward to prepare them. Let us now understand the various factors that hinder teachers from improvisation.

An informal survey carried out on finding the factors responsible for inability of teachers to improvise leaning materials for teaching mathematics and found out that most mathematics teachers do not possess the required skills needed for the improvisation of leaning materials. Some of the factors responsible for lack of improvisation skills among math teachers:

- Non specialization of teachers in mathematics education.
- Excessive teaching load, large class size and unavailability of tools.
- No improvisation incentives paid to teachers.
- No in-service training for acquisition of knowledge and skills required for improvisation.
- Lack of positive attitude: most math teachers seem to opine, teaching of math involves only the chalk-board as a tool. That’s more than sufficient.  
Ex: A teacher saying “The class is over! Let me rub the board. Fantastic! Today I used 10 chalk pieces to work out sums on the board for students...great feeling!”, will only indicate lack of positive attitude.
- Lack of exposure to the benefits of improvisation: Most teachers usually do not share their experiences in class rooms with fellow teachers. There is always a tendency of teachers to lessen the burden and accordingly they do not choose to take the ‘extra trouble’ of preparing learning materials. Had they known that painstaking of teachers in the preparation will surely be compensated in the sense by better grasping of math content by students and less strain on the part of teachers, they would surely have come forward.

### Check Your Progress - 1

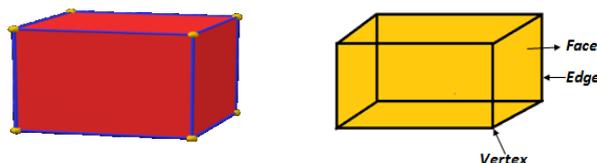
1. Define learning materials in mathematics instruction. Mention the various types of learning materials.
2. Mention any two needs for preparing learning material in math instruction
3. What are the skills needed to prepare/improvise the learning materials?
4. Why do most teachers lack the above needed skills? (any two)

### 3.4.3.2. Basic Consideration in the preparation / Improvisation of learning materials

#### Exercise II

Observe the two models below which represent a single idea of cuboid. Try to identify the difference between the two models

Figure 1 Figure 2



Yes! In the first one special care has been taken during preparation to highlight the basic components of a polyhedron (here cuboid) viz; faces (red paper); Edges (blue string) and Vertices (yellow bead). In the second model although the model is mathematically correct, it does not highlight the basic components which may fail to promote deeper understanding of the concept (particularly while verifying the Euler's formula in it!).

#### A. Basic Consideration in the preparation/Improvisation of learning materials

The following considerations are significant for preparation of any learning material:

- **Focus on the content to be taught**
- **Focus on the objectives to achieve using the learning material:** If your objective is to teach that not all closed figs with straight line segments become polygons, then focus on

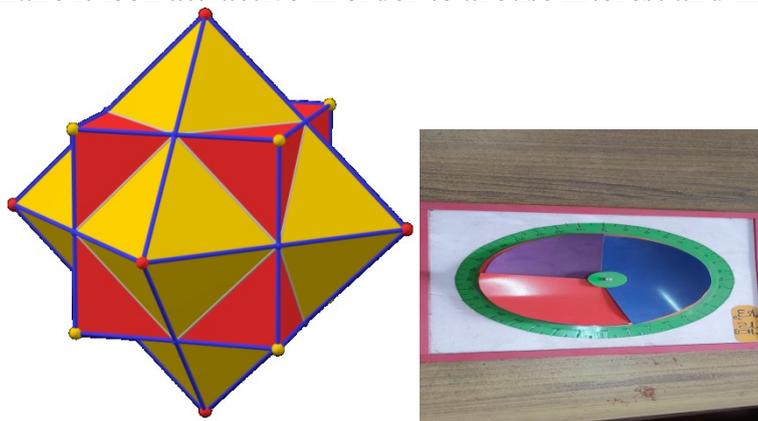
this objective motivates and directs the teacher to prepare a learning material either in the form of chart or a 3dimensional model specific to achieve this objective.

- **Preparation should be based on the awareness of the entry behavior of students (required previous knowledge) to interact with the learning material to be used.**

The following Situation gives a better understanding of this:

Venkatalakshmi, had kept this Sunday for preparing a learning material for her 9<sup>th</sup> graders on the definition of “**Sets**”. She thought for a while to decide on the materials that she can use. But it occurred to her that first she should decide what type of material students require? At this time her previous interaction with the class suggested that the students lack the ability to differentiate the meaning of two concepts related to the definition of ‘SETS’ viz.; ‘**well defined collection of objects**’; ‘**collection of well-defined objects**’. This gave her the insight to prepare two different charts for both the concept and later a chart with many illustrations wherein the students need to categorise them as belonging to any one of the above two concepts.

- **To make it look attractive in order to arouse interest and motivate students**



The above learning materials (to teach the concepts of polyhedron and pie chart), looks attractive as it catches the students with its vibrant colours! This becomes the basic requirement for the successful use of any learning material. However we should guard ourselves of depending only on these criteria. Although this is important one, alone cannot serve the purpose!.

- **Materials that can be used to enhance the durability of the learning material**
- For example, while preparing a model in mathematics decide whether the material should be either hard board material or thermo Cole? If thermo Cole is used then, a small bead from thermo Cole is cut the whole learning material becomes mathematically incorrect (in case of some math concepts)!
- **Use of low-cost no-cost materials available in the local environment is possible to prepare the material. one can also recycle or reuse the materials available.**
- **To cater to the needs of individual students:** Teacher prepares the learning material keeping the students and their level of maturity in mind whereas you will miss out this in the ones you purchase from the market place. Hence compared to the market available learning materials these cater to the needs of individual students.

Maximum efficiency of the prepared learning material can be availed only by the resourceful teachers who prepare with total involvement and put to use effectively. It should be borne in mind that these learning materials themselves do not possess go a long way in helping students better. The usefulness depends on what the teacher makes out of them i.e. the influence made on the students by the teacher with the materials.

Teachers should be skillful enough to use each one of them at the most appropriate point of time, as indiscriminate use of these materials may become counter-productive.

### B. Qualities of improvised learning materials

While preparing or improvising learning materials we should be aware of their qualities. They should possess the following qualities:

- **Appropriateness of learning materials to the age of the learners:** Any learning material is appropriate if it is suitable to the content, students, and environment. For example: consider the learning material for teaching the content 'OPERATIONS USING NUMBER LINE' below given:

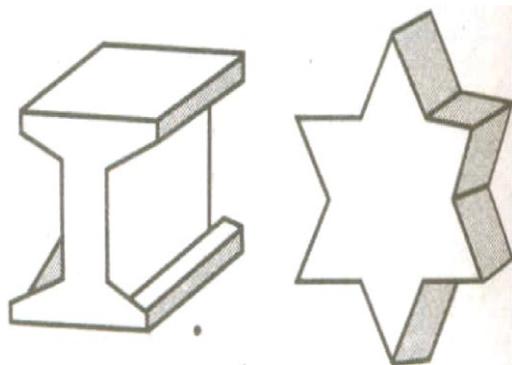


By observing the above learning material, you can make out that it suits the content very much and the learning environment, since the operations using number line is the content of the learning material. As the learning material is easy to handle and can be used to avail hands on experiences (because it is working model), it suits the environment and students as well.

- **Clarity in illustrations and simplification of concepts.** For example: consider the following learning material, it is very easy to prepare and this material furnishes a deeper understanding of the types of triangle beyond any reasonable doubt since it gives a comparative study of the concepts.



- **Adequacy in size and portable:** Look at the below pictures, both of which contain polyhedral in it. They are relevant, clear, and appropriate but they are not portable as they are prepared using thick wood!



If the teacher plans to prepare a learning material like the above one and chooses to use wood of reasonable thickness (thinking of durability) for its preparation then, it is at the cost of something else! yes! dear student, such heavy learning materials which are not handy are surely not portable! Teachers cannot even hold it in hands to show its various parts! such learning materials however good they may be in terms of content, appropriateness, relevance and clarity, does not serve the purpose of supplementing students' learning. Any learning material should be of reasonable size which facilitates i) the easy view of the content ii) easy transport to other classes of places where it is put to use.

- **Relevance to the lesson:** Any learning material is relevant if it is applicable to the topic/content focused to teach. For example observe the following learning material which the teacher of 7th class decides to use in order to teach 'Types of Angles'.



You can observe the learning material. Although the material can be used for the content 'types of angles', whether can be used to teach 'types of angles' is a question mark! yes observe keenly the above learning material, it appears more suitable for assessing students on the topic 'types of angles' using sticks provided, rather than teaching of 'types of angles'!

- **Interesting to the learners, durable and improvable:**

As discussed earlier, the learning materials should induce interest among students and help sustain it throughout. Hence teachers should give preference for making it interesting to the students.

Sometimes teachers forcibly prepare a material for the heck of using one in the class! This will in no way benefit the teaching learning process of mathematics. The content you teach should demand the use of some material in order to concretize and supplement students' learning. Such learning materials are worth preparing or improvising.

Preparation of learning materials demands involvement and labor on the part of the teacher. Therefore, care should be taken to use materials that are durable in nature, while preparing them.

- **Improved materials provide a cognitive bridge between abstraction and reality to students:** For example, provide a picture which helps the students to visualize a number line kept vertically besides a multistoried building (also with underground floors!). This can concretize and help align daily life illustration with the number line concept!

- **Improvisation saves cost** and in addition the teacher and the students make positive effort towards effective instruction. It is to the experts' experience that most of the tailor-made learning materials can be easily prepared using low cost materials available at immediate vicinity.

- Improvisation undertaken by teacher enables him to think and research for cheaper, better and faster methods of making the teaching and learning process easier for students

### **Check Your Progress - 2**

1. What are the basic Considerations in the preparation/Improvisation of learning materials?
2. What are the characteristics of an improvised learning material?

#### **3.4.4. Let us Summarise**

This unit covers the following aspects meaning types of learning material

- Improvisation of learning materials and its need
- Skill needed to prepare learning materials
- Basic considerations in the preparation of learning materials
- Qualities of prepared learning materials

#### **3.4.5. Answer to ‘Check Your Progress - 1 and 2’**

### **Check Your Progress - 1**

1. Learning materials refer to resources available to, and used by, a teacher for facilitating learning among students.

Such learning materials include charts, computers, and television, audio and visual materials.

- Audio materials:
- Visual materials:
- Audio-visual materials:
- Low-cost no-cost materials
- Improvisation / preparation
- Visual (Pictorial- Non Projected)
- Models and working models:

2. Math Teachers find it not much useful in spite of having such costly learning materials well within their reach! This is because most of such materials do not meet the specific needs of individual class. To substitute for the modern audio-visual materials in their non-availability (which are not cost effective even if they are available). Audio and audio-visual and digital resources cannot be used by math teachers as all schools may not be having the facilities.
3. Some of the skills needed in production of learning materials are cutting, folding, painting, colouring, manipulating, sorting, dismantling, assembling and mounting of devices and measurement. These are mechanical skills. All these skills go in vain if the teachers lack professional commitment, competence, creativity, initiative, and resourcefulness.
4. Some of the factors responsible for lack of improvisation skills among math teachers:
  - a) Non specialization of teachers in mathematics education.
  - b) Excessive teaching load, large class size and unavailability of tools.

### **Check Your Progress - 2**

1. Focus on the content to be taught; Focus on the objectives to achieve using the learning material:

1. Appropriateness of learning materials to the age of the learners:
  - Clarity in illustrations and simplification of concepts.
  - Adequacy in size and portable:
  - Relevance to the lesson:
  - Interesting to the learners, durable and improvable.

### **3.4.6. Unit end Exercises**

1. List and describe the different types of Learning Material.
2. Discuss the need for preparation or improvisation of learning materials
3. Explain the skills needed to prepare or improvise learning materials
4. What are the basic considerations in the preparation/Improvisation of learning materials?
5. Discuss the Qualities of improvised learning materials.

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## **Block 3 : Planning in Teaching and Learning Mathematics**

### **Unit 5 : Learning Resources in Mathematics**

#### **Unit Structure**

- 3.5.1. Learning Objectives
- 3.5.2. Introduction
- 3.5.3. Learning Points and Learning Activities
  - 3.5.3.1. How do learning resources help teachers?  
Check Your Progress - 1
  - 3.5.3.2. Digital resources  
Check Your Progress - 2
  - 3.5.3.3. Why is it important to find good resources and materials?  
Check Your Progress - 3
- 3.5.4. Let us Summarise
- 3.5.5. Answers to ‘Check Your Progress - 1, 2 and 3’
- 3.5.6. Unit end Exercises
- 3.5.7. References

#### **3.5.1. Learning Objectives**

After completing this Unit, the student teachers will be able to

- Define learning resources in mathematics;
- Identify the need of learning resources in math instruction; and
- Identify Advantages of learning resources for a math teacher.

#### **3.5.2. Introduction**

For many, the image that comes into mind the moment they hear the term ‘educational materials’, are of large, print, classroom textbooks with small type, outdated information, and content that covers the breadth but not depth of a subject etc. But learning resources are more than that. They are like any tools, which help both teachers and students to teach and to learn respectively. That means to say they are like the texts, videos, software, and other materials (used mostly by both teachers and students) that meet the expectations for learning prescribed by the curricula. They are things at our disposal to derive knowledge from. Dear student, if you are thinking what impact it can lay on the quality of instruction in schools, then here we go. In general, any school, which has inadequate resources and facilities such as textbooks, laboratories, chemicals, tools and equipment, teaching aids, stores, offices etc. is indicative of teacher-centered teaching approaches prevailing in it. Dear student can you guess the consequence of using ‘teacher-centered’ approach to teaching? Since the teacher is the sole source of knowledge in such cases, the students remain passive participants as they are expected to observe only the teacher and listen. This yields poor quality of learning. Such an approach is bad for math teaching and learning and soon kills the interest and breeds boredom among students in the subject. In this Unit let us discuss the how learning resources help in mathematics teaching.

### 3.5.3. Learning Points and Learning Activities

#### 3.5.3.1. How do learning resources help teachers?

##### Exercise I

Name some Learning Resources that you are aware of, or you came across as students which helped you in learning Mathematics.

As you answered the question, plenty of resources must have crossed your mind which must have helped you to learn the subject. Now let us discuss and see how it is useful in classroom teaching.

##### A. How do learning resources help teachers

As you are aware the subject mathematics is generally considered as dry and drudgery subject. Therefore, it is very important in mathematics classrooms to create a rich learning environment. Resource can come handy in creating such as environment. This helps in creating positive mind-set among students and goes a long way to open up the potential for growth in mathematics teaching and learning.

Using a range of teaching and learning resources and supplements, makes it easy for math teachers to connect the content, skills and concepts in mathematics and enhance students' understanding. The use of resources not only engages students in mathematics learning but also build students' confidence as mathematics learners and thinkers.

Let us try to understand more details regarding the need of learning resources in math learning.

##### B. Why need of learning resources?

You may be wondering as to, are teachers not resources? Teachers are an indispensable resource in teaching and learning but they can be rendered ineffective by any one or a combination of the following factors:

- Large classes that overburden and overload the teacher making things difficult to manage without any aid.
- Even though math teachers are well trained, some math concepts are so abstract in nature that the students find it difficult to grasp and need teachers to concretize these concepts for them. If the teachers are not ready to use learning resources to do the needful, it will be difficult to sustain interest.
- Lack of awareness of the availability of resources such as, visual aids, textbooks, chemicals or needed teaching material

Learning resources can go a long way to overcome the above discussed problem to a great extent. In the mathematics classrooms, teachers can use resources and expose students to opportunities that help them to:

- Develop ability to think mathematically and engage in it
- Solve math problems that demonstrate their understanding
- Apply math strategies and conceptual understanding in familiar and unfamiliar situations
- Recognize the relevance of their experiences in their environment through mathematical lens
- Use and connect what they are learning to contexts outside the mathematics classroom.

Learning resources are important because they support student learning and thus can significantly increase student achievement. For example, teachers can make use of readily available math worksheet and provide students with opportunities to practice a new skill gained in class. You realize from the above discussion that learning resources in math classes serve the purposes of learning experiences. Also math teachers who make abundant use of learning resources help students to,

- Engage with everything that is mathematics;
- Explore connections within math as well as in outer world
- Make connections between their mathematical knowledge, skills and understandings with other learning areas and the world around them.

Dear student may be you begin to appreciate the impact the math resources lay on the teaching-learning of mathematics. Let's try to discuss a few learning resources:

### C. Types of learning resources

Given below is the list of learning resources:

Textbooks (print and digital) Workbooks Worksheets Manipulative (blocks, beads, etc.) Flashcards Educator workshops Non-fiction books Posters Educational games	Apps Websites Software Online courses Activity books Graphic novels Reference books DVDs CDs Magazines & periodicals	Study guides Teacher guides Labs Models Movies Televisions shows Webcasts Podcasts Maps & atlases
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Courtesy: What Are Learning Resources? By AAP (Association of American Publishers) PreK-12 Learning Group

### Check Your Progress - 1

1. What are learning resources in mathematics?
2. Which approaches are emphasized if a math teacher uses math resources for teaching?
3. How does the use of learning resources help a math teacher?
4. Explain briefly the need of learning resources for math instruction.
5. What are the opportunities (any two) that the students can be exposed to by using learning resources?
6. How can you select the most relevant learning resource among a lot of them?

### 3.5.3.2. Digital resources

#### Exercise II

Name some digital resources that you are already aware of.

Although there are many resources available, the electronic resources usually referred to as e-resources are the talk of the day. Yes, dear student, teachers in 21<sup>st</sup> century cannot survive if they are computer & internet illiterate. Digital resources thus, gain the momentum. Digital resources encompass mostly all other resources in it.

#### Digital resources

Below given are a list of digital resources that both math teachers and students can make use of. Dear student it is suggested that you visit those resources on line and explore them.

- 1. Animation:** The animations, visually and dynamically presents concepts, models, processes, and/or phenomena in space or time. This can demonstrate processes which are difficult to describe or show through the print media (two dimensions). Many math concepts can be taught successfully using animation. For example, the definition of circle can be easily made to understand by using animation to show the formation of a circle from a set of points that are equidistant from a fixed point.
- 2. Assessment Tool:** Teacher/students can avail various formats of assessment. A student can use it for his/her self-assessment using 'assessment templates' available. New technologies for assessment are available too. Dear student you can collect some on-line tools and templates for your self-assessment to know your math competency.
- 3. Assignment:** there are various web sites with web pages wherein you find on-line assignments in the form of activities/follow up activities in any math topic are designed to enable students to learn skills and knowledge.
- 4. Case Study:** A narrative resource describing a complex interaction of real life factors are available. For example, the success of a specific learning strategy incorporated by students of a particular school etc. can be availed. Case studies will provide such illustrations and help learner to receive the concepts and factors in depth. Teachers also can know if any innovative technique for teaching has worked well anywhere else?
- 5. Collection:** A meaningful organization of learning resources such as web sites, documents, apps, etc. that provides users an easier way to discover the needed materials. Students can get all the supplementary support from this.
- 6. Development Tool:** Software development application platforms for authoring technology-based resources (e.g. web sites, learning objects, apps.). If some teachers are enthusiastic and capable of, then such teachers may join hands with other experts to develop some app/website that are useful to students.
- 7. Drill and Practice:** this is very significant aspect in the learning of mathematics. In regular classrooms it is difficult to keep aside sufficient time for this purpose. So interested students can use this resource and enhance their deeper understanding of the content. It requires users to respond repeatedly to questions or stimuli presented

in a variety of sequences. Users practice on their own, at their own pace. It is planned in such a way that exercises are far from the monotonous drilling.

- 8. E-Portfolio:** A collection of electronic materials assembled and managed by a user. These may include text, electronic files, images, multimedia, blog entries, and links etc. which constitute an e-portfolio. E-portfolios are both demonstrations of the user's abilities and platforms for self-expression, and, if they are online, they can be maintained dynamically over time.
- 9. Hybrid/Blended Course:** it is one where online course and in-person course are mixed into one. The organization and presentation of course curriculum required to deliver a complete course that blends online and face-to-face teaching and learning activities. Dear student you can access this through Google if you desire so.
- 10. Illustration/Graphic:** it is a process where the math concepts, models and processes are presented in visual form using diagrams, illustrations, graphics or info graphics in any file format including Photoshop, Illustrator and other similar file type etc. Students can easily avail and use them for a better learning.
- 11. Learning Object Repository:** A **searchable database** of at least 100 online math resources that is available on the Internet. Dear student beware! Guard yourself from what is; just a webpage with a list of links! This surely cannot become a learning object repository!
- 12. Online Course:** students who wish to enrich them in some area can do an extra math course that is online. The organization and presentation of course curriculum required to deliver a complete course fully online.
- 13. Online Course Module:** If a student wishes to only refer to the module without aspiring to take up the course, there are resources which present the module online that is independent of the complete course.
- 14. Open Journal - Article:** A math journal or a math article in a journal that is free of cost from the end user and has a Creative Commons, public domain, or other acceptable use license agreement.
- 15. Open Textbook:** An online textbook in mathematics offered by its author(s) with Creative Commons, public domain, or other acceptable license agreement allowing use of the eBook at no additional cost. The objective of this is to benefit the students who cannot afford purchase online or offline.
- 16. Photographic Image:** Instructional: Photos or images of real people (for example, mathematicians), places or things (for example photo of a cube is an example of the concept of polyhedron) that visually present concepts, processes and/or phenomena that enable students to learn skills or knowledge. These can be photographs, images, or stock photography (Stock photography is the supply of photographs, which are often licensed for specific uses. The stock photo industry, which began to gain hold in the 1920s, has established models including traditional macro stock photography, mid stock photography, and micro stock photography.)

