ful but infuses a keener interest into the study and provides one of the most powerful motives for the continued pursuit of work in this field.

**Motivation through Mathematics Clubs and Recreations**

It is a rare individual, especially child, who is not interested in games or in things which are unusual or unsuspected and which contain elements of surprise or of mystery. While mathematical puzzles, contests, and games cannot be permitted to pre-empt too much of the time allotted to regular class work, there is abundant evidence that the moderate and appropriate employment of such devices does add much of interest and zest to the courses.

Mathematics clubs provide an excellent means of stimulating and fostering mathematical study. Such clubs offer excellent opportunities for free consideration of matters of special interest to the members without the necessity of having the programs follow any particular organic sequence of topics such as is generally necessary in regular class instruction. Mathematical recreations are valuable and legitimate in relieving the tedium of necessary routine work and in presenting an aspect of mathematics the existence of which is at times not even suspected.

In life, objectives help to focus our attention and efforts; they indicate what has to be accomplished. In education, objectives indicate what the students have to learn; they are explicit formulations of the ways in which students are expected to be changed by the educative process. Objectives are especially important in teaching because teaching is a intensional and reasoned act. Teaching is intentional because it is primarily to facilitate student learning. Teaching is reasoned because what teachers teach their students is judged by them to be worthwhile.

The reasoned aspect of teaching relates to what objectives teachers select for their students. The intensional aspect of teaching concerns how teachers help students to achieve the objectives, that is, the learning environments the teachers create and the activities and experiences they provide. The learning environment, activities, and experience should be aligned with, or be consistent with, the selected objectives.
Need For a Taxonomy

What can teachers do when confronted with what they believe to be an exceedingly large number of vague objectives? To deal with the problem of vagueness, they need to make the objectives more precise. In a nutshell, teacher need an organizing frame work that increases precision and, most important, promotes understanding. A taxonomy is a special kind of frame work. In a taxonomy the categories lie along a continuum The objectives are classified in a taxonomy. A statement of an objective contains a verb and a noun. The verb generally describes the intended cognitive process. The noun generally describes the knowledge students are expected to acquire or construct. The most useful form for stating objectives is to express them in terms which identify both the kind of behaviour to be developed in the student and the content.

The structure of objectives

The domain of objectives is presented as a continuum ranging from quite general to very specific. Along this continuum, Krathwohl and Payne (1971) identified three evels of specificity called global. Educational and instructional guidance objectives, with the later commonly referred to as instructional objectives.

Global objectives are complex, multifaceted learning outcomes that require substantial time and instruction to accomplish. A global objective is something presently out of reach; it is something to strive for, to move toward, or to become. For teachers to use global objectives in their planning and teaching, the objectives must be broken down into a more focused, delimited form. Educational objectives describe student behaviour and some content on which the behaviour will be performed. Educational objectives occupy the middle range on the objective continuum. As such, they are more specific than global objectives but more general than the objectives needed to guide the day-to-day class room instruction that teachers provide. The purpose of instructional objectives is to focus teaching and testing on narrow, day-to-day slices of learning in fairly specific content areas.

Relationship of Global, Educational and Instructional Objectives

<table>
<thead>
<tr>
<th>LEVEL OF OBJECTIVES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope</td>
</tr>
<tr>
<td>Time Needed</td>
</tr>
<tr>
<td>Function</td>
</tr>
</tbody>
</table>

In terms of scope, global objectives are broad, whereas instructional objectives are narrow; that is, global objectives do not deal with specifics, and instructional objectives deal only with specifics. Global objectives may require one or even many years to learn, whereas instructional objectives can be mastered in a few days. Global objectives provide vision that quite often becomes the basis for support for educational programmes. At the other end of the spectrum, instructional objectives are useful for planning daily lessons.

Bloom’s Taxonomy

Following the 1948 Convention of the American
Psychological Association, B.S. Bloom took a lead in formulating a classification of “the goals of the educational process”. Three “domains” of educational activities were identified: Cognitive, Affective and Psychomotor Cognitive is for mental skills, Affective is for growth in feelings or emotional area, while Psychomotor is for manual or physical skills. Bloom and his co-workers established a hierarchy of educational objectives, which is referred to as Bloom’s Taxonomy, while attempts to divide objectives into subdivisions ranging from the simplest behaviour to the most complex.

