Chapter I

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1.1 MATHEMATICS EDUCATION

Mathematics education is the practice of teaching and learning mathematics. The predominant international trend in mathematics education since World War II can be characterized as “mathematics for all”. For a number of reasons this trend is now being challenged from various quarters. Firstly because it has to be admitted that by and large mathematics educators in western societies believe that mathematics education have not been too successful at really equipping the majority of population with the mathematical knowledge, insight and skills that are asked for. Bluntly put, many claim that the development towards mathematics for all has proved a bit of failure, at least partly. This has led some mathematicians and mathematics educators to question the overall plot and suggest that we should reserve serious mathematics education for the relatively few who can benefit from it at a reasonable investment of time and effort; while lowering the level of ambition with respect to the majority, in the hope that in this way we can avoid diluting the mathematics education of the former (selling away the crown jewels of mathematics) and avoid bringing excessive pain to the latter. This is in accordance with what can be found amongst an increasing number of industrialist, politicians and participants in public debates who fundamentally question the utility of mathematics to a common man in an era of computers, calculators and other technology. In other words, a threat to the “mathematics for all” is gaining momentum. Whatever position one wants to take to this threat it does require close attention.

Despite of all these arguments, the position of mathematics in school curriculum is inseparable/irreplaceable/indispensable.

1.2 IMPORTANCE OF MATHEMATICS

Graven (1998) replaced the term “Mathematics” with the broader Learning Area Mathematical Literacy, Mathematics and Mathematical Sciences (MLMMS).
This learning area represents a major shift in the philosophy of mathematics and mathematics education. MLMMS defines mathematics as:

*The construction of knowledge that deals with qualitative and quantitative relationships of space and time. It is a human activity that deals with patterns, problem-solving, logical thinking etc., in an attempt to understand the world and make use of that understanding. This understanding is expressed, developed and contested through language, symbols and social interaction (NDE, 1997).*

This definition places an emphasis on more socio-constructivist, learner-centered and integrated approaches to mathematics teaching and learning. This indicates a move away from the previous performance-based approach towards a more competence-based. Further approach more this definition indicates a shift away from the 'absolutist paradigm', which views mathematics as a body of infallible objective truth which has little to do with the affairs of humanity (Ernest 1991). The *Rationale* to MLMMS further states that mathematics should empower learners to 'understand the contested nature of mathematical knowledge' (NDE, 1997). MLMMS focuses its attention on constructing mathematical meaning in order to understand the world and make use of that understanding. Mathematical learning is to be relational, flexible, transferable and integrated with everyday life and other learning areas.

An information- and technology- based society requires individuals to think critically about complex issues, analyze and adapt new situations, solve problems of various kinds, and communicate their thinking effectively. The study of mathematics equips students with knowledge, skills and habits of mind that are essential for successful and rewarding participation in such a society. To learn mathematics in a way that will serve them well throughout their lives, students need classroom experiences that develop mathematical understanding; learn important facts, skills and procedures; develop the ability to apply the processes of mathematics; and acquire a positive attitude towards mathematics.

Learning mathematics results in more than a mastery of basic skills. It equips students with a concise and powerful means of communication. Mathematical structures, operations, processes and language provide students with a framework and tools for reasoning, justifying conclusions, and expressing ideas clearly. Through mathematical activities that are practical and relevant to their lives, students develop
mathematical concepts that they can apply in their daily lives and, eventually in the workplace.

The mathematics essential for a common man is expanding. Mathematics is much more than computation. It is a set of concepts, principles, and relationships which serves as a powerful symbol system and tool for describing and analyzing our world. Mathematics is not just learning how to manipulate numbers, but also collecting, displaying, and analyzing data; creating and identifying patterns, relations, and functions; developing a stronger sense of number and operation; and exploring spatial and geometric relationships. Today’s school mathematics purposefully emphasizes more on realistic and problem solving situations rather than the controlled one- or two-step word problems. As a result, mathematics students are more engaged in reading, writing, speaking, and listening. Understanding the problem becomes much more complex than knowing a list of key words -- ‘more’ means add, ‘less’ means subtract, ‘of’ means times -- to solve formulaic word problems.