**17. Quiz/Test:** Any assessment device intended to evaluate the knowledge and/or skills of learners. Some of the links for online quiz test for standard X is given below:

Links for online quiz test for standard X

1. [https://www.google.com/search?rlz=1C1CHBD\\_enIN804IN804&q=mock+test+papers+for+class+10+cbse+science&sa=X&ved=2ahUK EwjZkd3v2qXnAhUJT30KHbLBAJEQ1QIoB3oECAwQCA](https://www.google.com/search?rlz=1C1CHBD_enIN804IN804&q=mock+test+papers+for+class+10+cbse+science&sa=X&ved=2ahUK EwjZkd3v2qXnAhUJT30KHbLBAJEQ1QIoB3oECAwQCA)
2. <https://studyrankerstest.com/class-10-science-mcq/>
3. <https://www.jagranjosh.com/articles-cbse-class-10-online-test-1385545457-1>
4. [https://www.proprofs.com/quiz-school/story.php?title=science-grade-10\\_1](https://www.proprofs.com/quiz-school/story.php?title=science-grade-10_1)

**18. Reference Material:** Material with no specific instructional objectives and similar to that found in the reference area of a library. Subject specific directories to other sites, texts, or general information are examples.

**19. Simulation:** Simulation is a way to model random events, such that simulated outcomes closely match real-world outcomes. By observing simulated outcomes, researchers gain insight on the real world.

**20. Social Networking Tool:** Websites and apps that allow users to communicate with others connected in a network of self-identified user groups for the purpose of sharing information, calls for actions, and reactions.

**21. Tutorial:** Users navigate through a set of scaffolded learning activities designed to meet stated learning objectives, structured to impart specific concepts or skills, and organized sequentially to integrate conceptual presentation, demonstration, practice and testing. Feedback on learner performance is an essential component of a tutorial. Online tutoring is the process of tutoring in an online, virtual environment or networked environment in which teachers and learners are separated by time and space.

**22. Instructional Video:** A recording of moving visual images that show real people, places and things that enable students to learn skills or knowledge. Learning from the practices of others is a powerful way to improve teaching. Explore real mathematics teaching and learning by exploring everyday classrooms where educators are working to refine their mathematics teaching practices.

### Check Your Progress - 2

- What are digital resources? List any five digital resources
- Which digital resource can be used by teachers to know if any innovative technique for teaching has worked anywhere else?

### 3.5.3.3. Why is it important to find good resources and materials?

#### Exercise III

List the resources that you can refer to in order to teach the topic “Solids”? Also explain how each resource is useful in making the teaching of the topic effective.

Any novice teacher knows that access to resources can make a world of difference in both lesson planning and its execution. In addition, the use of diverse resources in teaching can help to create platform for thinking within a lesson, thus facilitating math learning. But the problem is, are there good resources? If so where does one find them?

Dear Student, through our earlier discussion you must be convinced about the importance of using resources in math education. But many beginning teachers struggle to find resources that are both appropriate and meaningful. However, finding ‘good’ resources can be a challenge, especially if one is unaware of where to look for. Now let's consider both these aspects one by one.

#### a) What constitutes a ‘good resource’?

- **Updated-** the resource selected should be current and updated.
- **Appropriateness-** this indicates that the resources are helpful in the sense that they will not distract the students from learning the content focused and thus help achieve the objectives.
- **Relevance-** this indicates the learning resources relate,
  - ✓ to the topic on hand i.e. it should communicate the content area focused,
  - ✓ to the interest of students
  - ✓ to the previous knowledge of the students to link relevantly to the topic on hand.
- **Quality-** this indicates that, the value of the lesson is found in the resource. It also indicates that the presentation in the resource (in whatever form it may be) is so effective that the students hardly get distracted from the focused information.

#### b) Where can one find resources?

- Any good library in the area can serve the purpose as well. Sometimes the school library will be enriched by the authorities to facilitate quality education. If not university libraries can certainly do the needful. Earlier you would find only printed books & newspapers in libraries but presently you can also find the CDs, videos etc..
- This being the era of internet, serves as an excellent tool for searching resources. Everything from videos, flyers, newspapers, blogs and ideas for activities can be found on the internet.
- Government bodies such as NCERT & DSERT offer resources either online or through printed books/magazines/new letters/journals etc. these have found to be of great demand by mathematics teachers. These resources are often created or chosen to serve as a platform for the teachers to avail them when required and equip themselves and in turn equip students.
- Math associations in the immediate vicinity can serve very well as learning resources for students.
- Teachers who are resourceful use real life situations as resources and convert everything and anything available around, as resources showing their ingenuity. For example:

- ✓ Students can be motivated to visit a temple and find out what math is involved in the entire temple!
- ✓ Similarly encourage the students to make an effort to understand the structure of an Ironing box which has been structured to do what it should.
- People and fellow teachers around may have better source of learning resources. Share the resources with each other.

### c) Advantages of using learning resources in math education

1. Resources help develop a 'growth mindset' among students. With the help of math resources teachers can overcome the socially acceptable thought "I was never good at math".
2. Resources help a teacher to 'back-map' their teaching. This helps to fill the needed gap in learning among students and make them ready for the next.
3. Many math concepts are abstract and all students are not equipped with the ability to grasp easily. Math resources come as a handy in this regard.
4. Resources can be used as a tool for formative evaluation. At the same teachers can also benefit from the feedback of the test and realize that testing is not something separate from your instruction.
5. Resources can initiate and encourage math talk. Effective teachers believe that true learning happens a lot around talking and doing math and not just drilling. Resources can trigger both math talk and math work.
6. Meaningful math education goes beyond memorizing formulae and procedures. Resources help teachers, to set high goals, create space for exploration and encourages teachers to work with students to develop a strong foundation for example: teachers should treat students like mathematicians and encourage them to explore, inquire. Whenever possible start the class with a broad topic, using resources probe students and elicit formula or idea from students rather than you yourself giving the formula. Resources help develop a stronger conceptual understanding and mental connections with the material for the student. Teacher can put the topic as "How are F, E and V of a polyhedron related?" For this elicit in each case of the exhibits used, the F, E and V and tabulate the same with keen observation. you will be surprised that the students can explore the relationship by themselves!
7. They have positive impact on the learner motivation
8. they provide authentic information and provide exposure to real setting.
9. They relate more closely to learners' needs.
10. They support more creative approach to teaching.

### Check Your Progress - 3

1. What are the qualities of a 'good resource'?
2. Mention any two importance of using learning resources in the classroom

### 3.5.4. Let us Summarise

This unit covers the following aspects

- Need and importance of learning resources in mathematics.
- Benefits of using learning resources in mathematics education.
- Meaning and sources of 'good resources' of mathematics.
- Types of learning resources (both digital and non-digital).

### 3.5.5. Answers to ‘Check Your Progress - 1, 2 and 3’

#### Check Your Progress - 1

1. They are like any tools, which help both teachers and students to teach and to learn respectively.
2. Learner centered approach
3. Resource can come handy in creating such an environment. This helps in creating a positive mind-set among students and goes a long way to open up the potential for growth in mathematics teaching and learning.

Using a range of teaching and learning resources and supplements, makes it easy for math teachers to connect the content, skills and concepts in mathematics and enhance students’ understanding. The use of resources not only engages students in mathematics learning but also builds students’ confidence as mathematics learners and thinkers. Let us try to understand more details regarding the need of learning resources in math learning.

4. Teachers are an indispensable resource in teaching and learning but they can be rendered ineffective by any one or a combination of the following factors:
  - large classes that overburden and overload the teacher making things difficult to manage without any aid.
  - Even though math teachers are well trained, some math concepts are so abstract in nature that the students find it difficult to grasp and need teachers to concretize these concepts for them. If the teachers are not ready to use learning resources to do the needful, it will be difficult to sustain interest.
  - lack of awareness of the availability of resources such as, visual aids, textbooks, chemicals or needed teaching material.
5. develop ability to think mathematically and engage in it
  - Solve math problems that demonstrate their understanding.
  - Apply math strategies and conceptual understanding in familiar and unfamiliar situations.
  - Recognize the relevance of their experiences in their environment through mathematical lens.
  - Use and connect what they are learning to contexts outside the mathematics classroom.
6. The relevance of the resources depends on what you intend to make students learn. For example,
  - Manipulative such as blocks and beads etc may not be of much use to you when you are teaching ‘commercial mathematics’.
  - A thesis on a theme under ‘Modern Algebra’ may not be of much use to a teacher educator teaching Pedagogical math.

#### Check Your Progress - 2

1. The electronic resources usually referred to as e-resources are the talk of the day. Yes dear student, teachers in 21<sup>st</sup> century cannot survive if they are computer & internet illiterate. Digital resources thus, gain the momentum. Digital resources encompass mostly all other resources in it.
  - Animation:
  - Assessment Tool:
  - Assignment:
  - Drill and Practice:

- E-Portfolio:
- Learning Object Repository:
- Open Textbook:

**2. Case Study:** A narrative resource describing a complex interaction of real life factors are available. For example, the success of a specific learning strategy incorporated by students of a particular school etc. can be availed. Case studies will provide such illustrations and help learner to receive the concepts and factors in depth. Teachers also can know if any innovative technique for teaching has worked well anywhere else?

### Check Your Progress - 3

**Updated-** the resource selected should be current and updated.

**Appropriateness-** this indicates that the resources are helpful in the sense that they will not distract the students from learning the content focused and thus help achieve the objectives.

**Relevance-** this indicates the learning resources relate,

- to the topic on hand i.e. it should communicate the content area focused,
- to the interest of students
- to the previous knowledge of the students to link relevantly to the topic on hand.

**Quality-** this indicates that, the value of the lesson is found in the resource. It also indicates that the presentation in the resource (in whatever form it may be)is so effective that the students hardly get distracted from the focused information.

Advantages of using learning resources in math education

- Resources help develop a 'growth mindset' among students. With the help of math resources teachers can overcome the socially acceptable thought "I was never good at math".
- Resources help a teacher to 'back-map' their teaching. This helps to fill the needed gap in learning among students and make them ready for the next.
- Many math concepts are abstract and all students are not equipped with the ability to grasp easily. Math resources come as a handy in this regard.
- Resources can be used as a tool for formative evaluation. At the same teachers can also benefit from the feedback of the test and realize that testing is not something separate from your instruction.

### 3.5.6. Unit end Exercises

1. What are learning resources in mathematics?
2. Which approaches are emphasized if a math teacher uses math resources for teaching?
3. How does the use of learning resources help a math teacher?
4. Explain briefly the need of learning resources for math instruction.
5. What are the opportunities (any two) that the students can be exposed to by using learning resources?
6. How can you select the most relevant learning resource among a lot of them?
7. What are digital resources? List any five digital resources
8. Which digital resource can be used by teachers to know if any innovative technique for teaching has worked anywhere else?
9. Mention any four advantages of using learning resources in math education
10. Mention any six digital resources related to teaching of mathematics
11. Mention any three sources where one can find 'good resources'

12. What are the qualities of a 'good resource'?
13. Mention any two importance of using learning resources in the classroom

### **3.5.7. References**

1. Maths Mastery Resources (<https://www.learningresources.co.uk/>)
2. Learning resources-TESS-India (Teacher Education through School-based Support)
3. Resources and materials: Best of Bilash: Improving Second Language Education
4. The Rational Number Project-University of Minnesota, The College of Education and Human Development (The Rational Number Project is an ongoing research project investigating student learning and teacher enhancement.)
5. Selected web resources for math instruction-UNIVERSITY OF MICHIGEN LIBRARY RESEARCH GUIDES
6. What Are Learning Resources? By Association of American Publishers (AAP)
7. 63 Awesome Websites for Teaching and Learning Math- post by We Are Teachers Staff <https://www.weareteachers.com/>

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8. Learning and Teaching Resources for Secondary Mathematics Prepared by Mathematics Education Section, EDUCATION BUREAU (EDB), the Government of the Hong Kong Special Administrative Region
9. Position paper, national focus group on teaching of mathematics, NCERT

## **Block 3 : Planning in Teaching and Learning Mathematics**

### **Unit 6 : Journals on Mathematics Instruction**

#### **Unit Structure**

- 3.6.1. Learning Objectives
- 3.6.2. Introduction
- 3.6.3. Learning Points and Learning Activities
  - 3.6.3.1. Details of a few Journals on Mathematics instruction
    - Check Your Progress - 1
  - 3.6.3.2. Advantages and Limitations of Journals in Mathematics
    - Check Your Progress - 2
- 3.6.4. Let us Summarise
- 3.6.5. Answer to ‘Check Your Progress - 1 and 2’
- 3.6.6. Unit end Exercises
- 3.6.7. References

#### **3.6.1. Learning Objectives**

After completing this Unit, the student teachers will be able to

- Define academic journals;
- define math journal;
- mention various journal related to;
  - math content
  - math pedagogy
  - research in math instruction
- identify the significant features of a few journals in math instruction;
- mention the online journal in math education;
- identify the advantages of journals in math education to stake holders; and
- recognize the limitations of journals.

#### **3.6.2. Introduction**

Among the many resources of learning Journals holds an important place in disseminating knowledge of higher order. Since Journals mostly consist of research studies and articles, they throw light to new dimensions of the subject. Journals can stimulate the interest of students to pursue higher studies in the subject as it consists of information of higher order. In this Unit let us understand the different Journals that are published in mathematics along with their features and also discuss its advantages and disadvantages.

#### **3.6.3. Learning Points and Learning Activities**

##### **3.6.3.1. Details of a few Journals on Mathematics instruction**

#### **Exercise I**

Name any Journal related to mathematics that you have read so far. What did it consist of? How did it help you in your mathematics learning?

Some of you might have gone through some mathematics journals while some of you may not have. Hence let us now acquaint ourselves with idea of mathematics journals and go through the pattern of a few of them.

### **A. Concept of Mathematics Journal**

Many publications issued at stated intervals such as academic issues (including scientific ones), or the record of the transactions of a society, are often called **Journal**.

#### **Academic Journals**

Journals are not too frequent. They are specifically related to one or the other subject or discipline. They include research articles mainly. Critical analysis on issues, phenomena also find a place in journal.

#### **Mathematics Journal**

Like any other Academic journals are periodicals, meaning they are published periodically example monthly or bi-monthly and contain a series of articles in each published issue. A journal of mathematics is a peer-reviewed, that publishes original research articles as well as review articles on all aspects of pure and applied mathematics.

A journal of mathematics if used properly, can impact on the teaching learning of mathematics. Therefore it becomes important to develop awareness regarding the different journal of mathematics available to both teachers and students. Math instruction in the absolute sense circumscribe the following components:

- math content,
- pedagogy in math and
- research in math pedagogy.

Hence journals in mathematics instruction should invariably include the journals in all the above-mentioned components. An effort is made here to furnish you with the required number of details regarding a few journal of mathematics. The links and other details provided here may be of some help to you. Read the details of the journal and decide what benefits you can get from it.

### **B. Different Mathematics Journals**

The journals discussed here furnish you with the following information:

- Name
- Publication
- Status (national/international)
- Access to authoring
- Significant features

#### **a) Teaching Mathematics and its Applications**

An international journal published by IMA

The significant features of the journal are:

- Provides a forum for the exchange of ideas and experiences that contributes to the enhancement of the quality of teaching and learning of mathematics at school level.
- Lays emphasis on the applications of mathematics and mathematical modeling within the context of world-wide mathematics education.

- The users of this journal being mathematics teachers, students, researchers and those concerned with curriculum development and assessment has created a niche of like-minded people with math background.
- Contributions to the journal are invited in two forms. Section A consists of research articles, based on empirical investigation and/or theoretical argument. The outcomes and conclusions of such articles go a long way to inform the improvement of mathematics teaching and learning at the relevant level.
- Section B consists of articles based on scholarly argument, informed by knowledge of research, such as innovative approaches to teaching-learning process

Most read articles in the journal:

- Monomials and polynomials: the long march towards a definition
- Improved engagement and learning in flipped-classroom calculus
- Mathematics teachers' and students' perceptions of transmissions teaching and its association with students' dispositions
- Why is it difficult to understand statistical inference? Reflections on the opposing directions of construction and application of inference framework
- oral assessment in mathematics and its implementation outcomes:

**b) International Journal for Mathematics Teaching and Learning - With Plymouth University**

The following are the salient features of the journal:

- Published only in electronic form. Publishes three - four issues per year.

**Bibliographic information**

ISSN: 2314-4629 (Print)

ISSN: 2314-4785 (Online)

DOI: 10.1155/1469

- focuses on mathematics teaching and learning for all ages up to university through relevant articles and reviews from around the world
- provides a medium for stimulating and challenging math ideas
- Offers innovation and practice in all aspects of mathematics teaching and learning
- Welcomes such contributions that,
  1. report
    - ✓ classroom research in mathematics that are relevant, quantitative and qualitative
    - ✓ international comparative research in math teaching
  2. report practices in teacher education as well as initiatives in the field of mathematics and also evaluate them.
  3. report successes stories in mathematics education
- provides immediate open access to its content with a view to facilitate free availability of research to public there by supporting a greater global exchange of knowledge.

**c) Journal of Mathematics Teacher Education: ISSN: 1386-4416 (Print) 1573-1820 (Online)**

The journal claims to be, devoted to research articles that seek to improve the education of mathematics teachers and develop teaching methods that better enable mathematics students to learn. The following are the salient features of the journal:

- The journal also publishes critiques of relevant reports and books helping the reader to get various perspectives of the article published.

- Covers all stages of the professional development of mathematics teachers and teacher-educators.
- Research papers reflect the main topics of the journal and go beyond local or national interest.
- *Journal of Mathematics* is a broad scope journal that publishes original research and review articles on all aspects of both pure and applied mathematics.

**d) Mathematics Teaching (MT)** published by Association of teacher of mathematics. In this journal the idea is not to conform to an ‘official’ view - whatever that may be - on the way mathematics should be taught. It gains significance for the reason that; instead the MT Editorial Board wants journal contributors to express their personal views, on the teaching and learning of mathematics.

The following are the salient features of the journal:

All the members of the association have a contribution to make, and experiences and insights to share.

Journal looks for articles reflecting on the practice of teaching mathematics.

Publishes articles of interest to its broad membership - from Foundation Stage, to Higher and Further Education - as well as research articles and articles from practical experience

Articles submitted are accepted for publication based on clarity, topicality, the extent to which they reflect on the knowledge and understanding of mathematics teaching and learning, and their contribution to inspiring further development and research.

**e) For the Learning of Mathematics** - an international journal of mathematics education.

The following are the salient features of the journal:

- The journal is published three times a year, in February, June and November.
- It is intended for the mathematics educator who is aware that the learning and teaching of mathematics are complex enterprises about which much remains to be revealed and understood.
- The journal aims to stimulate reflection on mathematics education at all levels.
- It promotes study of its practices and its theories such as:
  - ✓ to generate productive discussion;
  - ✓ to encourage enquiry and research;
  - ✓ to promote criticism and evaluation of ideas and procedures current in the field.

**f) The National Council of Teachers of Mathematics**

It is a public voice of mathematics education supporting teachers to ensure equitable mathematics learning of the highest quality for all students through vision, leadership, professional development and research in United States of America. It publishes different journals for members. They are listed below:

Six Journals in JSTOR	Date Range
• Journal for Research in Mathematics Education	• 1970 - 2020
• Journal for Research in Mathematics Education. Monograph	• 1985 - 2008
• The Mathematics Teacher	• 1908 - 2019
• Mathematics Teacher Educator	• 2012 - 2019
• Mathematics Teaching in the Middle School	• 1994 - 2019
• Teaching Children Mathematics	• 1994 - 2019
• The Arithmetic Teacher	• 1954 - 1994

You can find more details related each one of them, if you visit the website. However briefly two of those journals have been explained below for getting started!:

**g) Teaching Children Mathematics (TCM):** is an official journal and is intended as a resource for elementary school students, teachers, and teacher educators. The focus of the journal is on intuitive, exploratory investigations that use informal reasoning to help students develop a strong conceptual basis that leads to greater mathematical abstraction. TCM is published nine times a year, monthly August through May, with a combined December/January issue.

**h) Mathematics Teaching in the Middle School (MTMS):** an official peer-reviewed journal of the National Council of Teachers of Mathematics and is intended as a resource for middle school students, teachers, and teacher educators. The focus of the journal is on intuitive, exploratory investigations that use informal reasoning to help students develop a strong conceptual basis that leads to greater mathematical abstraction. MTMS is published nine times a year, monthly August through May.

**i) International Journal of Mathematics and its Applications (IJMAA)**

It is an international single peer-reviewed online academic research journal in all the streams of Mathematics and Its Applications. The salient features are as follows:

- The journal envisions is to create forum for review, reflection and discussion informed by the results of recent and ongoing research in every fields of Mathematics.
- IJMAA encourages new ideas and works in Mathematics and Its Applications
- It publishes high quality original papers, theory-based empirical papers, review papers, case reports.
- It aims to publish original work of importance in any field of pure and applied mathematics and its applications in other fields.
- It covers all areas of mathematics and its applications
- It provides immediate, worldwide, barrier-free access to the full text of research articles without requiring a subscription to the articles published in it.
- The publication costs are covered by the Author/Author's institution or Research funds.

**j) The Mathematics Student (Math Student; ISSN 0025-5742)**

- The Mathematics Student is being published since 1933. It is a quarterly periodical and the four numbers of it constitute a single volume. It is published in two parts: numbers 1 and 2 (January to June) as one part and numbers 3 and 4 (July to December) as the second part.