Cognitive domain is demonstrated by behaviour related to intellectual skills: comprehending information, organizing ideas, analyzing and synthesizing data, choosing among alternatives in problem solving, and evaluating ideas or actions.

Affective domain is demonstrated by behaviour indicating attitudes of awareness, interest, attention, concern, ability to listen and respond in interactions with others.

Psychomotor learning in demonstrated by physical skills like co-ordination, dexterity, manipulation, grace, strength, speed and actions which demonstrate the fine motor skills such as use of instruments or tools.

**Instructional Objectives: Cognitive Domain**

**Knowledge**

Knowledge is remembering of previously learned material. This may involve the recall of a wide range of materials, from specific facts to complex theories. In the knowledge level, the child knows only the information. This does not mean the information is meaningful to the student. Knowledge represents the lowest level of learning outcomes in the cognitive domain.

**Comprehension**

Comprehension is defined as the ability to grasp the meaning of material. This may be shown by translating material from one form to another (words to symbols) by interpreting material (estimating future trends (predicting consequences or effects). These learning outcomes go one step beyond the simple remembering of material, and represent the lowest level of understanding.

**Application**

Application refers to the ability to use learned material in new and concrete situations. This may include the application of such things as rules, methods, concepts, principles, laws and theories. Learning outcome in this area require a higher level of understanding than those under comprehension.

**Analysis**

Analysis refers to the ability to break down material into its component parts so that its organizational structure may be understood. This may include the identification of parts, analysis of the relationship between parts, and recognition of the organizational principles involved. Learning outcomes here represent a higher intellectual level than comprehension and application because they require an understanding of both of the content and the structural form of the material.

**Synthesis**

Synthesis refers to the ability to put parts together to form a new whole. Learning outcomes in this area stress creative behaviours, with major emphasis on the formulation of new patterns or structure. Examples of learning objectives at this level are: write
a well organized theme, propose a plan for an experiment, integrate learning from different areas into a plan for solving a problem, formulate a new scheme for classifying objects.

Evaluation

Evaluation is concerned with the ability to judge the value of material for a given purpose. The judgment are to be based on definite criteria. Learning outcomes in this area are highest in the cognitive hierarchy because they contain elements of all the other categories, plus conscious value judgments based on clearly defined criteria. Examples of learning objectives at this level are: judge the logical consistency of written material, judge the adequacy with which conclusions are supported by data.

Many of the behaviours of an individual are controlled more by feelings and emotions rather than by cognition. A student of mathematics who develops genuine interest in reading books related to mathematics, organizing mathematical recreational activities like puzzle context is a person who has undergone changes in his feelings and emotions. Such behaviours are said to be changes in the affective domain.

Instructional Objectives: Affective Domain.

Receiving

This means paying attention towards something. It indicates the ability of an individual to receive information. Awareness of the sources of information and willingness to receive the information are the sublevels of this category.

Responding

The learner participates actively in the process.

Regular in attention and motivation leads to responding.

Valuing

Valuing is based on the internalization of a set of specified values. The learner understands that the activity he is called upon to perform is valuable.

Organizing

The learner organizes values into priorities by contrasting different values, resolving conflicts between them, and creating a unique values system

Characterization

The values are imbibed and the learners behave in a pervasive, consistent, predictable manner.

Instructional Objectives

Psychomotor Domain

Along with the behavioural changes in the cognitive and affective domain the learner has to master certain skills to make the development complete. Speaking, Reading, Writing, Drawing are activities where motor co-ordination is required. Changes of this category leading to mastery of skills are said to be changes in the psychomotor domain.

Perception

The ability to use sensory cues to guide motor activity. This ranges from sensory stimulation, through cue selection, to translation.

Set

Readiness to act. It shows the desire to learn a new process.

Guided Response

The early stage in learning a complex skill that
includes imitation and trial and error. Adequacy of performance is achieved by practicing.

**Mechanism**

This is the intermediate stage in learning a complex skill. Learned responses have become habitual and the movements can be performed with some confidence and proficiency.

**Complex Overt Response**

The skillful performance that involves complex movement patterns proficiency is indicated by a quick, accurate, and highly co-ordinated performance, requiring a minimum of energy. This category includes performing without hesitation, and automatic performance.