1.3 CHANGING ROLES OF MATHEMATICS TEACHERS AND LEARNERS

In all of this, the need is to think about the way roles are changing. Nationally and internationally, teacher’s subject content knowledge is recognized as being of crucial importance (Goulding, Rowland & Barker, 2002). Teachers and learners, faced with new ways of approaching mathematics, have to stretch well beyond ‘business-as-usual’ because both are learning new skills, and are engaged as learners. Most of us -- teachers and students -- learned to do mathematics as a solitary activity and kept our mathematical thinking to ourselves. Teachers, facilitating a classroom environment where students learn to communicate mathematically, need to employ multiple instructional strategies/techniques such as mathematics laboratory, brainstorming, group discussion, group story writing, journals, and interviews. Multiple approaches to teaching mathematics as communication should allow learners to develop appropriate reading, writing, listening, and speaking skills necessary for communicating mathematically in numerous settings; discuss with others, reflect and clarify their own thinking about mathematical outcomes, and make convincing arguments and decisions based on these experiences; define everyday, work-related or test-related situations using concrete, pictorial, graphical, or algebraic
methods; establish links; appreciate the value of mathematical language and notation in relation to mathematical ideas.

Mathematics classes need to evolve as communities of competent problem solvers and communicators; it will take the combined skills of literacy and numeracy practitioners. The Committee on Science and Mathematics Teacher Preparation (CSMTP) (2001) recommends that

- Teacher education in science, mathematics, and technology be viewed as a continuum of programs and professional experiences that enables individuals to move seamlessly from college preparation for teaching to careers in teaching these subject areas;
- Teacher education be viewed as a career-long process that allows teachers of science, mathematics, and technology to acquire and regularly update the content knowledge and pedagogical tools needed to teach in ways that enhance student learning and achievement in these subjects; and
- Teacher education also is structured in ways that allow teachers to grow individually in their profession and to contribute to the further enhancement of both teaching and their disciplines.

Mathematics is a powerful learning tool. As students identify relationship between mathematical concepts and everyday situations and make connections between mathematics and other subjects, they develop the ability to use mathematics to extend and apply their knowledge in other curricular areas, including science, music and language.

The traditional curriculum allowed millions of people to be taught reliable procedures for finding correct answers to the important problems, without either the teachers or the students having to understand why the procedures worked. At the same time, students with high mathematics aptitude could learn substantially more mathematics, enough to support various technical or academic careers. However, times have changed. The success of traditional based curriculum has fostered a mathematically based technology, which in turn has created conditions in which that curriculum is no longer appropriate. One of the reasons underneath it is that we have cheap calculators which can do calculations with the push of a couple of buttons.
These machines are typically much faster and more reliable than we are in doing calculations. It has always been one of the strengths of mathematics to seek reliable and systematic methods of computation, which has often meant creating algorithms. Anything that has been algorithmized can be done by a computer. Automation of calculation is no longer a problem professionals have to worry about. At the same time, it means that calculation is much more prevalent than before. Hence people have to spend more time in determining what calculation to do. This is another reason that mathematics education needs to change.

Moreover, there are certain skills and competencies, namely, ‘Mathematical Competencies’ which are developed through learning of mathematics. These skills and competencies are essential for all in solving daily life problems or in sorting out hindrances in their daily lives. Various skills like reasoning, justifying conclusions, expressing ideas clearly, manipulation of numbers; collecting, displaying, and analyzing data; creating and identifying patterns, relations, and functions; developing a stronger sense of number and operation; and exploring spatial and geometric relationships; problem solving situations and other ‘Mathematical Competencies’ enables an individual to solve daily life problems. Development of these ‘Mathematical Competencies’ among students largely depends on quality of mathematics lessons they receive in schools. To improve quality of mathematics lessons, the mathematics teachers should be well-equipped with competencies specific to mathematics teaching.

1.4 PROSPECTIVE MATHEMATICS TEACHERS

The teacher is the one that translates educational philosophy and objective into knowledge and skill and transfers them to students in the classroom. It has to do with teachers desire to participate in the pedagogical processes within the school environment

In other words, the training program for prospective mathematics teachers must incorporate subject specific competencies i.e. mathematics teaching exit competencies. The contemporary requirement is a paradigm shift from traditional training to competency-based training.
1.5 COMPETENCY-BASED APPROACH

Throughout the world, millions of students go to school everyday. These students study subjects such as science, language and mathematics in courses usually scheduled to last the duration of the school academic session. Because progression through the various subjects in school is time-based, at any given time during the year the teacher is expected to be at a specific point in the textbook or course content. While not every student may progress at the same rate, the schedule typically at the same rate as that of a teacher. Tests are administered periodically to ensure a student understands the concepts and principles. Test scores are often compared to determine the grades of the students.