- very interesting feature of this journal is that Sri. S. S. Pillai, a brilliant Indian mathematician, who almost solved the famous "Warring Problem", published 8 papers in the Mathematics Student.
- In keeping with the current periodical policy, THE MATHEMATICS STUDENT will seek to publish material of interest not just to mathematicians with specialized interest but to the postgraduate students and teachers of mathematics in India. With this in view, it will ordinarily publish material of the following type:
  1. research papers,
  2. The texts (written in a way accessible to students) of the Presidential Addresses, the Plenary talks and the Award Lectures delivered at the Annual Conferences.
  3. general survey articles, popular articles, expository papers, Book-Reviews.
  4. problems and solutions of the problems,
  5. new, clever proofs of theorems that graduate/undergraduate students might see in their course work, and
  6. articles that arouse curiosity and interest for learning mathematics among readers and motivate them for doing mathematics.

### **Check Your Progress - 1**

1. What is academic journal?
2. Define math journals.
3. Highlight the details of any two journal of mathematics education.

### **3.6.3.2. Advantages and Limitations of Journals in Mathematics**

#### **Exercise II**

After having gone through the different journals of mathematics, list how these journals are useful for mathematics teaching and learning and also discuss its limitations.

I am sure you have identified several uses of Journals for mathematics teaching and learning. Let us now discuss them.

#### **Advantages of Journals**

- Provides a forum for the exchange of ideas and experiences contributing enhancing the quality of teaching and learning of mathematics at various levels.
- Lays emphasis on the applications of mathematics and mathematical modeling.
- Research outcomes and conclusions of journal articles go a long way to inform the improvement of mathematics teaching and learning at the relevant level.
- In journal, one finds weighted articles backed by knowledge of research.
- Math journal through relevant articles focus on mathematics teaching and learning for all ages up to university.
- Publishes articles to provide ample innovative ideas that are both stimulating and challenging.
- Motivates teachers to involve in class room research by publishing relevant research articles.
- Reports success stories in mathematics education to ignite the minds of both teachers and students.
- supports a greater global exchange of knowledge by facilitating free availability of research and its outcomes to public.

- Provide Critiques of relevant reports help develop various perspectives in the user, of the article published.
- Provides platform for those interested, to make contribution, experience and insights to share.
- Sort out experiences, solve problems and consider varying perspectives.
- Examine relationships with others and the world.
- Reflect on personal values, goals, and ideals.
- It reduces the possibility of error.

### **Limitations of Journal**

When the number of transactions is large, it is not possible to record all the transactions in journal. It will become bulky and voluminous. Also there may be one relevant article for the teacher to use and the rest may be of not any use! it may leave a doubt regarding its worthiness.

### **Check Your Progress - 2**

1. Mention any 5 advantages of math journals.
2. What are the limitations of using a journal.

### **3.6.4. Let us Summarise**

This unit covers the following aspects

- An idea of math journal
- Details of a few journals on math education
- Advantages and limitations of journal in math education

### **3.6.5. Answer to ‘Check Your Progress - 1 and 2’**

#### **Check Your Progress -1**

1. Academic Journals are specifically related to one or the other subject or discipline but they are not too frequent. They are. They include research articles mainly. Critical analysis on issues, phenomena also find a place in journal.
2. A journal of mathematics is a peer-reviewed, that publishes original research articles as well as review articles on all aspects of pure and applied mathematics.
3. You can select any two from this unit.

#### **Check Your Progress - 2**

1. Provides a forum for the exchange of ideas and experiences contributing enhancing the quality of teaching and learning of mathematics at various levels.
  - Research outcomes and conclusions of journal articles go a long way to inform the improvement of mathematics teaching and learning at the relevant level.
  - Math journal through relevant articles focus on mathematics teaching and learning for all ages up to university.
  - Motivates teachers to involve in class room research by publishing relevant research articles.
  - supports a greater global exchange of knowledge by facilitating free availability of research and its outcomes to public.
  - Provide Critiques of relevant reports help develop various perspectives in the user, of the article published.

2. When the number of transactions is large, it is not possible to record all the transactions in journal. It will become bulky and voluminous. Also there may be one relevant article for the teacher to use and the rest may be of not any use! it may leave a doubt regarding its worthiness.

### **3.6.6. Unit end Exercises**

1. Imagine you are asked contribute an article to a reputed journal, list out the topics that you would like to contribute your article on.
2. Prepare an article on a topic of your choice for publishing in a journal selecting any one explained in the unit accepting its norms.

### **3.6.7. References**

1. The Mathematics Student (Math Student ; ISSN 0025-5742 )
2. Journal of Mathematics Teacher Education ISSN: 1386-4416 (Print) 1573-1820 (Online) Springer link
3. <http://www.nctm.org> .
4. <http://flm.math.ca/>.
5. <http://www.m-a.org.uk/jsp/index.jsp>
6. <http://www.maa.org>
7. <http://www.atm.org.uk> .
8. <http://www.ams.org>

## **Block 4 : Assessment, Evaluation and Mathematics Teacher**

### **Unit 1 : Formal ways of Evaluation**

#### **Unit Structure**

- 4.1.1. Learning Objectives
- 4.2.2. Introduction
- 4.1.3. Learning Points and Learning Activities
  - 4.1.3.1. Meaning, Purpose, Steps and Types of Evaluation
    - Check Your Progress - 1
  - 4.1.3.2. Achievement Test
    - Check Your Progress - 2
- 4.1.4. Let us Summarise
- 4.1.5. Answers to ‘Check Your Progress - 1 and 2’
- 4.1.6. Unit end Exercises
- 4.1.7. References

#### **4.1.1. Learning Objectives**

After completing this Unit, the student teachers will be able to

- Explain the meaning of Evaluation;
- Explain the purpose of Evaluation;
- Specify the Steps of Evaluation;
- Explain the Types of Evaluation;
- Explain the meaning of Achievement Test;
- Describe the functions of Achievement Test; and
- Explain the Types of Achievement Test.

#### **4.1.2. Introduction**

One of the most important parts of the teaching-learning process is evaluation. However hard a teacher has worked on his/her instruction, unless he/she evaluates the outcomes of his/her instruction the learning does not become complete. There are several aspects which influence a teaching-learning process, which include the teacher’s capacity, environment, pupil’s capacity etc. These aspects by far effect the quality of the outcome of any learning process. In order to understand the effectiveness of the instruction and there after rectify its strength and weaknesses and take corrective measures a teacher will require the knowledge of the outcome. Evaluation gives this feedback to the teacher. Hence effectiveness of a teaching-learning process lies in how well the process has been evaluated. In the following Unit we shall discuss and understand what evaluation is and how one can construct a good evaluation process.

#### **4.1.3. Learning Points and Learning Activities**

##### **4.1.3.1. Meaning, Purpose, Steps and Types of Evaluation**

#### **Exercise 1**

In your classroom, I am sure you have seen a variety of students who respond differently to your teaching. Describe briefly in the space below, how exactly you go about checking if your teaching has reached your pupils.

As you answered the above question, I am sure you have specified many evaluation techniques which you must have used in your classrooms. Now let us understand evaluation in a more organized manner.

### **A. Meaning of Evaluation**

Evaluation is a process that includes measurement and possibly testing but it also contains the notion of a value judgment. If a teacher administers a test to the class and computes the percentages of correct responses, measurement and testing have taken place. The scores must be interpreted which may mean converting them to values like A's, B's, and C's and so on or judging them to be excellent, good, fair or poor. This process is evaluation because value judgments are made.

Evaluation is the value judgment on an observation, performance test, or any data whether directly measured or inferred. For Example, if a pupil gains a score of 32 on a test on education, this measure is evaluated by placing a meaning in it relative to standard, norm or some other situation. Thus, the score may be 'above average', 'fail' or indicative of below or above average effort on the part of the individual, or again that the score is 'good' for his/her age, but 'average for his/her particular class.

Evaluation is a comprehensive and continuous process which covers every aspects of an individual's achievement in the educative programme. It is an integral part of education in which students and teachers are partners. It signifies a wider process of judging student's progress in various aspects.

#### **Definitions**

**Ralph Tyler (1950):** "The process of determining to what extent the educational objectives is being realized."

**Encyclopedia of Modern Education (1943):** "The term evaluation frequently is used to refer to a great many informal situations in which one or more persons consider what value has followed from some particular experience. For instance, a class of children with their teacher may look back over the unit of work they are completing and consider what value the activities of the unit have had for them as a class and as individuals. Evaluation is used significantly in curriculum improvement."

**The concept of Evaluation in Education (1963) of the NCERT** considers evaluation as the "process of determination"

- The extent to which an objective is being attained
- The effectiveness of the learning experiences provided in the classroom
- How well the goals of education have been accomplished.

### **B. Purpose of Evaluation**

The following is the purpose of evaluation

1. To provide for the collection of evidence which will show the degree to which the pupils are progressing towards curricular goal
2. To permit teachers and supervisors evaluate the effectiveness of curricular experiences, activities and instructional methods.
3. To make provisions for building the growth of individual pupil, to diagnose their weaknesses and strengths, to point out areas where remedial measures are desirable.

4. To provide a basis for modification for the curriculum for the introduction of experiences to meet the needs of the individuals and groups of pupils.
5. To motivate pupils towards better attainment and growth.

### C. Steps involved in Evaluation

The process of Evaluation involves the following steps

- **Defining the Objectives to be Tested:** Determining and classifying what is to be evaluated always has priority in the evaluation process.
- **Stating the Objectives:** State objectives in terms of behavior modification i.e. learning outcomes
- **Selection of Evaluation Tools:** After the objectives are clarified, select the evaluation tools and techniques to appraise a group of them.
- **Efficacy of Tools :** Ensure that the selected tools satisfy the criteria of validity, reliability, objectivity and usability
- **Administering the Tools:** Administer the tool of evaluation selected or constructed to assess the selected objectives. This will yield raw scores of the students.
- **Interpretation of Data:** Interpret the scores obtained using various methods of interpretation.
- **Application of results:** Apply the results of evaluation to the teaching methods, learning activities and experiences.

### D. Types of Evaluation

P.W. Airasian and G.F. Madaus have classified classroom evaluation procedures as follows

1. Determine pupil performance at the beginning of instruction (Placement Evaluation).
2. Monitor learning progress during instruction Formative Evaluation.
3. Evaluate achievement at the end of instruction (Summative Evaluation).
4. Diagnose learning difficulties during instruction (Diagnostic Evaluation).

- i. **Placement Evaluation:** Placement Evaluation is concerned with the pupils entry level performance and focuses on the following. The aim of placement evaluation is to determine the position in the sequence of learning activities and the mode of instruction that is to benefit the pupil the most

This type of evaluation assesses

- Whether the students possesses the knowledge and skills required to begin the planned instruction.
- To what extent the student has already mastered the objectives of the planned course.
- Whether it is possible to place him in a more advanced course.
- The mode of instruction best suited to the student's needs, abilities and skills.

- ii. **Formative Evaluation:** The term formative denotes the ongoing or systematic assessment of students achievement while the term course or instructional programme is in progress. Feedback to the students and not the assignment of a grade should be the purpose of making a formative evaluation. The gathering of data during the time of programme for the purpose of guiding the developmental process is formative evaluation. A person who is continually being evaluated during the course will find many things that can be changed for the better during the operation of the programme. Thus, formative evaluation is most useful for the immediate decision making the

student face. The daily interaction between the teachers and students provides the students with necessary feedback for immediate decision making. The feed-back depends upon

- Determining what a student needs to know to facilitate further improvement.
- Gathering accurate data using a variety of appropriate devices (tools).
- Presenting these data to the student in a fashion he will comprehend.

Thus it is a continuous and integral part of instruction where one uses a variety of techniques such as attitude and aptitude inventories, checklists, rating scales etc other than the tests. It is an end in itself and its main function is the appraisal of value of evidences of value of evidences collected by the data gathering devices.

- iii. Summative Evaluation:** The term summative refers to assigning a grade for student's achievements at the end of a term, course or instructional programme. Therefore, making an overall assessment or decision with instructional programme is summative evaluation. It may focus only on a single aspect of subject matter achievement or skills. It is a means to an end and its main function is collection of evidences to determine the present status or position of a pupil in a particular area. It may be done off and on and it need not be an essential part of instruction. The interaction between the teacher and the pupil is very limited and the feedback that the pupil gets is much less when compared with the formative evaluation.
- iv. Diagnostic Evaluation:** Test results provide a basis for drawing conclusions about learning and teaching. A useful test not only provides information about student's achievement but also reveals the instructional effectiveness as well. Where instruction is of group nature, test results must be applicable to judgments of group progress. The interpretable tests give the teacher information on the adequacy of instruction. If proficiency on a particular object has not been demonstrated by many students, it is probably because instruction in this area has been less successful. Probably the learning experiences were insufficient for achievement of this objective. Changes in lesson plans or learning materials for attaining this objective should be seriously considered for subsequent instruction or replace those currently in use. Thus evaluation serves many important diagnostic purposes too.

### **Check Your Progress - 1**

1. What is Evaluation?
2. What is the purpose of Evaluation?
3. Which are the different types of Evaluation?

### **4.1.3.2. Achievement Test**

#### **Exercise 2**

In space provided answer how you would test the pupil's learning after teaching a particular topic?

There are many ways in which we can test a pupil's learning. Achievement Test gives us a systematic approach to test the attainment of various aspects of learning among pupils. Let us now understand it.

## **A. Meaning and Definition of Achievement Test**

Achievement means one's learning attainments, accomplishments and proficiencies in a selected subject matter. According to Dennis Baron and Harold W. Bernard the concept of achievement involves the interaction of three factors namely, aptitude for learning, readiness for learning and opportunity for learning. Achievement in education precisely speaking implies one's knowledge, understanding or skills in a specified subject or a group of subjects. Achievement constitutes an important tool of evaluation. It is necessary for the teacher to know how far the pupils have attained in a particular subject area. In the school evaluation programme, various forms of achievement tests are used to measure the accomplishment of the pupils.

**Thorndike and Hagen (1969)** "The type of ability test that describes what a person has learned to do is called an achievement test."

**Gronlund (1977)** defines an achievement test as "a systematic procedure for determining the amount a student has learned through instruction"

**Downie** "Any test that measures the attainments or accomplishments of an individual after a period of training or learning is called an achievement test."

**Super D.E.** "a proficiency test used to ascertain what and how much has been learnt or how well a task can be performed, the focus being on evaluation of the past without reference to the future, except for the implicit assumption that acquired skills and knowledge will be useful in their own right in the future."

From the above definitions a more comprehensive definition of an achievement test can be stated as "Achievement test is an instrument designed to measure the accomplishment of the student in a specified area of learning, after a period of instruction".

## **B. Functions of Achievement Tests**

The major functions of achievement tests are that they

1. Provide basis of promotion to the next grade.
2. Help in finding out at the beginning of the year where each student stands in the various academic areas.
3. Help in determining the relative position of a student in a particular subject or area of learning.
4. Motivate the students before a new assignment is taken up.
5. Help the teacher to see for himself how effectively he is doing, what is getting across to pupils and what is not.
6. Provide the teacher evidence relating to the realization of the objectives, effectiveness of the learning experiences provided and mode of instruction employed.
7. Help the teacher in identifying pupils difficulties and arranging for remedial measures.

## **C. Types of Achievement Tests**

**Achievement Tests used in schools are of two types**

1. **Teacher Made Achievement Tests:**A teacher uses different terms of evaluation techniques in a classroom situation. Teacher made test is one of the most valuable instruments in the hands of the teacher to solve this purpose. It is designed to solve the problems or requirements of the class for which it is prepared. It is prepared to

measure the outcomes and content of local curriculum. It is very much flexible so that it can be adapted to any procedure or material. In teacher made test the test items, time limit, instruction and procedure of scoring vary from test to test. These tests may be written or oral in nature. In teacher-made test both objective type and essay type items can be included.

2. **Standardized Achievement Tests:** Standardized tests are carefully constructed tests which have uniformity of procedure in scoring, administering and interpreting the test results. Generally these tests are norm-referenced tests that measure the pupil's level of achievement in various content and skill areas by comparing their test performance with the performance of other pupils in some general reference group."

#### **D. Types of Teacher-made Achievement Tests**

The teacher-made Achievement Tests are to two types

1. Oral Tests
2. Written Tests or Paper and Pencil Tests

**1. Oral Tests:** Oral Test is formal test which is conducted face-to-face with the examiner and is characterized by immediate verbal response. It is a practice in which the examiner poses questions to the pupil in spoken form. The pupil has to answer the question in such a way as to demonstrate sufficient knowledge of the subject to pass the exam.

##### ***Types of Oral Tests***

- a) ***Monologue Speaking (Presentation):*** Pupils are asked to perform some task or asked to talk or present something on a specified subject matter.
- b) ***Dialogue Speaking (Oral Interview):*** The pupils are put into a discussion with the teacher or the examiner where the examiner can ask questions.
- c) ***Multilogue Speaking (Discussions & Debates):*** The pupils are put into a discussion or debate and their proficiency in the subject matter is tested.

**2. Written Tests:** Written test is characterized by writing where a student needs to express his knowledge and understanding of a subject in the written form.

##### ***Types of Written Tests***

- a) ***Essay Type:*** **Robert L. Abel and David A. Frisbel** have defined Essay test as "*An essay test presents one or more questions or other tasks that require extended written responses from the person being tested*". It is very difficult to give an exact and perfect definition of an essay test. Usually an essay test refers to any written test that requires an examinee to write several paragraphs or passages. However answer may constitute even a sentence or paragraph or steps and cases.
- b) ***Short Answer Type:*** In simple language it may be stated that a short-answer type test is between an essay type test and an objective test.  
**Anthony J. Nitku** "Short answer items require the examinee to respond to the item with a word, short phrase, word or symbol."  
**Robert L. Abel and David A. Frisbel** "A short-answer test item aims to test knowledge by asking examinees to supply a word, phrase or number that answers a question or complete a sentence."

- c) **Objective Type:** R.L. Ebel and D. A. Frisbie (1986) define an objective test as “One that can be provided with a simple predetermined test of correct answers so that objective opinion or judgment in the scoring procedure is eliminated.”

Lou M. Carey (1988) defines an objective test as “Objective test items are called objective because they can be scored more objectively than any other type of item used to measure student’s performance. Selected response items include alternative response, matching, keyed and multiple choice items.”

### ***Types of Objective Type Test***

**1. Alternate Response Type Test Item:** In the alternate-response test, out of two responses only one is correct. A student selects one of the two responses and judges the truth otherwise of the statement. Some of the common variations of alternate-response test items are

- a) True- False
- b) Yes-No
- c) Right- wrong
- d) Correct –Incorrect

**2. Matching Type Test Items:** N.E. Gronlund (1985) “ The matching exercise consists of two parallel columns with each word, number or symbol in one column being matched to a word, a sentence or phrase in the other column. The items in the column for which a match is sought are called premise and the items in the column from which the selection is made are called responses.” There are several varieties of matching tests. In the traditional format, a matching test consists of two columns. The examinee is required to make some sort of association between each premise and each response in the two columns. He pairs the corresponding elements and records his answers.

**3. Multiple Choice Type Test Items:** According to N.E. Gronlund “A multiple choice test item consists of a problem and a list of suggested solutions. The problem may be stated as a direct question or an incomplete statement and is called the stem of the item. The text of suggested solutions may include words, numbers, symbols, or phrases and are called alternatives (also called choices or options). The pupil is typically requested to read the stem and the list of alternatives and to select the one correct or best alternative.”

A multiple item consists of two parts

1. The stem which contains the problem
2. Options or responses i.e. list of suggested answers.

### ***Forms of Multiple Type Test***

- a) **The correct answer form:** It contains three or more choices but only one of them is correct.
- b) **The best form:** One or more or all choices may be correct but one of them is the best answer.
- c) **The multiple response form:** The correct answer may consist of more than one choices and the examinee is asked to identify all those which are correct.
- d) **The incomplete statement form:** The stem is incomplete and can be completed by the correct choice. The examinee is asked to select the correct one.
- e) **The substitution form:** The word outlined in the stem is to be substituted by the correct response. Responses are given and the examinee is asked to select the one which can substitute the desired word.

- f) **The combined response form:** The choices are different phrases or sentences of a paragraph. The examinee is required to correct order of the phrases or sentences.

### Check Your Progress - 2

1. What is Achievement Test?
2. Which are the two types of Achievement Tests?

#### 4.1.4. Let us Summarise

- **Meaning of Evaluation:** The concept of Evaluation in Education (1963) of the NCERT considers evaluation as the “process of determination”.
  - ✓ The extent to which an objective is being attained.
  - ✓ The effectiveness of the learning experiences provided in the classroom.
  - ✓ How well the goals of education have been accomplished.
  - ✓
- **Purpose of Evaluation:** To permit teachers and supervisors evaluate.
  - ✓ the effectiveness of curricular experiences,
  - ✓ activities
  - ✓ Instructional methods.
- **Steps involved in Evaluation**
  - ✓ Defining the Objectives to be Tested
  - ✓ Stating the Objectives
  - ✓ Selection of Evaluation Tools
  - ✓ Efficacy of Tools
  - ✓ Administering the Tools
  - ✓ Interpretation of Data
  - ✓ Application of results
- **Types of Evaluation**
  - ✓ Determine pupil performance at the beginning of instruction (Placement Evaluation).
  - ✓ Monitor learning progress during instruction Formative Evaluation.
  - ✓ Evaluate achievement at the end of instruction (Summative Evaluation).
  - ✓ Diagnose learning difficulties during instruction (Diagnostic Evaluation).
- **Meaning and Definition of Achievement Test: Gronlund (1977)** defines an achievement test as “a systematic procedure for determining the amount a student has learned through instruction”.
- **Functions of Achievement Tests**
  1. Basis of promotion to the next grade.
  2. Finding out at where each student stands in the various academic areas.
  3. Determining the relative position of a student.
  4. Help the teacher to see how effectively he is doing
  5. Evidence relating to the realization of the objectives, effectiveness of the learning experiences provided and mode of instruction employed.
  6. Identifying pupil’s difficulties and arranging for remedial measures.