**Adaptation**

The learner responds effectively to unexpected experiences. Skills are well developed and the individual can modify movement patterns to fit special requirements.

### COGNITIVE DOMAIN

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>BEHAVIOURAL / KEY WORDS VERBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>Recalls, Recognizes, Names, Reproduces, outlines, States.</td>
</tr>
<tr>
<td>Understanding</td>
<td>Identifies, Converts, Distinguishes, Estimates</td>
</tr>
<tr>
<td>Explains</td>
<td>Generalizes, Translates, Compares, Classifies, Detects, errors, para phrases, Discriminates</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Application</th>
<th>Computes, Manipulates, Solves, Relates, Predicts, Constructs, Selects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis</td>
<td>Analyses, Breakdown, Associates, Examines</td>
</tr>
<tr>
<td>Synthesis</td>
<td>Combines, Compiles, Designs, Summarizes Creates</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Appraises, Justifies, Criticizes, Defends.</td>
</tr>
</tbody>
</table>

### AFFECTIVE DOMAIN

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>BEHAVIOURAL / KEY WORDS VERBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiving</td>
<td>Asks, Gives, Points to, Chooses</td>
</tr>
<tr>
<td>Responding</td>
<td>Answers, Performs, Recites, Reports, Discusses</td>
</tr>
<tr>
<td>Valuing</td>
<td>Initiates, Invites, Joins, Shares, Demonstrates</td>
</tr>
<tr>
<td>Organizing</td>
<td>Adheres, Alters, Formulates, Relates</td>
</tr>
<tr>
<td>Characterization</td>
<td>Influences, Qualifies, Solves, Verifies, Modifies</td>
</tr>
</tbody>
</table>

### PSYCHOMOTOR DOMAIN

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>BEHAVIOURAL / KEY WORDS VERBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception</td>
<td>Detects, Identifies, Isolates</td>
</tr>
</tbody>
</table>
Becoming A Reflective Mathematics Teacher

Behavioiural Objectives / Specifications

Behavioural objectives or performance objectives or specifications are terms that refer to a description of observable student behaviour or performance. Since learning cannot be seen directly, teachers must make inferences about learning from evidence they can see and measure. Behavioural objectives provide an ideal vehicle for making inferences. A well constructed behavioural objective describes an intended learning outcome. It communicates the conditions under which the behaviour is performed, a verb which defines the behaviour itself and the degree (criteria) to which a student must perform the behaviour.

In short instructional objectives are not directly observable and measurable. But their evidence of attainment can be collected through specifications.

Taxonomy Reframed: Educational Objectives for the 21st Century

The Taxonomy of Educational Objectives was one of the outstanding research work in the field of education. It is a framework for classifying statements of what we expect or intend students to learn as a result of instruction. The frame work was conceived as a means of facilitating, the exchange of test items among faculty at various universities in order to create banks of items, each measuring the same educational objective. The revision of this framework was developed in much the same manner forty five years later by Loren Anderson. (a former student of Benjamin Bloom). Hereafter, this is referred to as the Revised Taxonomy.

Revised Bloom’s Taxonomy: from One Dimension to Two Dimensions

In the original taxonomy, the knowledge category embodied both noun and verb aspects. The noun or subject matter aspect was specified in knowledge’s extensive subcategories. The verb aspect was included in the definition given to knowledge. This brought uni-dimensionality to the frame work at the cost of a knowledge category that was dual in nature and thus different from the other Taxonomic categories. This anomaly was eliminated in the revised taxonomy by allowing these two aspects, the noun and verb, to form separate dimensions, the noun providing the basis for the knowledge dimension and the verb forming the basis for the cognitive process dimension.

The Knowledge Dimension

The one – dimensional form of the original taxonomy becomes a two – dimensional table with the addition of the products of thinking (various forms of knowledge). Forms of knowledge are listed in the revised taxonomy on factual, conceptual, procedural and met cognitive.

Factual Knowledge is knowledge that is basic to specific disciplines. This dimension refers to essential facts, terminology, details or elements students must know or be familiar with in order to understand a
The revision’s primary focus is on the taxonomy in use. Bloom’s taxonomy was traditionally viewed as a tool best applied in the earlier years of schooling (primary and junior primary years). The revised taxonomy is more universal and easily applicable at elementary, secondary and even tertiary levels.