The Global move to Competency Based Approach has introduced a number of new concepts and chief among these concepts is the concept of competence (Azemikhah, 2005). This assertion argue that the shift in emphasis from input to output needs to be reflected “in evaluation of student performance, moving from knowledge as dominant, (even the single) reference. And that to (include) assessment centered on competences, capacities and processes closely related to work and activities as related to student development and in relation to academic and professional profiles already defined” (Govin & Alvarez, 2005). This shift in focus that has been further emphasized by the advent of educational programs involves two distinct paradigms that need to be understood by two distinctive mental models, i.e., “contents based mental model”, and the “competency based mental model”. While in the contents paradigm mental model, the focus is on contents, subjects and it is content based; in the competency paradigm, the focus is on competencies, unit of competency and it is competency based. The rapid spread and acceptance of globalization, the tremendous developments in information technology and the concentration of knowledge power in all areas is seen to have dramatically changed the educational environment from that which teachers are prepared for through the teacher training program. These led to demand for more education for novice teachers as a result of the need to develop a broader range of competencies/skills to succeed in the increasingly complex educational environment. The knowledge base, technical skills and competencies required of today's teacher have exploded over the last decade.
1.6 COMPETENCY

Competency is the state or quality of being adequately or well qualified to perform a task. Competency, a synonymous to ability, is nothing more than an ancient human value, for example, the right way of doing things is the competent way: the right way to perform a job; the right way to live and work in association and cooperation with each other. It refers to desired quality of a job performance.

The word ‘competency’ has been derived from Latin word ‘Competere’ which means ‘to be suitable’. While there are many definitions of competencies, most of them have two main components:

- Competencies are observable and measurable knowledge, skills and abilities.
- These knowledge, skills and abilities must distinguish between superior and other performers.

A competency is the capability to apply or use a set of related knowledge, skills and motives required to successfully perform “critical work functions” or “tasks” in a defined work setting.

- Knowledge: - Collection of information and retention of facts that an individual stores. Knowledge is necessary for performing a task but not sufficient.
- Skills: - An underlying characteristic of a person, which results in an effective and superior performance in a job.
- Motives: - A recurrent concern for a condition which selects/drives behaviour. Motives direct basic drive for all of our actions. It refers to the dynamics of our behaviour, which involves our needs, desires and ambitions/goals in life.

According to Boyatzis (1982), “Competencies are characteristics that are causally related to effective and/or superior performance in a job. This means that there is evidence which indicates that possession of the characteristic precedes and leads to effective and/or superior performance in that job”.

According to Guralnik (1984), “Competency means a condition or quality of being competent, ability, fitness, legal capability, power or jurisdiction”.

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Weightman (1994) in his book, 'Competencies in Action' defined competencies as, “Essentially competencies underlie the behaviors thought necessary to achieve a desired outcome. A competency is something you can demonstrate”.

In the views of Marshall (1996), “A competency is an underlying characteristic of a person, which enables him to deliver superior performance in a given job, role or situation”.

Kerka (1998) says competency “is individualized, emphasizes outcomes (what individuals know and can do), and allows flexible pathways for achieving the outcomes, making as clear as possible what is to be achieved and the standards for measuring achievement”.

Whiddett and Hollyforde (2003) definition is based on “behavior observed within the organizational setting”. They defined it as: “Competencies are behaviors that individuals demonstrate the job relevant tasks effectively within a given organizational context”.

Rankin (2004) defined it as “Competencies are, in essence, definitions of expected performance that, taken as a whole, should provide users with the complete picture of the most valuable behaviors, values and tasks required for their organizational success”.

The term "competency" became popular when Boyatzis defined the super performers as "competent managers" (Boyatzis, 1982). Spencer and Spencer (1993) defined competency as internal characteristics of an individual that produced effective and superior performance. Sparrow (1996) divided the term competency into three categories: organizational competency, managerial competency, and individual competency. He defined individual competency as list of behavioral characteristics related to job tasks. Schippment, Ash, Carr & Hesketh (2000) defined competency as adequate knowledge to successfully complete job tasks. Clearly, there is a wide range of definitions, even among a fairly homogeneous expert population, underscoring the difficulty of pinpointing a standard definition of the term. This lack of consensus should not be too surprising, given the multiple domains in which the terms "competent" or "competency" are prevalent (Schippment, et al., 2000). Based on current thinking the definition that best fits the attributes of competency is given by Arthey & Orth (1999): "A competency is a set of observable performance dimensions,
including individual knowledge, skills, attitudes, and behaviors, as well as collective
team, process, and organizational capabilities, that are linked to high performance,
and provide the organization with sustainable competitive advantage."

Although competency has been defined in several ways, its definition can be
generalized as ‘individual knowledge, skill, ability, or characteristics that bring
excellent performance.’ As the definition closely correlates with performance and it is
a factor to be valid from correlation with performance at its development (Mirable,
1997), it is greatly expected to be a management tool of recruiting, developing, and
evaluating highly potential people

In the words of McClelland (1973), “Competency is an underlying
characteristic of an individual that is causally related to criterion referenced
effective and/or superior performance in a job or a situation”. This definition given by
McClelland is the definition that has found acceptance among the practitioners. The
definition has three important elements (shown in bold above):-

‘Underlying Characteristic’ means that the competency is fairly deep and enduring
part of person’s personality and can predict behavior in wide variety of situations and
job tasks.