#### **A. Types of Achievement Tests**

1. Teacher Made Achievement Tests
2. Standardized Achievement Tests

#### **B. Types of Teacher-made Achievement Tests**

1. Oral Tests
2. Written Tests or Paper and Pencil Tests

#### **C. Types of Oral Tests**

1. Monologue Speaking (Presentation)
2. Dialogue Speaking (Oral Interview)
3. Multilogue Speaking (Discussions & Debates)

#### **D. Types of Written Tests**

1. Essay Type
2. Short Answer Type
3. Objective Type

#### **E. Types of Objective Type Test**

1. Alternate Response Type Test Item
2. Matching Type Test Items
3. Multiple Choice Type Test Items

#### **F. Forms of Multiple Type Test**

1. The correct answer form
2. The best form
3. The multiple response form
4. The incomplete statement form
5. The substitution form
6. The combined response form

#### **4.1.5. Answers to ‘Check Your Progress - 1 and 2’**

##### **Check Your Progress - 1**

1. Evaluation is a process that includes measurement and possibly testing but it also contains the notion of a value judgment. If a teacher administers a test to the class and computes the percentages of correct responses, measurement and testing have taken place. The scores must be interpreted which may mean converting them to values like A's, B's, and C's and so on or judging them to be excellent, good, fair or poor. This process is evaluation because value judgments are made.
2. The following is the purpose of evaluation
  - To provide for the collection of evidence which will show the degree to which the pupils are progressing towards curricular goal
  - To permit teachers and supervisors evaluate the effectiveness of curricular experiences, activities and instructional methods.
  - To make provisions for building the growth of individual pupil, to diagnose their weaknesses and strengths, to point out areas where remedial measures are desirable.

- To provide a basis for modification for the curriculum for the introduction of experiences to meet the needs of the individuals and groups of pupils.
- To motivate pupils towards better attainment and growth.

### 3. Types of Evaluation

- Determine pupil performance at the beginning of instruction (Placement Evaluation).
- Monitor learning progress during instruction Formative Evaluation
- Evaluate achievement at the end of instruction (Summative Evaluation).
- Diagnose learning difficulties during instruction (Diagnostic Evaluation).

### Check Your Progress - 2

1. Achievement test is a systematic procedure for determining the amount a student has learned through instruction.
2. Types of Achievement Tests
  - a) Teacher Made Achievement Tests
  - b) Standardized Achievement Tests

### 4.1.6. Unit end Exercises

1. Explain the meaning of Evaluation quoting pertinent definitions.
2. Explain the types of Evaluation.
3. What is the purpose of evaluation? Elaborate
4. Explain the steps of Evaluation.
5. What is achievement test? Elucidate
6. Which are the different types of Achievement Tests? Explain
7. Explain teacher-made Achievement Tests.
8. What is oral test? Mention its types.
9. What are the different types of Written Tests? Explain
10. Explain the meaning and types of Objective Type Tests.
11. Which are the different types of Multiple Type Test items? Give examples

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## **Block 4 : Assessment, Evaluation and Mathematics Teacher**

### **Unit 2 : Informal creative Evaluation**

#### **Unit Structure**

- 4.2.1. Learning Objectives
- 4.2.2. Introduction
- 4.2.3. Learning Points and Learning Activities
  - 4.2.3.1. Informal Assessment
    - Check Your Progress - 1
  - 4.2.3.2. Informal Assessment Techniques
    - Check Your Progress - 2
- 4.2.4. Let us Summarise
- 4.2.5. Answers to ‘Check Your Progress - 1 and 2’
- 4.2.6. Unit end Exercises
- 4.2.7. References

#### **4.2.1. Learning Objectives**

After completing this Unit, the student teachers will be able to

- Explain the meaning of Informal Assessment;
- Specify the types of Informal Assessment;
- Explain Unstructured Informal Assessment Techniques; and
- Explain Structured Informal Assessment Techniques.

#### **4.2.2. Introduction**

Evaluation is an important phase of learning process. In our previous unit we have already seen what evaluation is and how can we formally go about evaluating our pupils through achievement test. But there are several aspects and dimensions in learning which cannot be completely evaluated by formal methods of evaluation alone. Every moment the pupil is in the learning process there is new learning that is happening. Learning is a continuous process and it cannot be satisfactorily evaluated at a specified time. Just like learning being a continuous process, evaluation too has to be a continuous process. Evaluation will be satisfactory only when every aspect of pupils learning has been covered in it. There are many untraditional ways in which a pupils learning can be evaluated. These methods and techniques of evaluation do not demand structured ways and allows a teacher to evaluate as and when he/she wants. These also give scope to teacher’s creativity. Such techniques are informal in nature and come to be called as informal assessment techniques. In this unit let us understand what informal assessment is and also go through some of the informal assessment techniques.

#### **4.2.3. Learning Points and Learning Activities**

##### **4.2.3.1. Informal Assessment**

##### **Exercise 1**

Recall the several creative and untraditional evaluation techniques you have used in your classrooms and list in the space provided below.

As you answered the above questions several creative techniques must have crossed your mind which you might have used in your classrooms. Now let us see some more of such kind.

### **A. Meaning of Informal Assessment**

Informal Assessment is not data driven but rather content and performance driven assessment. "Informal" is used here to indicate techniques that can easily be incorporated into classroom routines and learning activities. Informal assessment techniques can be used at any time without interfering with instructional time. Their results are indicative of the student's performance on the skill or subject of interest. Unlike standardized tests, they are not intended to provide a comparison to a broader group beyond the students in the local project.

This is not to say that informal assessment is casual or lacking in rigor. Formal tests assume a single set of expectations for all students and come with prescribed criteria for scoring and interpretation. Informal assessment, on the other hand, requires a clear understanding of the levels of ability the students bring with them. Only then may assessment activities be selected that students can attempt reasonably. Informal assessment seeks to identify the strengths and needs of individual students without regard to grade or age norms.

While informal assessment utilizes open-ended exercises reflecting student learning, teachers (and students) can infer "from the mere presence of concepts, as well as correct application, that the student possesses the intended outcomes" (Muir & Wells 1983, 95). Another important aspect of informal assessments is that they actively involve the students in the evaluation process--they are not just paper-and-pencil tests.

### **B. Advantages of Informal creative assessment**

Informal assessment has the following advantages:

- Makes diverse levels of understanding and skill.
- Development is discernible and thus more addressable.
- Builds a classroom culture that acknowledges diversity as a learning asset for the whole group.
- It helps to create summative assessments (which is formal way) to the furthest extent possible.
- Permits a range of ways to express one's understandings of what they cover.
- It helps to incorporate a range of technology supports into teaching, as well as formative and summative assessment, for example.
  - ✓ Smart phones and apps that can turn text into sound and vice versa,
  - ✓ Post questions that others can read and respond to, and respond in an instant to teacher inquiries about what students know even graph the results. And all students should have access to such tools –
- To check for understanding, monitor learning progress, provide appropriate feedback to students, and inform instructional decisions, as well as for lesson planning.
- Formative assessment tools may involve the following and many more:
  - quick quizzes, asking students to build something, calling on students during class, and playing classroom games where students must apply what they have learned are used to gauge comprehension.
- researches support saying that such assessments, which engage the students providing them with a platform to respond what they know as against the formal assessment, equip the teacher with a lot of insight into students' thinking.

- These insights provide teachers with the knowledge to adjust lessons based on learner thinking and performance, as well as to teach to mathematics standards.

### Check Your Progress - 1

1. What do you mean by Informal Assessment?
2. List some advantages of Informal Assessment.

### 4.2.3.2. Informal Assessment Techniques

#### Exercise 2

Recall your school days, do you remember any other assessment techniques that your teacher used other than tests and exams to assess your learning? Name a few from your memory.

Every teacher would have used quizzes, riddles etc. in order assesses the mathematics learning in their classroom. Let us see what are the different Informal Assessment Techniques that we can use in our classrooms.

Informal assessment can be divided into two main types

1. **Unstructured:** Unstructured assessment is an assessment technique which may or may not have a structured assessment pattern. The unstructured methods frequently are somewhat more difficult to score and evaluate, but they can provide a great deal of valuable information about the skills of the children. e.g., student work samples, journals
2. **Structured:** Structured methods can be reliable and valid techniques when time are spent creating the "scoring" procedures. e.g., checklists, observations

### B. Unstructured Assessment Techniques

#### 1. Assessment through Contexts

Contexts play a major role as a vehicle for assessing insight, understanding, and concepts. Meyer (2001) distinguishes five different roles of the context: (a) to motivate, (b) for application, (c) as a source of mathematics, (d) as a source of solution strategies and (e) as an anchor for student understanding.

##### *i. Distance to students*

One can think of context as being certain “distances” from the students: the context that is closest is the private life (daily life); the next closest is school life, work, and sports; next is local community and society has encountered in daily life and beyond that are scientific contexts. In this way, one can define a more or less continuous scale that can be regarded as another aspect of the framework.

##### *ii. Relevance and Role of Context*

The real “first-order” use of context is when the context is relevant and needed for solving the problem and judging the answer. Second order use of context appears when one really needs to “mathematize” the problem in order to solve it, and one needs to reflect on the answer within the context to judge the correctness of the answer. For this reason, we expect first order context use in most of the shorter items (e.g., multiple-choice; open-ended, short answer), whereas second-order context use is most often restricted to formats that allow for more process-oriented activities that quite often represent second- and third-level competencies and skills. Special mention should be made of third-order context use, in which the context serves the construction or reinvention of new mathematical concepts.

### ***iii. Real Versus Artificial Versus Virtual Contexts***

It seems clear that when we emphasize mathematics education that will prepare our pupils to be intelligent and informed citizens, we have to deal with all kinds of real contexts. We have to deal with pollution problems, with traffic safety, with population growth. But does this mean that we have to exclude artificial and virtual contexts. The answer is no, but we need to be aware of the differences for students. A virtual context contains elements that are not drawn from any existing physical, social, practical, or scientific reality. They are of an idealized, stylized or generalized nature. An artificial context deals for instance with fairy tales-nonexistent objects or constructs.

## **2. Assessment through Discourse**

Discussing, explaining, justifying, illustrating, and analogizing are all features of reasoning in a mathematics classroom. Having an argument to find the appropriate mathematical solutions and definitions is generally considered as contributing both to the whole classroom's learning as well to each individual's progress (Wood, 1998; Cobb, Yackel, & Wood, 1993). Classroom interaction is based on the assumption that the students are at different "levels of mathematical and social competencies and skills" or that there are "framing differences" (Krummheuer, 1995).

Furthermore, the core of the argument means something different for each student, depending on the framing. This in turn leads to different levels of confidence. Important in argumentation is the ability to construct a structural similarity among several argumentation experiences in different situations. Such a "pattern" of similarly structured arguments is called a *topos*. The argumentation in classroom can contribute to the formation of a *topos* for an individual student, which leads to conceptual mathematical development.

## **3. Observations**

Observation is a direct mean of learning about students, including what they do or do not know and can or cannot do. Observations show which students perform better alone, and which perform better in groups. They give insight into how well students organize the result of a discussion on paper, how organized they are. They help teachers estimate confidence levels that are so important in order to engage in mathematical argument. Many teachers have relegated the important information gained from observation to second class status behind information that can be gained from a "test." Part of the problem is that observations are hard to organize in a systematic way and the information is too informal to make hard educational decisions. The introduction of new information technology such as PDIs and spreadsheets, however, makes it somewhat easier to make this format a more serious contender, especially for classroom assessment.

Beyer (1993) suggestions for using Observation as assessment

- ✓ Use your reflections as teacher in order to develop your own performance indicators. Performance indicators could indicate, for example, three simple levels do not understand, on the way to understanding, and really understanding the concept and aim only at very important mathematical concepts, limiting the scope but still getting very relevant information.
- ✓ Try to record student performance against your indicators on a regular basis.

#### **4. Homework**

Homework is not very often used as or perceived to be assessment, and certainly not if we are thinking about assessment as we see it. Quite often, little thought is given to the selection of homework problems (“just do the next sums”), nor there is an elaborate discussion about the results. This is not too surprising, given that many of the homework problems generally encourage only superficial and rote learning.

But a pre-planned homework can be a good basis for evaluation. The problems should be carefully selected to guarantee possibilities for different strategies in the students’ solutions. The teacher should first check whether the students have successfully accomplished the homework and made notes (grades) in special cases (better than, worse than). Invite students to write their homework on the blackboard, making sure those students represent different strategies and solutions. Here the teacher can assess the mathematical understanding of students and probe for further discussions to get a view into the depth of their understanding.

#### **5. Self-assessment**

Wiggins (1993): “An authentic education makes self-assessment central.” A practical implication of this postulate is that we should require students to submit a self-assessment with major pieces of work. Feed-back from the teacher will help make clear to the students how the teacher assesses in relation to their own perception of “quality.” This in turn will most likely improve the student’s learning through a better understanding of the criteria and especially the different levels of mathematical competencies as they play out on tests and tasks. Teacher can use this as the reference for her assessment on the pupil.

#### **6. Peer Assessment**

Peer assessment, like self-assessment, can take many forms. Students may be asked to grade an otherwise “traditional” test, to comment on an oral presentation by another student, or to construct test items or even whole tasks (Koch & Shulamith, 1991; de Lange et al., 1993; Streefland, 1990; van den Brink, 1987). The rate of success has not been well established because peer assessment is often introduced at the same time as other innovations such as group work (Webb, 1995). Peer assessment provokes a discussion among students about different strategies and solutions and helps them to clarify their views in a setting where they can feel safe. As a more concrete example of both self-assessment and peer assessment that relates in a positive way to our principles more particularly, positive testing we will next turn to “own productions” as assessment.

#### **7. Own Productions**

Own production refers to

- Solving relatively open problems that elicit divergent production due to the great variety of solutions they admit, often at various levels of mathematization.
- Solving incomplete problems that require self-supplying data and references before they can be solved.

#### **8. Extended Response–Open Questions**

Extended response–open questions give students the opportunity to get involved in a context with one or more open questions of relatively complex nature, where the student’s choice of which strategy to follow is not clear in advance.

## **9. Super Items**

Extended response “super items” (Collis, Romberg, &Jurdak, 1986) are tasks that give students the opportunity to get involved with a context or problem situation by asking a series of open questions of increasing complexity. The first few questions might be closed-open questions or open-open questions. These are followed by more difficult questions that may not have a Pre-definable set of possible answers. For such questions, multiple scoring and some adjudication of responses is likely.

## **10. Oral Tasks and Interviews**

In some countries oral assessment was usual practice, even as part of the formal national examination system. There are different forms:

- An oral discussion on certain mathematical subjects that are known to the students.
- An oral discussion on a subject covering a take-home task that is given to the students for 20 minutes prior to the discussion.
- An oral discussion on a take-home task after the task has been completed by the students.

Quite often the oral assessment format is used to operationalize the higher process goals.

## **11. Journals**

Journal writing is one of the least used forms of assessment. This seems to be because it is time-consuming, hard to score the mathematics separate from the reading and writing skills, and unclear how to score students’ work. But, like drawing schemata and graphs, writing mathematically shaping, clarifying, and discovering ideas is a very important mathematical ability.

## **12. Concept Maps**

White (1992) has suggested that concept mapping can be used with students to show how they see relationships between key concepts or terms within a body of knowledge. This activity, like own productions, forces students to reflect on such relationships and to develop a more integrated understanding, as opposed to learning isolated facts.

## **13. Progress-Over-Time Tests**

Progress over time has always been an implicit aspect of assessing. The next task was supposed to be more difficult than the previous one, and the curricular organization takes care of that aspect as well: everything that comes later is more complex or at a higher level. But we may need a more explicit way to measure mathematical growth. One way to do this is by using almost similar problems in tests given at different times. As an example, we refer to the Mathematics in Context Longitudinal Study, in which end-of-the-year tests were developed that contain one item (actually a super item). This item was revisited in all four end-of-the-year tests, albeit in a more complex form as the years progressed.

## **14. Anecdotal Record**

Anecdotal records are detailed, narrative descriptions of an incident involving one or several children. They are focused narrative accounts of a specific event. They are used to document unique behaviors and skills of a child or a small group of children. In mathematics it can help in assessing the mathematical skills of pupils and follow up the progress.

## **15. Portfolio**

Portfolio assessment is an assessment form that learners do together with their teacher. The portfolio contains samples of the learners work and shows growth overtime. By

reflection on their own work, learners begin to identify their strength and weaknesses of their own work. The weakness then becomes improvement goals. In portfolio assessment it is in quality that occurs and not in quantity.

### C. Structured Evaluation Techniques

1. **Check List:** Check-list usually offer yes/no format in relation to student demonstration of specific criteria in mathematics. They may be used to record observations of an individual, group or the whole class.
2. **Rating Scale:** Rating scale allows teachers to indicate the degree of frequency of the behaviors, skills and strategies displayed by the learner. Rating scale states the criteria and provides three or four response selections to describe the quality of frequency of student work. Teachers can use rating scales to record observations and students can use them as self assessment tools.
3. **Project:** According to Kilpatrick “Project is a unit of wholehearted purposeful activity carried on preferably in its natural setting.” Project method gives ample scope for the teacher to evaluate the mathematical skills of a pupil. By constructing well-planned evaluation criteria teacher can use this evaluation technique in a structured manner.

#### 4. Selection-Type Test

Multiple-choice, true-false, and matching items all belong to the same category: the selection-type items. They can be scored objectively. That means that equally competent scorers can score them independently and obtain the same results. These equally competent scorers are usually computers. And therein lies the real popularity of selection-type items: They can be easily scored. The rules for constructing a multiple-choice item are simple: A multiple-choice item will present students with a task that is both important and clearly understood and one that can be answered correctly only by those who have achieved the desired learning.

### Check Your Progress - 2

1. Which are the different types of Informal Assessment Techniques?
2. Name a few Informal Assessment techniques.

#### 4.2.4. Let us Summarise

- **Meaning of Informal Assessment**

Informal Assessment is not data driven but rather content and performance driven assessment. "Informal" is used here to indicate techniques that can easily be incorporated into classroom routines and learning activities. Informal assessment techniques can be used at anytime without interfering with instructional time.

- Informal assessment has the following advantages:
  - ✓ Makes diverse levels of understanding and skill.
  - ✓ Development is discernible and thus more addressable.
  - ✓ Builds a classroom culture that acknowledges diversity as a learning asset for the whole group.
  - ✓ It helps to create summative assessments (which is formal way) to the furthest extent possible.
  - ✓ Permits a range of ways to express one’s understandings of what they cover.

- **Informal assessment can be divided into two main types**
  - ✓ **Unstructured:** e.g., student work samples, journals
  - ✓ **Structured:** e.g., checklists, observations
  
- **Unstructured Assessment Techniques**
  1. Assessment through Contexts
    - I. *Distance to students*
    - II. *Relevance and Role of Context*
    - III. *Real Versus Artificial Versus Virtual Contexts*
  2. Assessment through Discourse
  3. Observations
  4. Homework
  5. Self-assessment
  6. Peer Assessment
  7. Own Productions
  8. Extended Response–Open Questions
  9. Super Items
  10. Oral Tasks and Interviews
  11. Journals
  12. Concept Maps
  13. Progress-Over-Time Tests
  14. Anecdotal Record
  15. Portfolio
  
- **Structured Evaluation Techniques**
  1. Check List
  2. Rating Scale
  3. Project
  4. Selection-Type Test

#### 4.2.5. Answers to ‘Check Your Progress - 1 and 2’

##### Check Your Progress - 1

1. Informal Assessment is not data driven but rather content and performance driven assessment. "Informal" is used here to indicate techniques that can easily be incorporated into classroom routines and learning activities. Informal assessment techniques can be used at any time without interfering with instructional time.
2. Informal assessment has the following advantages:
  - Makes diverse levels of understanding and skill.
  - Development is discernible and thus more addressable.
  - Builds a classroom culture that acknowledges diversity as a learning asset for the whole group.
  - It helps to create summative assessments (which is formal way) to the furthest extent possible.
  - Permits a range of ways to express one’s understandings of what they cover.

##### Check Your Progress - 2

1. Informal assessment can be divided into two main types
  - ✓ **Unstructured:** e.g., student work samples, journals
  - ✓ **Structured:** e.g., checklists, observations

## 2. Informal Assessment Techniques

- a) Assessment through Contexts
- b) Assessment through Discourse
- c) Observations
- d) Homework
- e) Self-assessment
- f) Peer Assessment
- g) Own Productions
- h) Extended Response–Open Questions
- i) Oral Tasks and Interviews
- j) Journals
- k) Concept Maps
- l) Progress-Over-Time Tests
- m) Anecdotal Record
- n) Portfolio

### 4.2.6. Unit end Exercises

1. Elaborate the meaning of Informal Assessment
2. List the advantages of Informal Assessment.
3. Which are the different types of informal assessment? Elaborate
4. Explain different Structured Informal Assessment Techniques.
5. Explain different Unstructured Informal Assessment Techniques.
6. Elaborate Assessment through context with an example?
7. How will assess your pupils through discourse?