In the national and international scenario, there is a newer reading in the teaching – learning process especially after the wider infusion of the cognitive and constructive psychological interpretations on learning. Gardner’s explorations of human intellect in terms of Multiple Intelligence theory triggered this paradigm shift from behaviorist to a new wider perspective. In essence, the wider lacuna that exist in the contemporary teaching – learning process in terms of evaluation can be minimized by incorporating the essential spirit of Revised Bloom’s Taxonomy.
A list of objectives and specifications to be followed in Mathematics classrooms

1. Objectives of the Cognitive domain.
   I. The learner gathers information (acquires knowledge) of mathematical terms, symbols, concepts, etc.
      Specifications: The learner:
      i. recalls the terms, symbols etc.
      ii. recognizes the terms, symbols etc.
   II. The learners comprehends (or develops understanding of) the terms, symbols, concepts, etc.
      Specifications: The learner:
      i. closely observes the phenomena
      ii. Compares items on the basis of the attributes
      iii. identifies relations
      iv. Identifies mistakes committed in the process of comprehending
      v. classifies objects or phenomena in terms of the attributes
      vi. Defines concepts in terms of the attributes
      vii. Gives one's own illustrations or examples for a concept
   III. The learner applies the learned information in new or unfamiliar situations.
      Specifications: The learner:
      i. identifies the purpose for application
      ii. Makes the unfamiliar familiar
      iii. Identifies the relation among the data available
      iv. Hypothesis a plan of action for solution
      v. tests the adequacy of the data for facing the new situation
      vi. Finds out additional data, if required
      vii. Arrives at generalizations.
      viii. Judges whether the conclusions arrived at are valid
      ix. establishes new relations or conclusions
      x. makes correct estimation.
      xi. Verifies every step on the basis of principles
      xii. Synthesizes the process involved in the solutions and summarizes the results systematically
      xiii. At every stage monitors the progress along the correct path.

2. Objective of the affective domain
   I. The learner develops healthy interest related to Mathematics.
      Specification: The learner:
      i. attends to articles related to mathematics from various media.
      ii. Reads books on great mathematicians.
      iii. Regularly uses mathematics library and mathematics laboratory
      iv. Likes company of mathematically talented persons.
      v. derives pleasure in solving mathematical puzzles.
      vi. Creates puzzles on one’s own.
vii. Seeks necessary clarifications from the teacher.

viii. Writes articles on the subject in the magazine.

ix. Collects illustrations, aids related to mathematics.

x. Prepares albums to preserve collections related to the subject.

II. The learner develops scientific attitude towards mathematics

Specifications: The learner:

i. Refrains from jumping into conclusions

ii. Accepts a proposition when and only when it is logically proved.

iii. Accepts errors without hesitation.

iv. Points out errors in facts, arguments, etc.

v. Exhibits habits of questioning.

vi. Shows eagerness to probe into problematic situations.

vii. Maintains precision, clarity, logical stability in verbal or written statements.

III. The learner appreciates the beauty of mathematics.

i. Appreciates the rhythm and beauty of geometrical and number patterns.

ii. Gets pleasure while experiencing the accurate and precise way of mathematical arguments.

iii. Constructs beautiful pattern using geometrical shapes.

3. Objectives of Psychomotor domain

I. The learner develops skill in

a. Computation

Specifications: The learner:

i. Performs the four primary operations with speed and accuracy.

ii. Uses short cut methods to make calculations.

iii. Works out computation mentally.

iv. Records the written form of computations systematically and clearly.

b. Drawing geometrical figures and graphs

Specifications: The learners:

i. Takes measurements accurately using instruments

ii. Estimates length, area etc without using the instrument

iii. Selects appropriate scales for drawing plans.

iv. Does free hand drawing fairly

v. Draws geometrical figures and graphs accurately using appropriate instruments.

vi. Labels figures or graphs correctly.

c. Interpreting given figures

Specifications: The learner:

i. Interprets graphs and charts correctly

ii. Identifies the relation connecting the various parts of a figure, graph or tables.

iii. Converts the measures in a diagrammatic representation to real measures with accuracy.