‘Causally related’ means that a competency causes or predicts behavior and
performance.

‘Criterion referenced’ means that the competency actually predicts who does what
well or poorly, as measured on a specific criterion or standard.

These three elements are further elaborated as below:

A. Underlying Characteristic- Competencies are underlying characteristics of
people and “indicate ways of behaving and or thinking, generalizing across
situations, and enduring for a reasonable period of time”. The competencies
have five basic characteristics, namely:

1. Motives: - Things a person consistently thinks about or wants that
cause action, motives drive, direct and select behavior towards certain
actions. Example: Achievement motivation people consistently set
challenging goals for themselves, take responsibility for accomplishing
them and use feedback to do better.
2. **Traits**: - Physical characteristics and consistent responses to situations. Example: Good eyesight is a physical trait of a pilot. Emotional self control and initiatives are more complex consistent responses to situations.

3. **Self Concept**: - A person’s attitude value or self image. A person’s values are reactive or respondent motives that predict what a person would do in short run. Example: A person who values being a leader would be more likely to exhibit leadership behavior.

4. **Knowledge**: - Information a person has in a specific area. Example: An accountant’s knowledge of various accounting procedures.

5. **Skill**: - Is the ability to perform certain mental or physical tasks. Example: Mental competency includes analytical thinking; the ability to establish cause and effect relationship.

B. **Causal Relationship**- Motives, traits, self-concept predict skill/behavior and action that in turn predict job performance outcomes, as in the

Motive/trait -------> Behavior------> Outcome

Competences always include an intent, which is the motive or trait force that causes action towards an outcome. Behavior without an intent does not form a competency. Behavior can include thought and feelings where thinking, feeling precedes or succeeds action.

C. **Criterion Referenced**- A characteristic of an individual is not a competency unless it predicts something meaningful in the real world. The characteristic is a competency if it can predict ‘superior’ or effective performance.

The concept of competence indicates person’s ability to keep a balance between qualifications and specific social conditions. Individual develops his/her competence through all life, in interactions with other people. Therefore competence is concurrent with work environment and human relationships. Competence can be studied only at a particular moment, in a particular place and in a way of particular task. Thus competence is an expression of qualification, which appears in ordinary work and interactions with co-workers. According to Leiba-O’Sullivan (1999), competence consists of knowledge, skills, ability and other; where other includes both...
interests and personality interests. Lucia and Lepsinger (1999) state, competence is the particular combination of knowledge, skills and characteristics needed to effectively perform a role in an organization. Knowledge is a set of beliefs about causal relationships in the world and an organization (Sanches, 2001). It is a body of information that has to be mastered by a professional in a particular field (Queeney, 1997). Knowledge helps people do things more effectively and efficiently. Skills are the abilities using which an individual has to do things (Sanches, 2001) and enables to utilize the knowledge when performing a particular work or assignment (Queeney, 1997). Knowledge and skills can be either highly tangible and measurable – or a far more complex to matter. Abilities concern the application of knowledge and skills in the practical settings, where judgment is used to deal with real situations (Queeney, 1997). Characteristics of a person are least readily measurable. It can be an aptitude, innate talent, or inclination that suggests a potential to acquire or use a particular kind of skill or knowledge. Competences should include both innate and acquired abilities.

1.7 COMPETENCY BASED TRAINING (CBT)

Competency-based training (CBT) is an approach to vocational education and training that places emphasis on what a person can do in the workplace as a result of completing a program of training. Competency standards are industry/profession-determined specifications of performance that set out the skills, knowledge and attitudes required to operate effectively in a specific industry or profession. Competency standards are made up of units of competency, which are themselves made up of elements of competency, together with performance criteria, a range of variables, and an evidence guide. Competency standards are an endorsed component of a training program.

How does competency based training work? The basic essential elements consist of functional analysis of the occupational roles, translation of these roles ("competencies") into outcomes, and assessment of trainees' progress in these outcomes on the basis of demonstrated performance. Progress is defined solely by the competencies achieved and not the underlying processes or time served in formal educational settings. Assessments are based on a set of clearly defined outcomes so that all parties concerned, including assessors and trainees, can make reasonably objective judgments about whether or not each trainee has achieved them. Potential
benefits of this approach include individualized flexible training and transparent standards.