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## **Block 4 : Assessment, Evaluation and Mathematics Teacher**

### **Unit 3 : Assessment Framework in Mathematics Instruction**

#### **Unit Structure**

- 4.3.1. Learning Objectives
- 4.3.2. Introduction
- 4.3.3. Learning Points and Learning Activities
  - 4.3.3.1. Focus areas for the assessment framework Standard - I and II  
Check Your Progress - 1
  - 4.3.3.2. Focus areas for the assessment framework Standard - III, IV and V  
Check Your Progress - 2
- 4.3.4. Let us Summarise
- 4.3.5. Answer to ‘Check Your Progress - 1 and 2’
- 4.3.6. Unit end Exercises
- 4.3.7. References

#### **4.3.1. Learning Objectives**

After completing this Unit, the student teachers will be able to

- Give the meaning of Assessment Framework;
- Mention various standards that should find place in Math Assessment Framework.
- Give the meaning of Math content;
- Cite example for math Processes;
- Explain the role of alternative assessment in Math assessment frame work;
- Explain the dynamic nature of assessment as learning experience;
- Explain the concept of 'equity and opportunities' in the light of Assessment framework in Mathematics Instruction;
- Explain the meaning of ‘Curriculum of all’ in Mathematics instruction;
- Explain the concept of openness as a standard in Mathematics assessment framework;
- Cite illustrate to show the issue in generalizing the results of Alternative Assessment; and
- Explain the idea of inference as the authenticity of tasks performed against performance criteria.

#### **4.3.2. Introduction**

Dear student as you are aware of, the aim of classroom assessment is to produce information that contributes to the teaching and learning process and assists in educational decision making. Therefore, it becomes significant to have a suitable framework for the classroom assessment of mathematics. The structure of the framework involves our philosophy, resulting in principles. Assessment framework in mathematics instruction should provide for all these aspects. The structure of the frame work involves our philosophy which yields to principles. Principles prescribe certain standard to assessment. The assessment frame work discussed here are based on the recommendations of NCF-2005 and ideas of are drawn from the NCTM assessment standards which offer excellent starting point. Dear student let us understand the standard for assessment framework one by one. What do these standards focus on? What principles can be derived out of these standards? etc. are pertinent questions. Let us try to find answers to them. If you are posed with a question, ‘what should get prioritized focus in the assessment framework’, You will surely come out with two areas of focus viz. content of mathematics and learning of mathematics by students. These are very

important to decide standards but they may not be sufficient. In this unit let use look into these aspects.

### 4.3.3. Learning Points and Learning Activities

#### 4.3.3.1. Focus areas for the assessment framework Standard I and II

##### Exercise 1

Discuss with your friends or brainstorm yourself and try to list some significant mathematics processes and write in the space provided below.

You would surely have identified several mathematical processes. Some significant mathematics processes are: Logical reasoning, If and then reasoning, Estimation, Calculation, Manipulation, Pattern identification, Construction, Tabulation, Budgeting, making connections, Averaging, Translation, Inductive and deductive thinking, using symbols appropriately, apply math idea to real life situation, generalization, problem solving, etc.

Assessment tasks should exhibit the mathematical processes used by the student. This is indicated by the ‘process of response’ by the students. Now let us discuss the framework for assessment of Mathematics.

The focus areas for the framework are discussed below. Here are the standards of assessment framework for mathematics instruction:

#### **Standard - I Mathematical Content**

The assessment in math should help in judging how well mathematics assessment reflects the important mathematics, which the students need to learn.

There are two aspects to assessment of content in mathematics:

##### **1. Mathematical content of the assessment**

Example: Assessment task: Define the concept of a circle.

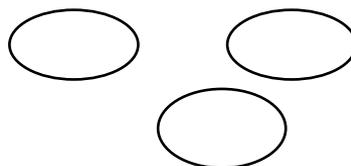
Math content involved in response of assessment: Definition of Circle.

##### **2. Mathematical process involved in response of the assessment (Consider both examples given below):**

Example:

- a) Assessment task: Define the concept of a circle
- b) Mathematical process involved: recollection (Reproduce from memory)  
(The Process here is predominantly memory!)

a). Assessment task: Which one of the given pictures represents the concept of a circle? Why?



If keenly observed you can make out that the first figure represents the concept of a circle. The second figure does not match with the concept as it has two centers (while construction using compasses' students make such mistakes!). The third figure does not match with the concept as it appears as though the circle is drawn using a bangle- like object and marked a point near centre as centre!

b) Mathematical process involved: matching the knowledge of the concept circle with that of the diagrams and to identify the one in which all the components of the concept circle are met. Here this problem provides platform for thinking and applying.

The above examples indicate the mathematics process reflected in the assessment. Mathematics process used to respond is nothing but the response process! As mathematization is the aim of math education, you understand that this aspect should find a place in assessment frame work.

The above discussion conveys the significance of math content as well as math processes in the framework of math assessment. This may probe you to pose the following questions for discussion:

What mathematical content should get assessed?

What mathematical processes are used for responding?

Let us discuss one after the other. If the content takes the focus in assessment task then it becomes necessary that the assessment tasks should reflect the **important mathematics** that is to be learned by students. Also, if the math processes should find a place in assessment framework then this means there is a concern that quality of mathematics is reflected also in the **process of response** to them. For clarity, in the above example of Math process, the first one (define the concept of circle) has significant content which can be reproduced by sheer memory and thus does not indicate any important learning (although the content is important!). From this you must have observed dear student that the response of students to given assessment task should **reflect both math content involved as well the response process** used. This is very important for the sheer reason that the content learning in math can range from superficial learning to meaningful deep learning

Dear student you should be aware that process of response is not easily and explicitly exhibited through the routine assessment task.

Take for example the following problems and try to identify the difference:

1. Find simple interest for an amount Rs.1600/-for 2 years @ 6.5% interest?
2. Reena took a loan of Rs 1200 with simple interest for as many years as the rate of interest. If she paid Rs 432 as interest at the end of the loan period, what was the rate of interest?  
a)3.6; b)6; c)18; d)cannot be determined; e) none of these (courtesy RBI 2003)

You can observe that the first assessment task takes the direct use of formula and its substitute by numerical values in the problem in order to find the solution. But in the second task, the student has to think, understand the problem with its twist probably using the same formula. In both cases the responses indicate the thinking process of the student. Monotonous application of formulae is not indicative of any quality thinking process (although thinking is there!). Assessment tasks should provide ample opportunity for thinking at the same time indicating this through the students' response. When traditional

types of assessment tasks do not indicate the process of response clearly, then other alternatives can be recommended.

Thus, the assessment framework should recommend various types of alternative assessment. These bring a lot of variation in terms of using strategies which are not traditional and sometimes do not even appear as an assessment task!

For example:

How would you represent a 5 storied building with 5 basements as well, on a number line?

Students' responses to the task, reflects the 'process of response' in most cases. If not one can adopt think aloud technique too.

Students can be given part of a task to work on, and their reactions when probed, can be used to construct a picture of their thinking on the task.

- Students also can be interviewed after an assessment to detect what they were thinking as they worked on it.
- Students' written work and videotapes of their activity can be used to prompt their recollections.

The framework is expected to make way for all these. If you observe the above activities of assessment keenly you will understand that, none of these approaches alone can convey a complete picture of the student's internal processes, but together they can help clarify the extent to which an assessment taps the kinds of mathematical thinking that matched with the teachers' target. Thus assessment as such should be interesting and should reflect important math being assessed with response process.

However, some issues do arise such as,

- The nature of 'important mathematics', is not based on a single aspect and there needs consensus among the stake holders regarding the math content that is important! Thus, the idea of 'important mathematics' needs to have a broader view of the curricular relevance.
- One more aspect that you have observed in the above examples, is that the assessment task deviates from the routine! This may pose challenge! The tools of mathematization involve thinking process. The assessment of the act of mathematization leads to new forms of student performance, which deviate from their routine performance. For example:

**Routine assessment task:** define a Polyhedron. (indicates routine performance)

**Assessment task for mathematization:** you are given a model of a polyhedron, highlight its components using either oral description or highlighting the components by the use of any other materials (unique performance).

- The interesting assessment tasks should encourage students to use the kind of intellectual processes that demonstrates the required mathematical power (reasoning, problem solving, communicating, making connections etc). There is always a fear of neglecting the real math part with the urge to prioritize the intellectual thinking process. That means such interesting tasks may only superficially surface the mathematics without students ever engaging in any serious mathematical thinking. This means that there should be congruence between an assessment and the curriculum (which is a must), may take a backseat!

However dear student, the discussion till now indicates that the assessment framework should incorporate the above-mentioned ideas in spite of the issues, with required shielding of them.

## **Standard - II Learning**

Assessment in mathematics should not gear itself towards declaring students as ‘promoted’ or ‘demoted’. The recent view of assessment calls viewing assessment as an integral part of the learning process rather than an interruption of it. This may direct us to pose the following question for discussion:

How can the assessment support, both the enhanced learning and effective instruction?

Assessment can support enhanced learning only if it is used as formative assessment. Teachers are the ones who know students well and are aware of their learning style and their entry behaviour.

Traditionally (which is in progress now also in our society) both standardized and classroom tests were designed using a psychometric model to be as objective as possible. Off late the realization has taken place that the alternative assessment movement affords teachers much more responsibility and subjectivity in the assessment process.

Why can't a third person do the assessment of students? Teachers are the best persons to make assessment of students. This decision is under the assumption that teachers know their students best because teachers have multiple, diverse opportunities for examining students' work performed under various conditions and presented in a variety of modes. Teachers observe the students as they learn. This means that teachers assess students even in the middle of their teaching.

Dear student observe the following examples of how assessment is made during and at the end of teaching:

### **Example-1**

Latha, a math teacher of a government high school, instructs her 9<sup>th</sup> graders, “students! I see that in each of your groups, you have prepared models of a polyhedron! They appear very beautiful and colourful! Now let me come to each group and you will explain the details of the concept that YOU have prepared. OK?”

### **Example-2**

Pinto, favourite math teacher of a local aided secondary school, completes his interaction with students on the topic ‘**Hire Purchase**’. Immediately after completing his lesson he starts distributing an ‘**exit slip**’ to students and instructs them “dear ones I hope you all have understood my interaction on Hire purchase, now take these slips and fill it and submit it to me”.

The exit slip had the following questions for the students to answer!

- Three things I learned
- Two questions I have
- One thing I didn't understand
- What I found most interesting

Thus when teachers have more responsibility for assessment, assessment can truly become almost seamless with instruction.

This gives one important information that if the assessment should lead to enhanced learning, then teachers who are aware of students' potentials need to use alternative assessment techniques.

A sound math curriculum suggests teaching to focus on child's resources to think and reason, to process, curiosity. This means that teaching and curriculum should align in their focus. Also what is focused in teaching should result in learning! If this is what they learn after teaching, should it not be reflected in the assessment?

Dear student in that case what should be the focus of assessment tasks? Think!

Yes you are right! The assessment task should align with the learning experiences. used to learn. As discussed earlier, student engagement in assessment tasks should be judged through a variety of activities which serve as evidences. These include teacher reports, students' reports and teacher observations of students' involvement in various activities. These varied activities which are but assessment tasks might enhance student learning in number of ways. There is very important claim that assessment should raise the expectations of performance level of both students and teachers. This yields to greater learning by students.

Assessment tasks should motivate students to respond constructively which indicate some significant learning **by all students** without any omission. This means assessments should support learning by successfully engaging even those students with limited mathematical competency, in solving meaningful problems. Dear student it is to your awareness also that whenever challenging problem is posed, students with limited mathematical competency are discouraged and choose to 'close off' even without demonstrating what content they know! This is because more often challenging problems are beyond the ability of grasping to such students since their knowledge lags behind the goals of reform. This may lead to negative learning.

Thus the framework for assessment in math instruction can include this aspect of focus. At least a part of the challenging problem is to be attempted by all students including once with limited math competency, thereby encouraging not to, stay away from attempting any problem. This is very important for developing the capability to continue learning. Along with the traditional assessment, alterative assessment techniques are to be used by teachers as formative assessment.

Formative assessments can help students guide their learning and evaluate one's own work. Scoring rubrics and sample responses are a few new forms of assessment tools that help students in this regard. Assessment framework can facilitate this type of assessment with the involvement of teacher (for desirable effects)

### **Check Your Progress - 1**

1. Explain two aspects of Math content.
2. Mention various Mathematics process.

### 4.3.3.2. Focus areas for the assessment framework Standard – III, IV and V

#### Exercise 2

Dear student what is your opinion regarding comparing math performance of students, say for example, from:

1. School to school
2. State to state
3. School to district
4. Student to state/national level?

As you thought about the different comparisons you must have realized the importance of framing the assessment framework based on these areas. Let us now discuss the focus areas for the assessment framework.

#### A. Equity and Opportunity

Assessment should be in such a way that it should give every student optimal opportunity to demonstrate mathematical power to the level of their ability. Equity has become an issue in some of the standardized tests and other tests by being biased against students, of particular backgrounds, with superficially perceived intelligence, socioeconomic classes, ethnic groups, gender or sometimes even the type of school in which the students study. Equity becomes even more of an issue when assessment results are used to label students or deny them access to other courses, programs, or jobs. The following questions may help understand this better:

Does the assessment task structured to measure what it should, measure it in all groups without any bias?

Are comparisons of results of assessments, with performance of others or against criteria?

Are all students, irrespective of any category accessible to assessment task?

As you might have rightly observed there are usually issues associated with the equity of assessment i.e., whether the assessment is unbiased? For example whenever an assessment includes complex tasks or tasks that are contextualized, which are not familiar to all students, create a huge disparity in the way tasks are understood and responded by different levels of students.

Also different learning atmosphere at home and at school can be a major factor in student's performance on educational assessments.

#### 1. School to school

As you are aware, no two schools are identical in their culture; schooling processes; academic atmosphere they create; commitment and attitude of teachers etc. This means the experiences provided by various schools are thus different, These factors do play a role on motivational aspects of learning better. Some schools may have **quality** teachers but with **no commitment** and the other might have both. The later may yield better results in the assessment tasks. On what ground are you comparing?

#### 2. State to state

In this case also comparison becomes an issue. States differ in their curricular activities, content inputs, transaction modes, local issues, commitment and attitude of teachers etc.

Dear student it is your turn to identify the factors which pose barrier for comparing students' math performance in the following groups,

### **3. School to district**

#### **4. Student to state/national level?**

Indeed, for similar reasons it is not easy to compare the math performance of students from one group to another.

Thus, you are now convinced that comparison of assessment is not so simple without equity! One way is to bring in some modifications in the assessment tasks keeping in mind the equity.

However, any comparison (across sites as in 1 and 2 or levels as in 3 and 4) should be justified and examined either statistically or by a judgmental lining process. This brings the assessment format into picture. Did you know that formats of assessment do impact on the performance?! Some studies on this reveal that (de Lange, 1987);

- Certain formats favour boys more than girls,
- boys do better under time pressure than girls;
- girls seem to fare better when there is more language involved;
- certain contexts are more suited for boys, others for girls;
- cultural differences do impact on students' performance.

There is, therefore a need for assessment to cater to various contexts (such as, background culture of students, school culture, perceived intelligence etc.).

Assessment formats should get modified to cater to various levels of students and also for students with varying culture. For such reasons only assignment of both individual and group work as well as the use of both time-restricted (formative tests may in the form of written tests/performances or time bound activities such as experimenting in math lab etc.) and unrestricted assignment (projects, out of the school activities etc.). Thus offering wide variety of opportunities for assessment only can make the assessment fair. If the assessment is fair that means equity component has been taken care of to a great extent! If equity exists then comparability is no more an issue.

Thus, the framework should make provisions to incorporate various types of assessment tasks eliciting the same math content depending upon the ability/style with which they have grasped the content. This discussion has focused and answered the first question we raised in the beginning.

The second question that was raised under 'equity and opportunities' involves questions of whether students have the opportunity to learn important mathematics (whether they have been taught the important mathematics that is being assessed in manner required). Yes for reasons of equity, all students need to have the experience of getting 'the important mathematics' assessed. This means that every student's experience should be so that he is taught the important math 'in that manner itself' in which it is being asked in the assessment.

It is agreeable that whatever is tested by the assessment tasks, should have become part of their math curriculum and have been taught it. Then such an experience makes it the **curriculum of all students**. This means the contents of curriculum are to be interpreted in

the similar manner by all schools and so should be the transactions. Students should have the opportunity to learn the material tested. This makes a democratic path way for all students to receive similar teaching of mathematics. This helps in giving the same exposure to all students who undergo teaching of specific math content.

Dear student, when do we say that math is learnt by students? Yes! when they learn the content prescribed along with the process involved. Let us know this better.

All math chapters and units should be analyzed and the learning points in each of them to be listed as 'math content' and list the process involved in learning against each of them. You get a table of the form given below as a sample.

### Important learning in the mathematics of standard X of Karnataka secondary board

Sl. No.	Units covered	Math content	Process involved
1	3	Commercial Mathematics	Budgeting Estimation Calculation

Dear student you might be wondering as to how can this help solve equity problem?

This guides the teacher to expose students during transaction, to those specific mathematics process that have been identified. Also focus on imbibing those processes among students with a simultaneous reflection (in order to develop insight of student learning). If every school of the state and nation follow this, then such a curriculum becomes **curriculum of all!** In such case, where is the problem of equity?

This clearly indicates that the mathematics curriculum should convey 'single voice' with regard to interpretation of math content and math process. **These math processes provide bench mark as criteria for assessment.** This clarifies that comparison of results of assessments should be with performance criteria!

The third question that we raised under 'equity and opportunities' involves aspects that are associated with pedagogical aspects. We all agree that assessment tasks do have positive impact on students learning. Then as a right, should not such an assessment be accessible to all students?

According to NCF-2005, vision of mathematics instruction requires a pedagogy that helps students learn mathematics that is accessible to them and relevant to their lives. This requirement affects assessment as well. Dear student it is to your awareness that whenever the assessment tasks pose challenging math problems then most students cannot even make efforts to attempt those questions. This means that such assessment tasks are giving them a feeling that mathematics is not approachable. This could be for various reasons such as, Students,

- Lack experience of learning of that particular content during instruction.
- some are scared by the challenging questions posed in the assessment tasks who close off even without responding to those tasks which they know!

To make the assessment approachable, assessment must provide ways for every student to begin work on the posed problem even if they cannot complete them as fully or as their teachers wish them to. One important consequence of posing more complex problems is, students start feeling superficially the complexity of other problems also! It is very important that prior planning is made to construct assessments that provide access and are approachable.

## **B. Openness and Generalization: Standard - IV**

### **a. Openness:**

Math testing like testing of any other subject, had been quite a secretive process. i.e., both the test questions and answers were carefully guarded, and criteria for judging performance were generally set behind the scenes by authorities unknown to students. This tradition is on-going, even these days. On the contrary many believe that open and dynamic assessment serve the students best. This speaks about the assessment where expectations and scoring procedures are openly discussed and jointly negotiated. Consider the following illustrations.

Saraswathi, class teacher of 8<sup>th</sup> grade of an unaided school in Putturu, was excited. She had reasons for her excitement. She gave a test the previous day on 'construction of circles'. Today she took the assessment questions and involved students in the process of preparing scheme of marking. It was a wonderful experience where students asked everything what they wanted to know about the mechanism of assessment such as,

- How much marks can be allotted for individual steps?
- What is the most significant part of answer to a question?
- What general aspects are not supposed to be a part of assessment?
- Should language be given top most priority? Why?

Finally they all came to a consensus of a format and criteria of assessment. She heard some girls talking..."if the teacher had done this earlier I would've had the idea to prepare myself for the test and would have performed better".

Dear student, what did you infer from the above citation?

Students need to know from teachers,

- what is expected of them as response,
- procedure used to score their work,
- what are the components of good explanation etc.
- samples of model responses of various assessment tasks if available is to be used as a reference.
- Teachers should have examples of all the different tests possible, exhaustively along with scoring rubrics and possible student work.
- Students should be made to understand why these tests are given, and what will be done with the results

Unfortunately, standardized tests (a Standardized test is a test that is administered and scored in a consistent or 'standard' manner) cannot be administered to a large population of students if students are made to know all of the above information in advance! Schwarz (1992). (find the reference).

But presently there are approaches to the filing, indexing, and retrieving of previously used problems, that are Publicly available. Richly indexed databases of problems and projects provide opportunity for scrutiny, discussion, and debate about the quality and correctness of questions and answers. It seems that it may not be a long way to go, to reach this! Dear student you agree that, openness and clarity are prerequisites for any proper classroom assessment system.

### **b. Generalization:**

As you are aware, comprehensive evaluation leads its path through 'alternative assessments'. But inferences that can be made using alternative assessments have become an issue. Discussion on the following questions may throw some light on this:

- a. What generalizations do the teachers make using the results of alternative assessment?
- b. How far are the generalizations thus made are justifiable?
- c. To what extent can an teacher generalize from a student's score in the following context?

- on a particular set of tasks to other tasks?

The example below gives an idea above shows :

Pramila is wondering about Parveen as it is obvious from previous experiences that Parveen is unable to add when carry-overs are there. But astonishingly gave the correct total when orally asked to add five 3digit numbers!

- on the assessment format of a task to other formats?

Observe the following for clarity

Venkatalakshmi held three assessment formats out of which two prepared by herself and the third one prepared by her friend. She administered all of them and obtained students' score. She was wondering looking at them, although all of them assessed the learning on the same concept, which one is the best in assessing the learning of the students?

- on the occasion of assessment to the other occasions (during formative test and after summative test)?

On a very calm and pleasant day Joyce as declared earlier gave group assessment activities such as 'role play' from daily life situations, on a math topic 'profit and loss'. She had instructed that she would assess them in group. The role play was witnessed by her fellow math teacher Lakshmi as well. Students could do very well. Later she gave a written test on the same content. She found 65% students could extend their understanding and answer but the rest of the students in an utter confusion state.

- on a particular scorer to other scorers?

Joyce confused, decided (situation continued from the above) to consider the first group activity for the assessment and scored the students. Later she made Lakshmi who had also witnessed the role play to assess them in groups, just for curiosity. To her surprise, they differed a lot! This was even more evident when openly both discussed.

Dear student, as you have observed all the discussion and the citations, you must have understood that there are plenty of issues regarding generalization of the results of alternative assessment. Let us see if this can be tackled and fixed.

In order to generalize, one way is to accumulate evidences in the focused areas most extensively till date. This depicts consistency and suggests good reliability of the assessment process.

Do you think that accumulating evidences is easy? It is not! This demands systematic training of the raters/assessors. The assessment framework for math instruction suggests that for generalisation to be justified, the raters should have undergone systematic training in the following areas.

- to use explicit criteria for scoring responses in an organized manner
- to use well-chosen responses, as exemplars in assigning performance levels.

This can bring uniformity in generalization to some extent.

## **Standard - V**

### **Inferences**

Assessment task should not end as mere collection of tasks but the evidences obtained from them should lead to some sort of inference. Changes in formative assessment have resulted in new ways of thinking about reliability and validity as they apply to mathematics assessment. Observe the following illustration:

Mr. Sridhar sitting in the staff room is worried. He is asking his fellow teacher “Mahadev, you know Ragini could not get her division problems right in last week’s test. Today I gave the same test to students.....but to my surprise Ragini got 2 of her problems right! Now I am worried about the reliability of the test items!

Dear student you know that reliability is that factor of a test which makes a test trustworthy as it fetches same evidence (same marks) any number of time you administer it. Probably with this background if you read the above citation, you will have a better grasp! From the above citations what can be inferred? Can we doubt the reliability of the question item?

The above example helps you to grasp that when assessment is embedded within instruction, it becomes synonym to learning experience and highlights students’ strong and weak points thus catering to better learning.

At this point it becomes unreasonable and meaningless to expect and apply the standard idea of reliability! You recollect the idea of reliability of an assessment task which says that a student’s achievement on similar tasks at different points in time should be similar. When the new outlook is to view assessment as part of the teaching and learning process, reliability in the traditional sense is something to be avoided once and for all! Presently if we offer the students the same tests at different moments, we should note differences,

- in levels of increment gain in learning,
- may be in the use of different strategies,
- may it be different answers in some cases.

This is welcome change in understanding the concept of reliability. Instead if the tests yield the same results (and thus are reliable), then our teaching has failed! That means new forms of assessment prompt a re-viewing of traditional notions of validity, reliability etc. Nevertheless, it is difficult to know how new types of assessment (e.g., student projects or portfolios) can be used for decision making without either collapsing them into a single score (thereby losing all of their conceptual richness) or leaving them in their raw, un-simplified, and difficult-to-interpret form. In classroom assessment, what is more important is the **authenticity of the tasks i.e., examining performance against the criterion situations.**

The above discussion has helped you to understand the various standards that the assessment frame work for math instruction should possess. All the points above discussed give away some valuable principles that should be focused on while using assessment in math instruction.

### **Principles for Classroom Assessment**

Jan de Lange in his book on 'Frame for class room assessment in math', list following principles :

1. The main purpose of classroom assessment is to improve math learning (Gronlund, 1968; de Lange, 1987; Black & Wiliam, 1998; and many others).
2. The mathematics is embedded in worthwhile (engaging, educative, authentic) problems that are part of the students' real world and mathematics assessment should follow the same foot print.
3. Methods of assessment should be such that they enable students to reveal what they know, rather than what they do not know (Cockcroft, 1982).
4. A balanced assessment plan should include multiple and varied opportunities (formats) for students of varied abilities to display and document their achievements (Wiggins, 1992).
5. Assessment Tasks should operationalize all the goals of the curricula (not just the "lower" ones). In order to achieve this, plan for performance standards, including indications of the different levels of mathematical thinking (de Lange, 1987).
6. Assessment criteria should be made public and consistently applied; and should include examples of earlier grading of that student, showing his/her exemplary work and work that is less than exemplary.
7. The assessment process, including scoring and grading, should be open to students.
8. Students should have opportunities to receive genuine feedback on their work.
9. The quality of a task is not defined by its accessibility to objective scoring, reliability, or validity in the traditional sense but by its worthiness to solve a problem (authenticity), fairness, and the extent to which it meets the above principles.

Dear students, any math teacher who takes his/her math instruction seriously, uses the above principles as a "check list".

### **Check Your Progress - 2**

1. Is comparing Math performance of students from, 'school to school, state to state, school to district, student to state/national level Possible? Why?
2. What is the meaning of **Curriculum of all**?
3. Mention various principles for class room assessment of Math instruction.

#### 4.3.4. Let us Summarise

This unit covers the following aspects

- Focus areas for the assessment framework: Math content, learning of specific math, equity and opportunity, openness and generalization, inferences
- Principles of classroom assessment

#### 4.3.5. Answer to ‘Check Your Progress - 1 and 2’

##### Check Your Progress - 1

1. There are two aspects to assessment of content in mathematics:
  - Mathematical Reasoning
  - Mathematical process involved in response of the assessment.
2. Logical reasoning, If and then reasoning, Estimation, Calculation, Manipulation, Pattern identification, Construction, Tabulation, Budgeting, making connections, Averaging, Translation, Inductive and deductive thinking, using symbols appropriately, apply math idea to real life situation, generalization, problem solving, etc.

##### Check Your Progress - 2

1. Comparison of assessment is not so simple without equity! One way is to bring in some modifications in the assessment tasks keeping in mind the equity.
2. Whatever is tested by the assessment tasks, should have become part of their math curriculum and have been taught it. Then such an experience makes it the **curriculum of all students**.
  - The main purpose of classroom assessment is to improve math learning (Gronlund, 1968; de Lange, 1987; Black & Wiliam, 1998; and many others).
  - The mathematics is embedded in worthwhile (engaging, educative, authentic) problems that are part of the students’ real world and mathematics assessment should follow the same foot print.

#### 4.3.6. Unit end Exercises

1. How does assessment tasks for Mathematization differs from Routine assessment task?
2. Mention any 2 assessment activities that deviate from traditional ones.
3. Why should assessment tasks align with the learning experiences?
4. Explain with illustrations the two aspects of any math contact.
5. What assessment is embedded in math instruction, the assessment becomes learning experiences- substantiate.
6. Explain Three areas of ‘equity and opportunity’ in the light of math Assessment Frame work.
7. Analyse the use of Alternative assessment in the light of openness, generalizaion and inference of class room assessment in math.

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## **Block 4 : Assessment, Evaluation and Mathematics Teacher**

### **Unit 4 : Diagnostic Tests**

#### **Unit Structure**

- 4.4.1. Learning Objectives
- 4.4.2. Introduction
- 4.4.3. Learning Points and Learning Activities
  - 4.4.3.1. Meaning, Need and Levels of Diagnostic Test  
Check Your Progress - 1
  - 4.4.3.2. Characteristics and Construction and Uses of Diagnostic Test  
Check Your Progress - 2
- 4.4.4. Let us Summarise
- 4.4.5. Answers to 'Check Your Progress - 1 and 2'
- 4.4.6. Unit end Exercises
- 4.4.7. References

#### **4.4.1. Learning Objectives**

After completing this Unit, the student teachers will be able to

- Explain the meaning of Diagnostic Test;
- Explain the need for Diagnostic Test;
- State the levels of Diagnostic Test;
- Specify the Characteristics of Diagnostic Test;
- Explain the steps of Constructing a Diagnostic Test; and
- State the uses of Diagnostic Test.

#### **4.4.2. Introduction**

Teaching is a challenging task because it involves not just transfer of knowledge but many other aspects related to a pupils development. Many a times a teacher might feel that inspite of teaching in a satisfying manner the outcome from the pupils is not satisfactory. In such cases there arises a need to rectify what went wrong so that the teacher can correct on those aspects for a better outcome from the pupils. Sometimes it could be the teaching method or the content of teaching while other times it could be the pupil's outlook towards learning. Whatever may be the problem it is the duty of the teacher to find out means and methods so that the pupils learning become complete. To aid and assist in diagnosing the learning gap of student Diagnostic tests are useful. In this Unit we shall see what Diagnostic Test is and how to construct it.

#### **4.4.3. Learning Points and Learning**

##### **4.4.3.1. Meaning, Need and Levels of Diagnostic Test**

#### **Exercise 1**

Recall your classroom and answer as to what you would do if your student/students fared badly in test given by you?

I am sure you would have answered that you would find out why the student/students have done badly in their test. May be you would call the student and ask him why he/she has fared badly and they would give a personal reason for their failure. Have you ever used any specific procedure to find out why the student has fared badly? It not just enough if we just in

general try to find out why the student has not done well in the test but use a systematic procedure to know why and where exactly has the student gone wrong. This is called as Diagnostic Test. Let us now see what Diagnostic Test is, why we need it and what its characteristics are.

### **A. Meaning of a Diagnostic Test**

English and English (1958) have defined a diagnostic test as “ One designed to locate the particular source of a person’s difficulties in learning, especially in school subjects, thus providing clues to what further measures of instruction, guidance, or study are needed”.

A diagnostic test is a test designed to locate specific learning deficiencies in case of ‘specific individuals’ at a specific stage of learning so that ‘specific efforts’ could be made to overcome those deficiencies. It helps the teacher in identifying the status of the learner at the end of particular lesson, unit or course of learning as to what ‘specific teaching or learning points’ have been properly grasped by the learner. If such a deficiency is located in several students, it becomes obvious to the teacher to reflect upon whether something went wrong with his method of teaching. It is also possible that the entire group of students suffering from that particular learning difficulty might not have the basic knowledge required for benefitting from further learning. After administering a diagnostic test or a battery of diagnostic tests to students, a teacher takes remedial measures to overcome the deficiencies thus discovered.

### **Educational Diagnosis**

As obvious, the term diagnosis has been borrowed from the medical profession where it implies “identification of diseases by means of patient’s symptoms”. The word diagnosis is used more or less in the same sense in education. The only difference perhaps is that in medical diagnosis it is physical or an organ breakdown that is examined, while in educational diagnosis it is the failure of the process of education or learning that is located and attended to be remedied. We may say that educational diagnosis is “the determination of the nature of learning difficulties and deficiencies”. Of course, it cannot stop only at the identification of weaknesses in learning but has to go a little deeper to locate their causes and also suggest remedies for getting rid of them.

### **B. Need for Diagnostic Test**

Most standardized and teacher made achievement tests are designed to give an indication of how far the student has progressed towards the accomplishment of specific objectives measured by the test. These objectives however are grouped in broad categories. They cover a broad area and result in a total score which reflects overall achievement in the area tested. Thus, the teacher can say that the pupil is doing well in arithmetic or poorly in arithmetic, but they do not know why, nor do they know what the concepts are causing difficulty. It will identify students who are having relative difficulty in an area, but it will not identify the causes of the difficulty. Such survey (achievement) tools serve useful functions, but in order to help the student with disability, the teacher will need to analyze the nature of the difficulty and the causes for the trouble. There are tests which have been devised to provide information about the specific nature of pupil’s difficulties in given subject areas. These tests are called diagnostic tests. Any test can be used as a diagnostic test in a limited way by examining student’s performance in the individual items which make up the test rather than on the test as a whole. Thus, diagnostic tests measure somewhat narrower aspects of achievement than survey tests. In other words, diagnostic tests yield measures of highly related abilities underlying achievement in a subject. They are designed to identify particular strengths and weaknesses on the part of the individual child and within reasonable limits to

reveal the underlying causes. The diagnostic test attempts to break a complex skill like computation into related parts such as addition, subtraction, multiplication and division and to provide separate measures of these sub-skills. Such measures can help the teacher locate the sources of difficulty using which constructive action can be taken.

### C. Levels of Diagnosis

Good diagnosis moves hand in hand with good teaching and a teacher should be as much concerned with it as with the latter. Ross and Stanley have identified five levels of diagnosis, which are

1. Who are the pupils having trouble?
2. Where are the errors located?
3. Why did the errors occur?
4. What remedies are suggested?
5. How can the errors be prevented?

The first four are grouped as corrective diagnosis and the last is known as preventive diagnosis. Most of the diagnosis resorted to by teachers will be corrective in nature by which measures are taken to make up the deficiencies while the highest form will remain preventive diagnosis with the help of which deficiencies are prevented from occurring. The immediate concern of the teacher may be correction. The corrective diagnosis can be done at the following levels

- a) **Classification:** It is the process of sorting out students into groups particularly of underachievers and lower achievers. The reference point for each student, should rightly be his own expected achievement and students have to be classified with regard to their levels of expected achievement. If they have not reached their expected level of performance, they will be the ones who are in need of remediation. However, if they have crossed their level, some enrichment programme may be planned to help them improve their achievement further.
- b) **Finding the nature of the difficulties:** In this level of diagnosis the specific areas of difficulties have to be identified. Achievement test, unit test, etc can be used for this purpose as they cover as many learning points as possible. The item-wise analysis of such test helps in locating the weakness of the students. If most of the students do poorly on a particular learning point, it is an indication that something is wrong with the instruction relating to that point. But this type of analysis gives no ideas regarding the causation of these errors which will have to be sought by other means.
- c) **Finding the causes of difficulties:** This is the most difficult stage in diagnosis. The main difficulty of this stage lies in the fact that a test appraises only the products only the products of learning and not the process of learning. They may establish where the breakdown in learning has taken place but can seldom reveal anything about the causes of it. These causes are generally varied and complex in nature. We have to seek them in different areas, some of which need not be connected in any way with classroom instruction or school. Broadly speaking, underachievement may be due to factors within the student, or environmental factors outside the control of the students or a combination of the two.

Most of the causes internal to the students may however be located in the areas of scholastic aptitude, retardation of basic skills, study habits, physical factors and emotional factors. Tools such as interviews, checklists, rating scales, questionnaire etc can be used to locate the causes of difficulties.

- d) Providing Remedial Measures:** After identifying the causes of the difficulties, the next stage is planning and applying remedial measures. There is however, no set pattern and no cut-and tried formulae for remediation. In some cases, it may be a simple matter of review and re-teaching. In others, an extensive effort to improve motivation, correct emotional difficulties and overcome deficiencies in work and study habits may be required. The hard fact is that, for two students having the same learning difficulty may have suffered it, because of different causes and may have to be tackled differently. Moreover, since each individual is unique, remedial programmes have to be planned accordingly. Obviously, the planning of remedial programmes will differ considerably from individual to individual.

Despite the different methods and techniques needed in remediation, there are certain guiding principles that apply to all subject area and provide a framework in which the teacher can co-operate.

- Remediation should be accompanied by strong motivational programme.
- Remediation should be individualized in terms of the psychology of learning.
- There should be continuous evaluation giving the pupil knowledge of results.
- Remediation programme may not always need a separate time allocation. But they will always need some extra work for both the teachers and the affected students.

- e) Preventing the difficulties from occurring:** Prevention is better than cure in education as elsewhere. A programme of diagnostic testing should help an imaginative teacher in getting an insight into the types of possible errors that are likely to occur in learning, their possible causes and the ways of preventing them in future. Thus educational diagnosis does not and should not end at remedial measures, but also should become a means for improving instruction, modifying curriculum and also for refining instructional materials and strategies. The real importance is rather in the prevention of its reappearance elsewhere under similar conditions. Any weakness identified should form the basis for decisions relating to reducing the probability for their recurrence in the future.

### **Check Your Progress - 1**

1. What is a Diagnostic Test?
2. Specify the need for Diagnostic Test.
3. What are the levels of Diagnosis in Education?

### **4.4.3.2. Characteristics, Construction and Uses of Diagnostic Test**

#### **Exercise 2**

If you were asked to find out the reasons for the poor performance of a pupil in a particular test, what procedure would you follow?

You might have your own plans of how you would go about finding out the reason for the poor performance of a pupil. Now let us see what characteristics of an effective Diagnostic Test are and how to construct it and also analyze it's uses.

### **A. Characteristics of an effective Diagnostic Test**

Cook, Walter W. (1958) has stated the following characteristics of an effective diagnostic test

1. It should be an integral part of the curriculum, emphasizing and clarifying the important objectives.
2. Its test items should require responses to be made to situations approximating as closely as possible to be functional.
3. It must be based on experimental evidence of learning difficulties.
4. It should reveal the mental processes of the learner sufficiently to detect points of error.
5. It should suggest or provide specific remedial procedures for each error detected.
6. It should be designed to cover a long sequence or learning systematically.
7. It should be designed to check forgetting, by constant review of difficult elements as well as to detect faulty learning.
8. It should reveal pupils progress in objective terms.

### **B. Construction of Diagnostic Test**

Diagnostic tests may be standardized or teacher made, but teacher made diagnostic tests will be more effective and economical than standardized tests. The norms which constitute a strong point with standardized tests are not called for in diagnosis as the purpose is to discover the weaknesses of individual students rather than compare their achievements.

The preparation of a diagnostic test requires a special technique different from the one used for building a survey test. Nevertheless, the stages of preparation will be more or less the same as in the case of survey tests. The difference mainly lies in the details of these stages.

The designing of a diagnostic test is significantly different from a survey test. A teacher requires much more data on the specific difficulties of the pupils. Diagnostic tests have therefore to be much longer than survey tests to make necessary subtests sufficiently reliable. It also requires a more detailed content analysis. The unit on which a diagnostic test is based should be broken into learning points with an attempt not to omit any of them. The diagnostic procedure is based on the assumption that mastery of the total process can be no stronger than that of the weak link in the chain of related concepts or skills. Accordingly, each concept, skill or learning point called into play in the test process is identified at the time of designing and then measured.

As far as a diagnostic test is concerned, it is not very important to know the relative importance of the various learning points as it is in the case of survey tests. We are not to decide their relative weightage. The basic principle is to cover all of them to give an unbroken sequence. Perhaps for each learning point, an adequate number of questions will have to be given to provide decisive evidences.

All the forms of questions can be employed for testing different learning points. As we want to collect evidence on all the points, it is desirable to use either short answer or objective type questions. Supply type of questions seem, however, to have an edge over selection type because they reveal the process of thinking in addition to the product of thinking. Such questions will help the student who wants to respond in a manner different from what is provided for in the responses. It appears, therefore, that for diagnostic test, short answers involving one or two steps be preferred especially in subjects like Mathematics. Whatever be the form of questions, they should in general be easy ones.

No rigid time limit need be specified in the case of diagnostic test. Diagnosis should be individualized as much as possible and every student should be allowed as much time as he reasonably needs.

It may be noted that as we do not have to relate content and process, the preparation of a blueprint may altogether be avoided in a diagnostic test. The items are designed so as to throw light on the weaknesses of the students and therefore the questions have to be specifically related to the learning points. The scope of the answer or the level of precision expected should also be made clear.

After the items on different learning points are written, they have to be assembled into a test. The basis of arranging test items in diagnostic test is entirely different from other tests. There appears to be a good deal of justification in favour of clubbing questions around learning points even when they are of different forms. The learning forms themselves can be arranged in increasing order of their complexity. If they are so arranged, the students do not have to change their mental sets very frequently. Moreover, this arrangement also helps in analyzing the responses of students with a view to identify their weaknesses, which is one of the important tasks in diagnostic testing.

To complete the test, a set of instruction may be drafted. It should also be provided with a scoring key and marking scheme. Finally the test is edited and reviewed to weed out inaccuracies or lapses of wording etc.

The steps in constructing the diagnostic test may be summarized as follows

- Identification of the problem
- Detailed content analysis.
- Listing all the learning points
- Arranging the learning points in the logical sequence
- Writing test items, (preferably two or three items for free response type) for each learning point
- Clubbing the items around the learning points
- Providing clear instructions
- Preparing scoring key and marking scheme.
- Providing the time limit as required by individual students.
- Administration of the test

After administering the test, the following procedure may be followed for analyzing the performance and identifying the weaknesses

- Item-wise analysis of the performance of each student.
- Qualitative and quantitative analysis for identifying the strengths and weaknesses.
- Identification of the causes for learning difficulties.
- Preparation of a diagnostic chart for each student.
- Planning and implementing highly individualized remedial programmes.
- Evaluating the effectiveness of the programme.

### **C. Uses of Diagnostic Tests**

Following are the uses of diagnostic test

The diagnostic tests

- Point out inadequacies in specific skills.

- Locate areas in which individual instruction is required.
- Furnish continuous information in order that learning activities may be most productive of desirable outcomes.
- Serve as a basis for improving instructional methods, instructional materials and learning procedures.

#### **Check Your Progress - 2**

1. What are the Characteristics of effective Diagnostic tests?
2. List the steps in construction of a Diagnostic Test

#### **4.4.4. Let us Summarise**

- **Meaning of Diagnostic Test:** One designed to locate the particular source of a person's difficulties in learning, especially in school subjects, thus providing clues to what further measures of instruction, guidance, or study are needed".
- **Need for Diagnostic Test:** diagnostic tests yield measures of highly related abilities underlying achievement in a subject. They are designed to identify particular strengths and weaknesses on the part of the individual child and within reasonable limits to reveal the underlying causes. The diagnostic test attempts to break a complex skill like computation into related parts such as addition, subtraction, multiplication and division and to provide separate measures of these sub-skills. Such measures can help the teacher locate the sources of difficulty using which constructive action can be taken.
- **Levels of Diagnosis**
  1. Classification
  2. Finding the nature of difficulties
  3. Finding the cause of difficulties
  4. Providing remedial Measures
  5. Preventing the difficulties from occurring
- **Characteristics of an effective Diagnostic Test**  
Cook, Walter W. (1958) has stated the following characteristics of an effective diagnostic test
  1. It should be an integral part of the curriculum, emphasizing and clarifying the important objectives.
  2. Its test items should require responses to be made to situations approximating as closely as possible to be functional.
  3. It must be based on experimental evidence of learning difficulties.
  4. It should reveal the mental processes of the learner sufficiently to detect points of error.
  5. It should suggest or provide specific remedial procedures for each error detected.
  6. It should be designed to cover a long sequence or learning systematically.
  7. It should be designed to check forgetting, by constant review of difficult elements as well as to detect faulty learning.
  8. It should reveal pupils progress in objective terms.
- **Steps for Construction of Diagnostic Test**
  - Identification of the problem
  - Detailed content analysis.