For a person to be assessed competent they need to demonstrate the ability to perform tasks and duties to the standard expected in employment. CBT focuses on the development of the skills, knowledge and attitudes required to achieve those competency standards. One of the primary features of CBT is that each learner’s achievement is measured against the competency standards rather than against the achievement of other learners. Under the CBT approach, each learner is assessed to find the gap between the skills learners need and the skills the learner’s already have. The difference between the two is called the skills gap. A training program is then developed to help the learner acquire the missing skills.

**Skills required – current skills = skills gap**

Competency-based training is aimed at developing curricula from an analysis of roles/performance and skill gap to be filled on completion of the educational/training program. Rather than examinations in traditional training program that simply assess mastery of course material, the focus in competency-based approach is on the ability of students to demonstrate proficiency or competency in these external roles.

The Competency Based Movement Started in Early 1970s as an education initiative for a more effective and practically useful curriculum. In a traditional educational system, the unit of progression is time and it is teacher-centered. In a competency based training, the unit of progression is mastery of specific knowledge and skills and is learner and/or participant-centered. Two key terms used in competency based training are:

- **Skill-** A task or group of tasks performed to a specific level of ability or proficiency which often use cognitive, affective and psychomotor domains and typically requires manipulation of abilities/capabilities and classroom situations.

- **Competency-** A skill performed to a specific standard to a specific condition.

There are subtle difference between skills and competencies. Competencies tend to be the reservoir that collects all of the knowledge, skills, and abilities (referred to as KSAs) of an individual. In other words, a competency is the capacity to draw upon and apply a set of related knowledge, skills, and abilities to successfully perform...
a work role, function, or task. Competencies often serve as the basis for skill standards that specify the level of knowledge, skills, and abilities required for success in the workplace. Skill standards in turn form the basis for measurement criteria to assess competency attainment.

Competency-based training has as its major aim the development of a competent workforce. It emphasizes what the individuals can do in the workplace after completing a period in training. The training program is directly related to the expectations of the job. Competency-based training differs from traditional training in that, trainees think in terms of output. These outputs are referred to as outcomes. These are explicit and serve as foundation on which planning is based. Competencies are further broken down into component parts and each of these is identifiable. According to Bowden (1997) the following characteristics are peculiar to competency-based training.

- **Focus on outcome**- These outcomes are relevant to workplace requirements.
- **Greater workplace relevance**- It emphasizes the importance of applying knowledge to the tasks to be performed in the workplace. This is different from traditional training where the concern has been expressed that theoretical or bookish knowledge is often emphasized at the expense of the ability to perform a job.
- **Outcomes are observable competencies**- These are what set clear goals for educational programs.
- **Assessments as judgments of competence**- The assessment takes into consideration the knowledge, skills and attitudes acquired and the actual performance of the competency. The primary focus of the competency-based training is on the mastery of skills (Sullivan, 1995).


- Competencies to be achieved are carefully identified, verified and made public in advance.
- Criteria to be used in assessing achievement and the conditions under which achievement will be assessed are explicitly stated and made public in advance.
The instructional program provides for the individual development and evaluation of each of the competencies specified.

Assessment of the competency takes the participants knowledge and attitudes into account but requires actual performance of the competency as the primary source of evidence.

Participants progress through the instructional program at their own rate by demonstrating the attainment of the specified competencies.

According to Foyster (1990), Delker (1990) and Norton (1987) there are a number of characteristics of competency-based programs. Key characteristics are summarized as below.

- Competencies are carefully selected.
- Supporting theory is integrated with skill practice. Essential knowledge is learned to support the performance of skills.
- Detailed training materials are keyed to the competencies to be achieved and are designed to support the acquisition of knowledge and skills.
- Methods of instruction involve mastery learning, the premise that all participants can master the required knowledge or skill, provided sufficient time and appropriate training methods are used.
- Participant’s knowledge and skills are assessed as they enter the program and those with satisfactory knowledge and skills may bypass the training or competencies already obtained.
- Learning should be self-paced.
- Flexible training approaches including large group methods, small group activities and individual study are essential components.
- A variety of support materials including print, audiovisual and simulations (models) keyed to the skills being mastered is used.
- Satisfactory completion of training is based on achievement of all specified competencies.

Competency-based training is based upon the candidate’s ability to demonstrate attainment or mastery of teaching skills/competencies performed under certain conditions to specific standard. The major differences between traditional training and competency-based training can be summarized in a table as follows.
### Table 1.1

**Showing Major Differences between Traditional and Competency-Based Training**

<table>
<thead>
<tr>
<th>Traditional training</th>
<th>Competency-based training</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Focused on one center.</td>
<td>➢ Flexibility in terms of centers.</td>
</tr>
<tr>
<td>➢ Reliant on a teacher.</td>
<td>➢ Learner led.</td>
</tr>
<tr>
<td>➢ Teacher centered.</td>
<td>➢ Teacher as a facilitator.</td>
</tr>
<tr>
<td>➢ Competitive culture in the classroom.</td>
<td>➢ Competition against competencies.</td>
</tr>
<tr>
<td>➢ Program based on knowledge and skills.</td>
<td>➢ Program based on competence.</td>
</tr>
<tr>
<td>➢ Program designed for the whole class.</td>
<td>➢ Programs designed to suit individual learning styles.</td>
</tr>
<tr>
<td>➢ Limited amounts of practice.</td>
<td>➢ Ample opportunities provided for practice.</td>
</tr>
<tr>
<td><strong>Resources</strong></td>
<td></td>
</tr>
<tr>
<td>➢ Often based on textbooks.</td>
<td>➢ Variety of resource materials.</td>
</tr>
<tr>
<td>➢ Sometimes not in accordance with educational objectives.</td>
<td>➢ Resources aligned with educational objectives.</td>
</tr>
<tr>
<td>➢ Restricted access to resources.</td>
<td>➢ Easy access to resources.</td>
</tr>
<tr>
<td><strong>Staff</strong></td>
<td></td>
</tr>
<tr>
<td>➢ Academic experts.</td>
<td>➢ Skilled facilitators with experience.</td>
</tr>
<tr>
<td>➢ Accustomed to controlling what, when, where and in what context the class learns.</td>
<td>➢ Works closely with learner to identify needs and design and deliver to address needs.</td>
</tr>
<tr>
<td>➢ Prior experience of the learner not recognized.</td>
<td>➢ Prior learning and experience accredited.</td>
</tr>
<tr>
<td>➢ Written examinations are major part of assessment.</td>
<td>➢ Participant’s knowledge and skills assessed as they enter the program. Variety of assessment strategies.</td>
</tr>
<tr>
<td>➢ Fixed time table.</td>
<td>➢ Flexible time table- different entry points. Self paced learning.</td>
</tr>
<tr>
<td>➢ Graded for superior performance.</td>
<td>➢ Learner led readiness for assessment.</td>
</tr>
<tr>
<td>➢ Assessment of knowledge and skills.</td>
<td>➢ Explicit standard of performance as reference point for assessment.</td>
</tr>
<tr>
<td>➢ Percentage of content selected from the curriculum for assessment.</td>
<td>➢ Theory is integrated with skill practice.</td>
</tr>
<tr>
<td>➢ Areas to be tested unknown to students.</td>
<td>➢ Assessment is transparent.</td>
</tr>
<tr>
<td>➢ Participants pass or fail.</td>
<td>➢ Assumes that all participants can acquire competencies given sufficient time and relevant methods of training.</td>
</tr>
</tbody>
</table>
Most broadly, competency-based approach is an educational reform that seeks a closer fit between higher education and the needs of the society for both skilled employees and capable citizens. It focuses on learner performance (learning outcomes) in reaching/achieving pre-specified goals and objectives.

Different from other reform initiatives, competency-based training is outcome oriented and assessment oriented. It initiates a process about the desired outcomes of education/teacher training and the means to assess them. The outcomes are specified into competency statements and are broken down into components and sub-components which provide more direction to the learning necessary to achieve each competency. Because the expected outcomes are clearly defined, this style of assessment places the emphasis on diagnosis and improvement until competency is achieved. The competency-based approach is a goal-oriented approach with pre-defined competencies/outcomes, predecided assessment criterion and learning experiences.

Weightman (1994) in his book ‘Competencies in action’ stated that, “Competency is about performance-how we define it, develop it, acquire it, and so on. Some desired performances, or competencies, are easy to define, measure and develop[…] However, many desired performances or competencies are much more complex and are difficult to observe or measure[…] But even in these difficult-to-judge areas, we can usually agree that some individual’s performance is more effective than that of others[…] What the competency movement tries to do is to analyze what it is that makes some people’s performance better than that of others, and to list the component factors which go to make up these competent performances”.

Performance refers to the act of performing; of doing something successfully; using knowledge as distinguished from merely possessing it. Performance encourages us to look at not only what people say but what they do including at how we perform in our day to day lives. Considering the consequences of our actions and encouraging ourselves to move away from protecting self interests, etc the risk of attaining the set goals is paramount. It allows us to open our minds to the possibility of not only aiding
our students, but in the process of learning from both mistakes and successes. It obliges to grow and continuously acquire new skills that in the end make us better at our roles as teachers in an otherwise thankless profession. Thus, performance begins in the classroom. To a degree a teacher’s performance can be discerned by how well his/her student does in class. Their success rests not only on teacher’s ability to effectively teach a subject but just as importantly; rests also upon student’s shoulders, i.e. their willingness to learn is paramount. Performance is the accomplishment of a task in accordance with a set standard of completeness and accuracy. While a person may have the skills or knowledge (competency) to perform a task, does not mean he or she will have the desire (attitude) to do, so correctly (performance). In other words, competencies give a person the ability to perform, while attitudes give a person the desire to perform.