- Listing all the learning points
  - Arranging the learning points in the logical sequence
  - Writing test items, (preferably two or three items for free response type) for each learning point
  - Clubbing the items around the learning points
  - Providing clear instructions
  - Preparing scoring key and marking scheme.
  - Providing the time limit as required by individual students.
  - Administration of the test
- **Procedure for analyzing the performance and identifying the weaknesses**
    - Item-wise analysis of the performance of each student.
    - Qualitative and quantitative analysis for identifying the strengths and weaknesses.
    - Identification of the causes for learning difficulties.
    - Preparation of a diagnostic chart for each student.
    - Planning and implementing highly individualized remedial programmes.
    - Evaluating the effectiveness of the programme.
  - **Uses of Diagnostic Tests**

The diagnostic tests

- Point out inadequacies in specific skills.
- Locate areas in which individual instruction is required.
- Furnish continuous information in order that learning activities may be most productive of desirable outcomes.
- Serve as a basis for improving instructional methods, instructional materials and learning procedures.

#### 4.4.5 Answers to ‘Check Your Progress - 1 and 2’

##### Check Your Progress - 1

1. One designed to locate the particular source of a person’s difficulties in learning, especially in school subjects, thus providing clues to what further measures of instruction, guidance, or study are needed”.
2. Diagnostic tests yield measures of highly related abilities underlying achievement in a subject. They are designed to identify particular strengths and weaknesses on the part of the individual child and within reasonable limits to reveal the underlying causes. The diagnostic test attempts to break a complex skill like computation into related parts such as addition, subtraction, multiplication and division and to provide separate measures of these sub-skills. Such measures can help the teacher locate the sources of difficulty using which constructive action can be taken.
3. Levels of Diagnosis
  - Classification
  - Finding the nature of difficulties
  - Finding the cause of difficulties
  - Providing remedial Measures
  - Preventing the difficulties from occurring

## Check Your Progress - 2

### 1. Characteristics of an effective Diagnostic Test

Cook, Walter W. (1958) has stated the following characteristics of an effective diagnostic test

1. It should be an integral part of the curriculum, emphasizing and clarifying the important objectives.
  2. Its test items should require responses to be made to situations approximating as closely as possible to be functional.
  3. It must be based on experimental evidence of learning difficulties.
  4. It should reveal the mental processes of the learner sufficiently to detect points of error.
  5. It should suggest or provide specific remedial procedures for each error detected.
  6. It should be designed to cover a long sequence or learning systematically.
  7. It should be designed to check forgetting, by constant review of difficult elements as well as to detect faulty learning.
  8. It should reveal pupils progress in objective terms.
1. The steps in constructing the diagnostic test may be summarized as follows
- Identification of the problem
  - Detailed content analysis.
  - Listing all the learning points
  - Arranging the learning points in the logical sequence
  - Writing test items, (preferably two or three items for free response type) for each learning point
  - Clubbing the items around the learning points
  - Providing clear instructions
  - Preparing scoring key and marking scheme.
  - Providing the time limit as required by individual students.
  - Administration of the test

#### 4.4.6. Unit end Exercises

1. Explain the meaning of Diagnostic Test.
2. Justify the need for Diagnostic Test in Mathematics.
3. What are different Characteristics of an effective Diagnostic Test.
4. What is meant by Diagnosis in Education? Explain.
5. Explain the steps in the construction of a Diagnostic Test.
6. Elaborate the steps of analyzing the performance and identifying the weakness of a pupil.
7. Elaborate the uses of Diagnostic Test.

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## **Block 4 : Assessment, Evaluation and Mathematics Teacher**

### **Unit 5 : Remedial Teaching in Mathematics Instruction**

#### **Unit Structure**

- 4.5.1. Learning Objectives
- 4.5.2. Introduction
- 4.3.3. Learning Points and Learning Activities
- 4.5.3.1. Types of Learning styles  
Check Your Progress - 1
- 4.5.3.2. Educational Implications of using multi-sensory strategies for remedial measures in Mathematics  
Check Your Progress - 2
- 4.5.3.3. Selection of Remedial measures  
Check Your Progress - 3
- 4.5.4. Let us Summarise
- 4.5.5. Answer to ‘Check Your Progress - 1, 2 and 3’
- 4.5.6. Unit end Exercises
- 4.5.7. References

#### **4.5.1. Learning Objectives**

After completing this Unit, the student teachers will be able to

- Explain the importance of remedial measure in mathematics teaching;
- Mention some tips for selecting methods for remedial teaching;
- List out some of the methods for remedial measures; and
- Suggest remedial measure for a problem area in the learning of mathematics.

#### **4.5.2. Introduction**

In the previous unit we have discussed in detail about the diagnostic tests, need & importance as well as construction of diagnostic tests

Mathematical understanding and reasoning are essential components of success in all walks of life. How did this precious mathematics subject teach or learn?

The following difficulties among the secondary and higher secondary students are a common feature,

- More than half of the students incorrectly measure the units.
- Often get confusion between the areas and volumes in the word problem and between square and cubic units.
- Students performance on measurement task decreases significantly when the numbers are in fraction.
- Students have poor understanding in random and non- random distribution of objects.
- Poor understanding in the algebraic identities.
- Students have found difficulties in solving algebraic word problems.
- Difficulties in trigonometrically ratios for the beginners of trigonometric concept.
- Understanding in trigonometry identities.
- Application of integral calculus

Most teachers teaching math are aware of this fact. But they do not know how they can help them. It appears most students in many schools are memorizing the concept without understanding. Teachers need to include in each teaching presentation at least three basic learning modalities (auditory, visual, and tactile), to meet the needs of most students and this may work as remedy to most of students' problems.

In order to remediate students in a certain area, it's important first to understand the definition of remedial. remedial instruction is the process of providing help to students who are experiencing difficulties so that they can understand and master the concept with which they are struggling. In math, each concept is the foundation for new learning, and when a student has not mastered one concept they are unable to move on to the next concept. In this case, remediation helps to get the student back on track so they can continue their learning on the math continuum.

Teaching remedial math means that you will be working with students who might be missing foundational skills that are required for learning higher level concepts. Whether because of a learning difficulty or another situation that impacted their learning, these are students, for example, who may not have mastered adding one-digit numbers and are now being asked to add two-digit numbers with regrouping.

This unit will provide methods and strategies that you can use to effectively teach students who need remediation in math.

### **4.5.3. Learning Points and Learning Activities**

#### **4.5.3.1. Types of Learning styles**

##### **Exercise 1**

Dear students, have you through your schooling observed that different people of different methods and styles of learning. Can you recall a few types? What type of learning style do you possess, write in the space below.

I am sure you would have observed that every student have their own learning style which could be different from the others. As there are students with different learning styles, the teachers' teaching may not be matching to their style of learning. Let us know about the various styles of learning.

##### **A. Types of Learning styles**

- a) **Kinesthetic style:** Learning through doing: The kinesthetic learners must do something to learn it. This person is actively involved in learning and loves to flex those large motor muscles. There is a lot of body movement going on when these learners are in their learning. Students build false interpretations of geometrical terms from their exposure to a limited number of static pictures in text. For example, many students claim that two lines cannot be parallel unless they are in the same length or are oriented vertically or horizontally.
- b) **Tactual style:** Learning through sensations and teaching: The tactual learner learns through the sense of touch and small motor experiences. Tactual learners are also often aware of the emotional signals, subtle and blatant, that others send. They may be sensitive to odors in their environment. They often are adept at using their hands, and

they benefit from touching things to get to know them better. These are the tree - hands-on learners. Examples we show the clear figure of the Pythagoras theorem by means of Paper folding.

- c) **Auditory style:** Learning through hearing Auditory learners love discussion, and can readily be overheard by teachers in a classroom situation, describing mathematical relationships and thereby indicating the developing state of their insight and understanding of the topic begins learn by listening, remembering what was discussed rather than seen, speak in rhythmic patterns , talk to themselves while working, move their lips and pronounce the words as they read, enjoy reading aloud and listening, can repeat back and mimic, can find writing difficult, are better at telling , are frequently eloquent speakers are talkative, love discussion, and go into lengthy descriptions. Example: we record the trigonometry ratios by songs. All the ratios in the trigonometry are between 1 and 0. These types of learning they learn more interestingly and understand the concept correctly.
- d) **Visual style:** Learning by seeing: When it comes to more formal math instruction, there are specific techniques that will help make it more accessible to visual learn. They prefer the study materials like charts, filmstrips, notes and flashcards, a picture is a worthy way more than a thousand words, so seeing math problems represented in 3D cartoon format is incredibly useful. Almost every child's educational software publisher has created at least one math program for children. every focusing in the content to be learned is to be highlighted with different colours so that such students notice and learn the similar way.

Dear student we discussed various learning styles of students. As there exists differences in their learning styles any one type may not suit the others and learning may not take place. It becomes important for a teacher to first identify the need for remedial teaching.

## **B. Need for remedial teaching**

### **a) Identify the need**

Imagine someone goes to a doctor and complains about 'acidity' problem. The doctor interacts and comes to know about the symptoms of acidity. Doctor now is sure of about the patient suffering acidity. But he knows that to fix this problem without knowing the issue it is not going to be fixed. He wanted some more information. The doctor is aware that 'acidity' is the symptom of so many diseases. You don't have enough information yet to really diagnose how to fix the issue.

This is how you need to approach remedial teaching. You can't just throw a bunch of ideas or strategies at the problem and hope something works for the student. You must first identify the specific area in which the student is struggling so you can begin to create a plan and strategies for remediation.

Using the example of the student struggling with one digit addition - you need to figure out if he hasn't mastered one digit addition because he has spatial difficulties that are interfering with his ability to regroup. Or has he even mastered counting? You would first need to identify what is causing the difficulty before you can begin working to help the student learn.

## **b) Use a Variety of Approaches**

Math education lends itself especially well to approaching concepts from a variety of different angles. Just think of the wide variety of ways students can solve a simple addition problem. They can draw a picture of objects and count them, use manipulatives, write a story, count on a number line, or count in their head. When teaching remedial math, it is important to explore as many approaches to learning as possible to help your students.

For example, you may have to teach a student who is struggling with comparing fractions. For some reason, this student may just not grasp this concept, no matter how hard they try. Sitting down with the student, you discover that the student is just staring at the fractions trying to will the answer into existence.

The best strategy that can be used for remedial measures of math learning is to use multisensory strategies.

Multisensory strategies in mathematics teaching: Almost all math curriculums are text-based, auditory style programs (remember reading is an auditory activity, not a visual activity because reading involves words processed as language, and not visual image processing). - When students are able to represent a problem or mathematical situation in a way that is meaningful to them, it becomes more accessible. Using representation - whether drawings, mental images, concrete materials, or equations—helps students organize their thinking and try various approaches that may lead to a clearer understanding and a solution. (Fennell & Rowan, 2001) Mathematics is an abstract and cognitive subject. Being abstract nature of mathematics most of the student find difficult to perceive it. Teachers are constantly looking for ways or tools to help their pupils understand the underlying concepts of the lessons. Multi-sensory instruction is a highly creative instructional method and the strategy tailored to meet out the individual needs, abilities and learning styles. Learning mathematics through the multi-sensory integrated learning strategies are able to increase the students understanding and build a knowledge base for each of the content area effectively.

### **Check Your Progress - 1**

1. Mention various types of learning styles of students
2. How would you identify the need for remedial teaching?

### **4.5.3.2. Educational Implications of using multi-sensory strategies for remedial measures in mathematics**

#### **Exercise 2**

Think of why we need Remedial Teaching and write in the space below.

As you answered you have thought of its uses both at the personal level and at the educational level now let us discuss its educational implications.

The following are the educational implications:

- Being abstract nature of mathematics, it is difficult for the students to learn mathematics. Multi-sensory strategies through ICT make student's attention towards their study.
- It is a more effective method which brings the concepts to the memory storage for long period of time in long term memory store and enthusiasm towards their subject.

- Learning by doing is more effective methodology than any other method. Multi-sensory strategies fulfill all their needs.
- The influences of Multi-sensory strategies make the mathematical activities to be undertaken and provide powerful guide to teachers making choices about pedagogical approaches and classroom organization.
- Using Multi-sensory Integration strategies can help pupils to access, select and interpret information, recognize patterns, accuracy, review and modify their work to improve the quality, communicate with others and present information, evaluate their work, improve their efficiency, be creative and take risks, gain confidence and independence
- Teacher should select or create mathematical tasks that take advantage of what Multi-sensory Integration strategies can do effectively and well-graphing, producing dynamic images, computing and providing access to data.
- In most classrooms, there will be at least one student that needs remediation in math. This is a situation every teacher faces and the methods and strategies detailed in this lesson will help you effectively aid your students.

However, since mathematics education should enable students for mathematization and visualization of abstractness etc., multisensory integration may sometimes curb the ability to visualize.

As you know it is very important that as a teacher your educational diagnosis of students in mathematics does not end at only identifying the specific learning difficulties. You follow it up until difficulty no more exists. Any diagnostic test should further direct towards providing remedial measure.

You have witnessed that normally people suffering from similar diseases get similar treatment i.e., similar remedy for their equivalent problems. This is true since the cause of the disease /problem (in most cases) is same for all. But can the same remedy happen in educational diagnosis? Why don't you explore it by participating in the following illustration?

When a topic on **'Translating problem situations into mathematical sentences'** was taught to a secondary class of 30 students it was noticed that 5 students failed to learn. When diagnostic test was administered, the missing of links (i.e. pre-requisite links) which caused these learning difficulties, were identified as follows:

Students lacked one or more of the following links:

- **Knowledge of basic operations and symbols e.g. Addition (+), subtraction (-), multiplication (x) and division (/), equal (=), greater than(>), less than (<)**
- **Translation of word phrases into mathematical phrases. E.g. '5 times 2' is a word phrase while its mathematical counterpart is  $2 \times 5$  and not  $5 \times 2$ .** (There are students who understand '5 times 2' as  $(5+2)$  or  $(2+5)$  also!)
- **Minimum language vocabulary required to understand, associate the word phrase, mathematical operations and mathematical phrases.** (Usually you notice that vocabulary is a common stumbling block in way of solving statement problems.)

The students who have failed to learn the topic ‘**Translating problem situations into mathematical sentences**’, might be suffering from any one or more of the above identifying areas which created learning difficulty. Thus you have noticed that all five students have failed to learn the ‘**same**’ learning point (every learning point itself is a competence). But their disabilities are **different**, (i.e. pre-requisites are different.) Do you think you can plan for a common remedial measure, to all five? Therefore remedial work should be prescribed to meet a problem area which is specific to individuals.

You will also notice that many times ‘problems of learning’ mathematics is approached more effectively by clarifying just a mathematical principle than by mechanical drill on isolated facts.

One very good e.g., for this will be this: It is much more effective to have students discover and understand the ‘role of zero and one’ with respect to multiplication than to drill on ‘all facts’ in which 0 & 1 are factors!

### **Check Your Progress - 2**

1. What are the educational implications of using multisensory strategies for remedial measures? (any 4)

### **4.5.3.3. Selection of Remedial measures**

#### **Exercise 3**

Think how would you plan Remedial Lesson for your mathematics class for needy students and write in the space below.

Let us now discuss how to select methods for selecting Remedial Measures.

Here are a few tips that may help you for selecting methods for remedial measures:

- Before planning for remedial measure, make sure that you have gained as much information as possible regarding the specific areas of difficulty.
- To motivate the students, include meaningful problems as far as possible. Community based problems will be worth solving.
- Instead of making the students only to work out problems, change their roles by encouraging them to write/create some problems. This no doubt stimulates interest in them.
- To boost their self-confidence (which is very important for effective learning), start the remedial work with simple problems.
- Giving compliments for deserving students no doubt enhances the speed of learning as well as the effectiveness.
- Some exercises should be framed for refining skills. Such exercises should stress, speed & accuracy.
- The exercises should be of various types including oral and written responses.

Remediation programmes in mathematics may not always require a separate time allocation for them. Yes of course, they always mean some extra work for both teacher and the affected students. This could also be an integrated part of regular teaching. Little more attention to under achievers, keeping in mind their weakness to learn and also providing well planned assignments that are geared to remove their difficulties will certainly do the trick! Never forget that remedial teaching is not any other different type of teaching, it is just ‘**GOOD TEACHING**’!

Sometimes a question like, “**can’t we prevent such learning difficulties among students?**” may arise in you. You are right for, ‘prevention is better than cure’ in education also, as elsewhere. If you happen to be a classroom teacher for fairly a long period, you would even sense that prevention is not only better but also easier than cure.

The basic purpose of diagnosis can very well be used in the prevention of learning difficulties of students. The teacher through intellectual anticipation of the probable areas causing difficulties can do this. Indeed it may be reiterated that the ultimate goal of educational diagnosis should be prevention. If this becomes the purpose of every mathematics teacher, then in future you can hardly find any mathematics phobic!

Remedial instruction in mathematics is the process of providing help to students who are experiencing difficulties in learning mathematics concepts so that they can understand and master concept with which they are struggling.

Thus, Remedial work not only aims at bringing 100 percent accuracy but also at a reasonable rate of speed i.e., it stresses on both speed and accuracy.

### **Check Your Progress - 3**

1. When do you plan for a remedial work in mathematics?
2. Mention only 4 tips for selecting methods for remedial work.

#### **4.5.4. Let us Summarise**

This unit covers the following aspects

- Meaning, need and importance of remedial teaching
- Approaches to identify the problem in math learning.
- Educational implications of using multi-sensory strategies for remedial teaching in mathematics.
- Suggestions for selecting remedial measures

#### **4.5.5. Answer to ‘Check Your Progress - 1, 2 and 3’**

##### **Check Your Progress - 1**

1. Types of Learning styles
  - Kinesthetic style:
  - Tactual style:
  - Auditory style:
  - Visual style:
2. You must first identify the specific area in which the student is struggling so you can begin to create a plan and strategies for remediation. Using the example of the student struggling with one digit addition - you need to figure out if he hasn't mastered one digit addition because he has spatial difficulties that are interfering with his ability to regroup. Or has he even mastered counting? You would first need to identify what is causing the difficulty before you can begin working to help the student learn. Math education lends itself especially well to approaching concepts from a variety of different angles. They can draw a picture of objects and count them, use manipulative, write a story, count on a number line, or count in their head. When teaching remedial math, it is important to explore as many approaches to learning as possible to help your students.

### Check Your Progress - 2

- Being abstract nature of mathematics, it is difficult for the students to learn mathematics. Multi-sensory strategies through ICT make student's attention towards their study.
- It is a more effective method which brings the concepts to the memory storage for long period of time in long term memory store and enthusiasm towards their subject.
- Learning by doing is more effective methodology than any other method. Multi-sensory strategies fulfill all their needs. The influences of Multi-sensory strategies make the mathematical activities to be undertaken and provide powerful guide to teachers making choices about pedagogical approaches and classroom organization.

### Check Your Progress - 3

1. After planning for remedial measure, make sure that you have gained as much information as possible regarding the specific areas of difficulty.
2. Tips for Selecting Methods for Remedial Work.
  - To boost their self-confidence (which is very important for effective learning), start the remedial work with simple problems.
  - Giving compliments for deserving students no doubt enhances the speed of learning as well as the effectiveness.
  - Some exercises should be framed for refining skills. Such exercises should stress, speed & accuracy.
  - The exercises should be of various types including oral and written responses.

#### 4.5.6. Unit end Exercises

1. Explain the types of learning styles.
2. Discuss the need for Remedial Teaching
3. Explain the Educational Implications of using multi-sensory strategies for remedial measures in mathematics
4. How would you select Remedial Teaching in Mathematics? Discuss
5. How would you plan for remedial work on the topic 'polygons'?
6. How would you use multisensory strategies to provide remedial measures for a math topic of your choice?

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## **Block 4 : Assessment, Evaluation and Mathematics Teacher**

### **Unit 6 : Competencies and Characteristics of Mathematics Teacher**

#### **Unit Structure**

- 4.6.1. Learning Objectives
- 4.6.2. Introduction
- 4.6.3. Learning Points and Learning Activities
  - 4.6.3.1. Competencies of Mathematics teacher  
Check Your Progress - 1
  - 4.6.3.2. Mathematical competencies that a math teacher should possess  
Check Your Progress - 2
  - 4.6.3.3 Characteristics of a mathematics teacher  
Check Your Progress - 3
- 4.6.4. Let us Summarise
- 4.6.5. Answer to ‘Check Your Progress - 1, 2 and 3’
- 4.6.6. Unit end Exercises
- 4.6.7. References

#### **4.6.1. Learning Objectives**

After completing this Unit, the student teachers will be able to

- List the general competencies of a Mathematics teacher;
- Mention the Mathematical competencies of a math teacher;
- Cite example for each of the competencies of math teachers from math content; and
- The various characteristics of a math Identify.

#### **4.6.2. Introduction**

For an effective math class, there is no ‘one size fits all’ approach and what works well for you at your school may not work well for another at their – and vice versa. A ‘good’ math’s lesson can be as varied in scope, structure, content and delivery as the degree of difference in teachers and classrooms- i.e., potentially infinite! But to a great extent, it depends on the ingenuity of the teacher. The very nature of math concepts is that no math lesson exists in isolation. That means each lesson you teach will be one component of a broader topic. A ‘good mathematics lesson’ will always necessarily be a part of a sequence of lessons which will ideally build mathematical understanding, improve fluency, build problem solving capacity and then develop mathematical reasoning skills. It is needless to say that the math teacher should be competent enough to develop these skills and much more! In this Unit let us discuss what they are

#### **4.6.3. Learning Points and Learning Activities**

##### **4.6.3.1. Competencies of Mathematics teacher**

##### **Exercise 1**

Dear student, discuss with your friends and identify ‘what should effective math instruction look like?’

May be your identification matches with what Shellard and Moyer (2002) have identified. They identify three critical components that should prevail in a good math instruction. They are:

The teaching of mathematics, should result in,

- a. Developing conceptual understanding
- b. Developing children's procedural literacy, and
- c. Promoting strategic competence using meaningful problem-solving investigations

To possess mathematical competence means having knowledge of, understanding, doing, using and having a well-founded opinion about mathematics in a variety of situations and contexts where mathematics plays or can play a role. Competence of a math teacher can be defined as the **necessary teacher behaviour** for the conservation of components that constitutes effective mathematics teaching and learning at least within the structure of classrooms and schools. Shellard and Moyer's identification too confines to similar ideas. Competent mathematics teacher is someone who in an effective and efficient way, is able to help his or her students build and develop mathematical competencies.

### **A. Pedagogical Competencies That a Teacher Should Possess with Particular Regard to Mathematics**

**1. Curriculum competency:** To analyse, assess, relate to, and implement existing mathematics curricula and syllabi, and to construct new ones.

**2. Teaching competency:** To devise, plan, organise and carry out mathematics teaching, create rich spectrum of teaching/learning situations; find, assess, select and create teaching materials; inspire and motivate students; discuss curricula and justify teaching/learning activities with students.

**3. Uncovering of learning competency:** To uncover, interpret and analyse students' learning of mathematics, as well as their notions, beliefs and attitudes towards mathematics. Includes identifying development with the individual student.

**4. Create a testing pathway:** Testing is not something separate from your instruction. It should be integrated into your planning. Give a five – minute quiz to confirm students have mastered the math skill covered in the day's lesson. Now-a-days capable digital resource designed to monitor your students in real time are available. These can be invaluable tools. This takes care of finding a path way to test the students. But assessment itself is a competency.

**5. Assessment competency:** To identify, assess, characterize, and communicate students' learning outcomes and competencies, so as to inform the stake holders and assist the individual student. This includes selecting, modifying, constructing, critically analyzing, and implementing a varied set of assessment forms and instruments to serve different formative and summative purposes. All of these have to be geared toward different categories of recipients in different situations, and at different levels, paying attention to the individual student's needs and opportunities.

**6. Collaboration competency:** To collaborate with different sorts of colleagues in and outside mathematics, as well as others (parents, authorities) concerning mathematics teaching and its conditions.

**7. Professional development competency:** To develop one's own competency as a mathematics teacher (a meta-competency), including participate in and relate to activities of professional development, such as in-service courses, projects, conferences; reflect upon one's own teaching and needs for development; keep oneself up-dated about new developments and trends in research and practice.

### **Check Your Progress - 1**

Mention various competencies of a math teacher.

#### **4.6.3.2. Mathematical competencies that a math teacher should possess**

##### **Exercise 2**

List the different mathematical competencies that a teacher should possess to be efficient in his/her teaching.

A competent mathematics teacher must possess the eight competencies to a degree relevant for the educational level on which his / her teaching takes place. In this unit an effort is made to provide you with the significance of each math competency so that you identify the significance a math teacher possessing the same.

The math teacher should possess the following eight competences under two major categories:

- a) **The ability to ask and answer questions in and with mathematics:** This ability demands the possession of the following competencies:
1. Mathematical thinking competency – mastering mathematical modes of thought
  2. Problem handling competency – formulating and solving mathematical problems  
Modelling competency – being able to analyse and build mathematical models concerning other subjects or practice areas
  3. Reasoning competency – being able to reason mathematically.
- b) **The ability to deal with mathematical language and tools:** This ability demands the possession of the following competencies:
1. Representation competency – being able to handle different representations of mathematical entities
  2. Symbol and formalism competency – being able to handle symbol language and formal mathematical systems
  3. Communication competency – being able to communicate, in, with, and about mathematics
  4. Aids and tools competence – being able to make use of and relate to the aids and tools of mathematics.

## **A. Competencies under the ability to ask and answer questions in and with mathematics:**

- a) Mathematical thinking competency:** Mathematical competence is the ability to develop and apply mathematical thinking in order to solve a range of problems in everyday situations. Let us deal this competency rather in a detailed manner. Mathematical thinking is looking at things (be it numerical, structural or logical) analytically by breaking them down to their essentials, in order to identify the underlying patterns. It transforms the math content and the learning to artistry by taking away math from drudgery.
- b) Problem handling competency:** Students should be engaged in solving problems posed in math class, as well as those that occur in real-life situations. They should be encouraged to construct new mathematical meaning from their problem-solving efforts. First, students must make sense of problems, make connections to the math they know, and then translate the problems into mathematical terms. According to the NCTM (2000), Good problem solvers "monitor and reflect on the process of mathematical problem solving" and adjust their use of strategies as needed. By analyzing the significance of this competence for both learner and teacher, NCTM declared that "Problem solving must be the focus of school mathematics in the 1980s" (NCTM 1980).
- c) Mathematical modelling:** A Mathematical model is a description of a system using Mathematical language. Mathematical models are used in almost all fields of education. Mathematical Models can range from simple to complex. Mathematical modelling uses real world problems which blends theoretical constructs and practical consideration as a basis for teaching mathematics skills, competencies, and applications. The teacher with this competency is able to move through intricate concepts of how students perceive math, how instructors teach and how both can become better learners.

A teacher who is competent in math modelling,

- **Always try to find some ways in the maths** he/she teaches related to the real world. For example: while teaching division (sharing equal between groups), teacher can connect with sharing of an apple with a friend or more!
- **'Make the maths visible' in other subjects**, by drawing attention to, or providing a verbal explanation of, how mathematics is used across in other academic disciplines as and when you are teaching them.
- structure the field or situation to be modeled.
- Mathematize (i.e., interpreting mathematical models in terms of 'reality' to 'mathematics').
- DE mathematize (i.e., interpreting mathematical models in terms of 'reality').
- Tackle the model (working within the mathematics domain).
- validating the model.
- reflect, analyze, offer critique of models and model results.
- communicate about the model and its results (including the limitations of such results).
- Monitor and have control of the modelling process.

**d) Reasoning competencies:** Mathematical reasoning is a part of mathematics where we determine the truth values of the given statements. But what is the role of a math teacher in this? Prominent role a math teacher is an inbuilt structure in mathematics to provide ample opportunities for such reasoning. This competence developed through the teaching of math, go a long way in helping students to apply in daily life situations. Now let us know what aspects are involved in mathematical reasoning.

Thinking and **reasoning competencies** mean more than simply using your mind to produce thoughts. But it is the ability to use your thought process to form conclusions, inferences, or judgments.

## **B. The ability to deal with mathematical language and tools:**

### **a) Representation competency**

Representational competence in mathematics is the ability to use representations meaningfully to understand and communicate mathematical ideas and to solve problems. In mathematics education, a representation is a way of encoding an idea or a relationship, and can be both internal (e.g., mental construct) and external (e.g., graph). Thus, multiple representations are ways to symbolize, to describe and to refer to the same mathematical entity. They are used to understand, develop, and to communicate different mathematical features of the same object or operation, as well as connections between different properties. Multiple representations include graphs and diagrams, tables and grids, formulas, symbols, words, gestures, software code, videos, concrete models, physical and virtual manipulatives, pictures, and sounds, number lines, graphs, arrangements of concrete objects or manipulative, physical models, mathematical expressions, formulas and equations, or depictions on the screen of a computer or calculator – that encode, stand for, or embody mathematical ideas or relationships. Though equations and graphs are the most common types of mathematical models, there are other types that fall into this category. Some of these include pie charts, tables, line graphs, chemical formulas, or diagrams.

To call something a representation thus includes reference to some meaning or signification it is taken to have. Such representations are called *external* – i.e., they are external to the individual who produced them, and accessible to others for observation, discussion, interpretation, and/or manipulation.

Very aptly Representations can be understood as the thinking tools for doing mathematics. Representation in mathematics play critical role not only on deepening students learning of mathematics, but also in providing students with multiple entry points and access to the study of mathematics. The National Research Council(2001) noted "mathematics requires representations. In fact, because of the abstract nature of mathematics, people have access to the mathematical ideas only through the representations of those ideas".

A math teacher competent in this uses representations to "organize, record, and communicate mathematical ideas" NCTM.

The use of multiple representations supports and requires tasks that involve decision-making and other problem-solving skills. Estimation, another complex task, can strongly benefit from multiple representations. Teachers who aim at conceptual understanding first and then move to developing procedural fluency, frequently use multiple representations for

their instruction. This helps the teacher in developing deeper understanding of the abstract concepts and connections between them.

This competence if the math teacher possesses, then the following benefits are the consequences!

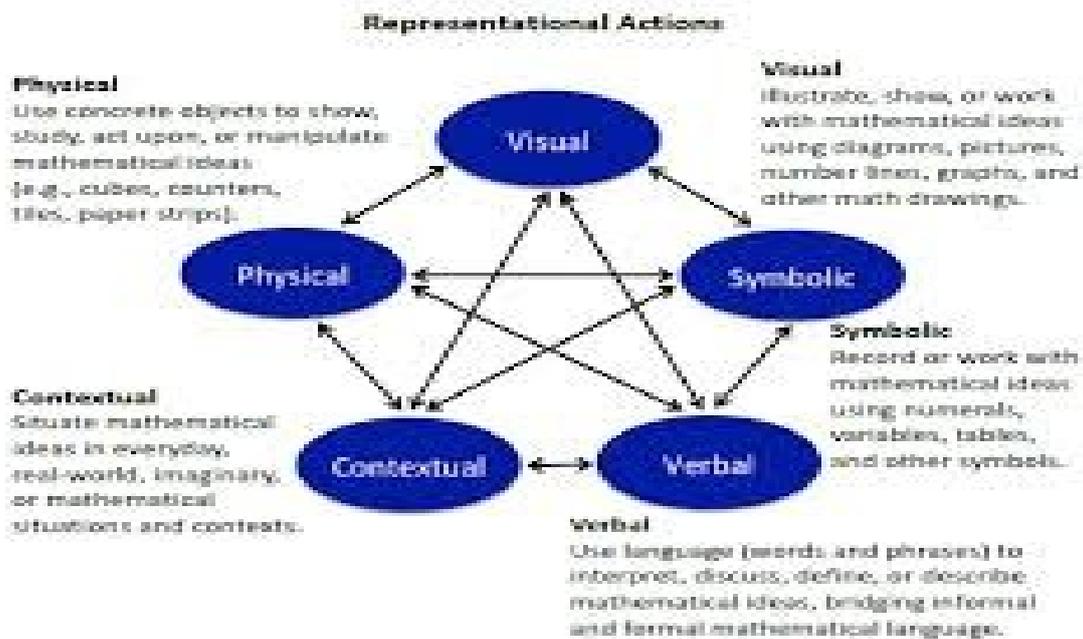
Tasks that involve multiple representations can sustain intrinsic motivation in mathematics, by supporting higher-order thinking and problem solving.

Representations play critical role in not only deepening student learning of mathematics, but also in providing students with multiple entry points and access to the study of mathematics. The National Research Council (2001) noted, "Mathematics requires representations. In fact, because of the abstract nature of mathematics, people have access to mathematical ideas only through the representations of those ideas".

In considering implications for classroom practice, DeAnn Huinker in his paper, **Representational Competence: A Renewed Focus for Classroom Practice in Mathematics** suggest the following abilities as illustrative of proficiency or competence in using representations meaningfully in mathematics:

Representational competence includes

- being able to convey a mathematical idea in various forms;

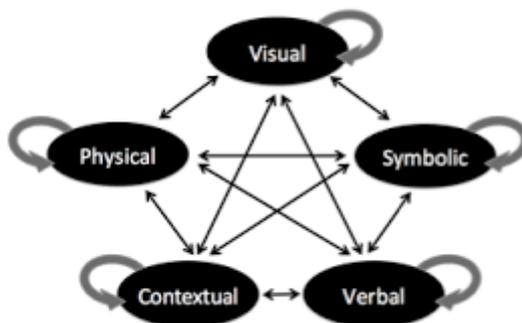


- Knowing when and why it is appropriate or valuable to use particular mathematical representations;

Visual Representations	Verbal Representations	Contextual Representations	Physical Representations	Symbolic Representations
Illustrate, show, or work with mathematical ideas using diagrams, pictures, number lines, graphs, and other math drawings.	Use language (words and phrases) to interpret, discuss, define, or describe mathematical ideas, bridging informal and formal mathematical language.	Situate mathematical ideas in everyday, real-world, or imaginary situations, using a variety of discrete and continuous measures (e.g., people, meters, yards).	Use concrete objects to show, study, act upon, or manipulate mathematical ideas (e.g., cubes, counters, tiles, paper strips).	Record or work with mathematical ideas using numerals, variables, tables, and other symbols.

Figure 2. Representational actions.

- Being able to translate between and within modes of representations and



- being able to use representations flexibly to solve problems

- b) Symbol and formalism competency:** Means being able to handle symbols and formal mathematical language that is to
- decode symbol and formal language
  - translate back and forth between Mathematical symbol language and natural language
  - Treat and utilize symbolic statements and expressions, including formulas)
  - Use variables, solve equations and perform calculations

This means Understanding, manipulating and making use of symbolic expressions; using constructs based on definitions, rules and conventions, formal systems. This competency seeks to develop understanding

**c) Communication competency:**

Math teachers have traditionally focused on teaching content, whereas to expand their instruction to promote students' mathematical practice skills there are more challenging standards that encouraging teachers can do, most of which depend heavily on learning to communicate effectively about math. Recent studies also have shown that there is consensus among teachers that effective communication is critical for more rigorous instruction and

deeper mathematics learning. Of late, many math teaching materials and resources include tasks that require effective communication. It is to your awareness also that if we do not create a platform where they are communicating about math effectively, students receive little or no instruction on how to do so! Naturally, this sets them up for failure. It is the teachers' competence to explicitly teach these essential skills and give ample opportunities to practice independently, is the need of the hour. A math teacher who is competent in math communication can in turn develop awareness among students regarding the aspects that make math talk and math writing effective.

### **The Essentials of Mathematical Communication for a teacher:**

Mathematics is a language of its own. It has its own communication, which is an essential part of mathematics and mathematics education. It is a way of sharing ideas and clarifying understanding. Development in mathematics has occurred only because of math communication. Through communication, ideas become objects of reflection, refinement, discussion, and amendment. The same idea is expressed by NCTM when it said, "The communication process also helps build meaning and permanence for ideas and makes them public" (National Council of Teachers of Mathematics [NCTM], 2000, p. 60).

This standard requires that teachers establish a learning environment in which students develop the habit of reflection through conversation, beginning in the early grades. NCTM has rightly prescribed communication as one of its standards. This standard is explicit in emphasizing the importance of following aspects:

Students being able to,

- "organize and consolidate their thinking through communication,"
- "communicate their mathematical thinking coherently and clearly to their peers, teachers, and others"
- "analyze and evaluate the mathematical thinking and strategies of others"
- "use the language of mathematics to express mathematical ideas precisely".

The above expectations for students can become true only by teachers who are competent in all the above-mentioned abilities.

There can be two considerations of this competence viz., Incoming and outgoing.

Incoming communication includes reading, decoding, interpreting statements and mathematical information.

Outgoing communication includes explaining, presenting and arguing.

A math teacher who is competent in math communication incorporate the following activities in order to encourage and involve the students to prepare to share their thinking:

- Review what they know about math related to the topic,
- Make mathematical connections,
- Organize their ideas,
- Determine the relative importance of their ideas to the math topic,
- Decide which ideas to share with others,
- Identify the appropriate mathematical vocabulary terms to use when communicating their ideas,

- Compose a statement that clearly explains their ideas, and then
- Express their thinking orally, with representations, and/or in writing.
- Additionally, students must use the following skills in conversations or when reading other students' written communications:
- Listen to or read others' mathematical ideas,
- Compare those ideas to what they already know and think,
- Construct new knowledge or meaning by melding the new ideas with their own thinking,
- Decide what thoughts to include in a response,
- Compose a response, and
- Deliver the response.

When students are actively engaged in multiple methods of communication, the roles of teacher and learner intermingle. As a result, teaching and learning become more visible to both teachers and learners.

#### **d) Aids and tools competence**

Scaffolding is very important in math instruction to develop deeper and meaningful understanding of math content. A math teacher who is competent in using aids and tools makes use of manipulative as aids and tools. Manipulation tools make it easier for students to learn and understand basic skills. These are ideal when students learn best through hands-on-experience and building rather than traditional lessons and repetition.

The use of blocks, fruits, balls or other manipulation tools help students learn the basics of place value, addition, subtraction and other areas of basic math. According to Kate Nonesuch on the National Adult Learning Database of Canada, manipulation tools help show down the process of problem solving so that students are able to fully understand the information.

Thus a competent mathematics teacher must possess the above mentioned eight competencies to a degree relevant for the educational level on which his / her teaching takes place.

#### **Check Your Progress - 2**

1. Mention various mathematical competencies that a math teacher is expected to possess.

#### **4.6.3.3. Characteristics of a mathematics teacher**

##### **Exercise 3**

Think about, what personal characteristics of a mathematics teacher would make him/her to be very effective and write in the space below.

To be competent enough in the above-mentioned competence a math teacher should possess some characteristics. They have been listed as given below:

- Interested in the subject math as well as to teach mathematic
- Positive attitude towards mathematics and its teaching
- Knowledge of subject matter
- Inspiration to do drill work
- Knowledge of individual differences

- Knowledge of different teaching methods
- Power to know the difficulties of the students
- spend lots of time on concept formation
- conceptual understanding of core knowledge required in the practice of teaching
- Fluency in carrying out basic instructional routines
- strategic competence in planning effective instruction and solving problems that arise during instruction
- mindful delivery, which means approaching our lessons remembering that getting into the minds of our students usually requires conscious effort. some ideas for this are, **allow mathematics to be playful; Tell stories to exemplify concepts; Use a range of resources; Remember the importance of ‘student voice’**

### Check Your Progress - 3

What are the characteristics of Math teacher?

#### 4.6.4. Let us Summarise

##### ➤ Six competencies of math teachers

- Collaboration competency
- Curriculum competency
- Teaching competency
- Uncovering of learning competency
- Create a testing pathway
- Professional development competency

##### ➤ Math competencies of a math teacher

###### a) The ability to ask and answer questions in and with mathematics:

This ability demands the possession of the following competencies:

- Mathematical thinking competency – mastering mathematical modes of thought.
- Problem handling competency – formulating and solving mathematical problems.
- Modelling competency – being able to analyse and build mathematical models concerning other subjects or practice areas.
- Reasoning competency – being able to reason mathematically.

###### b) The ability to deal with mathematical language and tools:

This ability demands the possession of the following competencies:

- Representation competency – being able to handle different representations of mathematical entities
- Symbol and formalism competency – being able to handle symbol language and formal mathematical systems
- Communication competency – being able to communicate, in, with, and about mathematics
- Aids and tools competence – being able to make use of and relate to the aids and tools of mathematics.

#### 4.6.5. Answer to ‘Check Your Progress - 1, 2 and 3’

##### Check Your Progress - 1

A competent mathematics teacher must possess six pedagogical competencies with particular regard to mathematics

1. Curriculum competency:
2. Teaching competency
3. Uncovering of learning competency:
4. Create a testing pathway  
Assessment competency
5. Collaboration competency
6. Professional development competency

##### Check Your Progress - 2

###### a) The ability to ask and answer questions in and with mathematics:

This ability demands the possession of the following competencies:

- Mathematical thinking competency – mastering mathematical modes of thought
- Problem handling competency – formulating and solving mathematical problems
- Modelling competency – being able to analyse and build mathematical models concerning other subjects or practice areas
- Reasoning competency – being able to reason mathematically.

###### b) The ability to deal with mathematical language and tools:

This ability demands the possession of the following competencies:

- Representation competency – being able to handle different representations of mathematical entities
- Symbol and formalism competency – being able to handle symbol language and formal mathematical systems
- Communication competency – being able to communicate, in, with, and about mathematics
- Aids and tools competence – being able to make use of and relate to the aids and tools of mathematics.

##### Check Your Progress - 3

###### 1. Characteristics of a mathematics teacher

To be competent enough in the above-mentioned competence a math teacher should possess some characteristics. They have been listed as given below:

- Interested in the subject math as well as to teach mathematic
- Positive attitude towards mathematics and its teaching
- Knowledge of subject matter
- Inspiration to do drill work
- Knowledge of individual differences
- Knowledge of different teaching methods
- Power to know the difficulties of the students
- spend lots of time on concept formation
- conceptual understanding of core knowledge required in the practice of teaching
- Fluency in carrying out basic instructional routines
- strategic competence in planning effective instruction and solving problems that arise during instruction

- mindful delivery, which means approaching our lessons remembering that getting into the minds of our students usually requires conscious effort.

#### **4.6.6. Unit end Exercises**

1. Which are the Pedagogical Competencies that a Teacher should possess with particular regard to Mathematics?
2. Elucidate Mathematical competencies that a math teacher should possess
3. What are the characteristics of a Mathematics Teacher?
4. Distinguish between the competencies of a Math teacher with that of math competencies of a math teacher.
5. Cite illustrations for eight math competencies of a math teacher.

#### **4.6.7. References**

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