![Diagram](image)

Attitudes change with various events in a person’s life. These emotional changes also vary in length of time. Various definitions of competencies include attitudes, such as, beliefs, values, traits and motives. But usually, people ride an emotional roller coaster throughout their lifetime, which makes performance a combination of competencies and attitudes.

Competency can be described as a set of knowledge, skills, and abilities, and behavioural attributes which are required to deliver superior performance in a job position. The competency – based approach is a goal – oriented approach with predefined competencies/outcomes, pre-decided assessment criterion and learning experiences which are observable.
SKILLS + KNOWLEDGE + ATTITUDE = OBSERVABLE BEHAVIOR

OBSERVABLE BEHAVIOUR = PERFORMANCE APPRAISAL RATING

Competency which can be described as a set of knowledge, skills and abilities and behavioral attributes which are required to deliver superior job performance; can be assessed in relation to certain objective standards. In Competency-based education 'Teaching Performance Assessment' (TPA) is designed so as to give the teacher candidate an opportunity to develop, redefine and demonstrate their knowledge, skills and abilities during teacher preparation program.

Competency-based training redefines the roles of students and faculty in education and also the relationship between them. For students, it demands that they become self-motivated learners who play an active role in their own education. Students have to demonstrate satisfactory performance and competency in order to fulfill the requirements of the curriculum; they cannot be regarded simply as receptacles to be filled with knowledge. Faculty members must act as mentors rather than as lecturers by observing the performance of the students and building interactions with them to facilitate learning towards competency. In addition, faculty
must move away from paper and pencil tests of comprehension and design assessments that measure performance in real life settings. Moreover, students and faculty members must together recognize that competency-based education is difficult to constraint within the academic calendar. Achieving competency does not necessarily occur within a fifty minutes class or one academic session, but instead a range of learning experiences over varying amounts of time may be required before a student’s performance reaches prescribed level. Accordingly, the training program for prospective mathematics teachers must be based upon acquisition of certain exit competencies essential for teaching mathematics; prior to the completion of training program. The contemporary requirement is that, before completion of pre-service training program, the mathematics teachers master the requisite competencies essential for teaching of mathematics, i.e. exit competencies or threshold competencies for prospective mathematics teachers.

1.8 EXIT COMPETENCIES/ THRESHOLD COMPETENCIES

A competency is an underlying characteristic of an individual, which results in performance or effective and superior performance in a job. It is a combination of body of knowledge, set of skills and cluster of appropriate motives/traits that an individual possess to perform a given task effectively and efficiently.

Depending upon the competency requirements during various levels of a training program, the competencies can be considered at two levels, namely:

- Entry level competencies
- Exit level competencies

Entry level competencies are the requisite basic skills which students require while entering a training program; to be successful in it. These entry level competencies are critical to improving instruction; accounting for student performance, and enhancing the performance.

Exit level competencies are knowledge, skills and attitudes, a student must be able to demonstrate prior to completion of a program (associated degree or certificate). According to Boyatzis (1982), “A threshold competency is a person’s generic knowledge, motive, trait, self image, social role or skill which is essential to perform a job, but is not causally related to superior job performance.”
According to Spencer and Spencer (1993), competencies can be broadly categorized into two types – **threshold/exit** and **differentiating competencies**.

- **Threshold competencies** are the essential characteristics that everyone in a job must possess in order to perform the job at a minimally effective level; however, they do not distinguish superior from average performance.

- **Differentiating competencies** are the characteristics – a motive, trait and/or pattern of behaviour – that distinguish superior from average performers.

Schematic representation of the relationship between the level of a competency and performance is shown below in figures 1.1 and 1.2.

![Figure 1.1](image1.png)

Figure 1.1 shows threshold level of a job performance

![Figure 1.2](image2.png)

Figure 1.2 shows superior performance in a job
Figure 1.1 represents threshold competency and 1.2 represents those competencies that are predictive of superior performance, i.e. differentiating competency. The schematic representation is a comparison of relationship of threshold competency and performance; as compared to relationship between differentiating competency and performance.

A training program must have a complete list of all the exit competencies/outcomes required for all student trainees. The list must be foundation document for building degrees/certificates courses and lessons delivered. In a teacher training program, the exit profile i.e., outlines of exit competencies to be attained; is of utmost importance. It defines the global expected outcome for prospective teachers in any particular subject. It results from the integration of all learning objects targeted. It represents an entity encompassing all components of an educational program. It defines what student teachers/prospective teachers will be able to do; what they will have become; how competent they will become at the end of the teacher training program. The exit profile integrates key competencies associated with expertise/proficiency in various disciplines/subjects included in the educational program. The exit profile is not achieved through a stacking process of acquired competencies but through a constant effort aimed at integration. One of the major purposes of the exit profile is to assure a shared vision of the achievement of educational program objectives which, in turn, encourages convergence of all learning and teaching activities without which the program approach is not possible. The training program framework, which translates the training program strategy and planned learning pathway, is also determined while keeping the exit profile in sight.

Another important purpose of the exit profile is to serve as the key reference for comprehensive assessment. At the end of a teacher training program, student teachers/prospective teachers will have had the opportunity to demonstrate the acquisition of all prescribed competencies. The integration of acquired competencies is still to be demonstrated; this is the main reason and focus of comprehensive assessment.

1.9 COMPETENCY PYRAMID

Considering various definitions/viewpoints of different authors, Lucia and Lepsinger (1999) presented a competency pyramid. The competency pyramid model includes both innate and acquired aspects. It is essentially a pyramid built upon the foundation of inherent talents, incorporating the types of skills and knowledge that can be acquired through learning efforts and learning experiences.
The pyramid indicates that the performance of an individual is based on their aptitudes and personal characteristics, which in turn provide skills and knowledge necessary to perform the desired behaviours. Performance of prospective mathematics teachers is determined by their teaching aptitude in mathematics and other personal characteristics. This refers that the exit competencies, that prospective mathematics teachers are expected to acquire, largely depends on their teaching aptitude and other personal characteristics. All of an individual’s behaviours, actions, thoughts and beliefs are influenced by his/her inner drive to succeed. The need for success or attainment of excellence is regarded as achievement motivation.

1.10 ACHIEVEMENT MOTIVATION

Over the years behavioral scientists have observed that some people have an intense need to achieve; others, perhaps the majority, do not seem to be as concerned
about achievement. A goal oriented behavior of an individual with a felt need and a
power to achieve higher may be regarded as achievement motivation. Motivation can
be defined as the driving force behind all the actions of an individual. The influence
of an individual’s needs and goals both has a strong impact on the direction of their
behavior. Motivation gives both direction and intensity to human behavior.

Achievement motivation refers to the need of success or the attainment of
excellence. Achievement motivation is a psychological concept that links personality
traits and social background of an individual with his or her level of ‘need for
achievement’. Achievement motivation is a task oriented behaviour that allows the
individual’s performance to be evaluated according to some internally and/or
externally imposed criterion. It involves the individual in competing with others at
some standards of excellence.

DeCecco (1970) defined achievement motivation as expectancy of finding
satisfaction in mastering challenging and different performances.

According to International Encyclopedia of Social Sciences (1972),
“Achievement motivation is an important determinant of aspiration, effort and
persistence when an individual expects that his performance will be evaluated in
relation to some standard of excellence. Such behaviour is called achievement
oriented” (Sills, 1972).

Arnold, Eysenck and Meili (1972) viewed achievement motivation as a
construct designed to explain inter and intra individual differences in the orientations,
intensity and consistency of achievement motivation.

Evans (1978) stated that most people feel some sense of urgency to strive for
success in various aspects of their life, and this general push has been termed as
achievement motivation.

achievement motivation as the desire to accomplish difficult tasks and overcome
obstacles and an individual is not so much concerned with success or failure in given
task as with attaining a certain standard set for himself or herself (Goldenson, 1984).

Mehndirata (1997) has defined achievement motivation as the psychological
need and energetic drive that prompts an individual to strive for and work towards
mastering his or her environment by the successful accomplishment of a goal or goals
accompanied by a sense of satisfaction and self-worth.
Coleman (2001) defined achievement motivation as a social form of motivation involving a competitive drive to meet standards of excellence.

From the above definitions, it can be concluded that achievement motivation is a strong urge to excel. It refers to the behaviour of an individual who strives to accomplish something, to do his best, to excel others in performance. This involves competition with a particular standard of excellence of performance. Achievement motivation is thus a learned motive to compete and to strive for success. Success becomes a goal, which must be achieved in one way or the other. Motivation to achieve is instigated when an individual knows that he is responsible for outcome of some venture, when he anticipates explicit knowledge of results that will define his success or failure and when there is some degree of risk i.e., some uncertainty about outcome of effort.

American Psychologist David Clarence McClelland (1917-1998) was fascinated by this phenomenon. He is most noted for his need-based motivational model. In his book ‘The Achieving Society’ (1961) he defined achievement motivation as “the need to perform well or striving for success, and evidenced by persistence and efforts in the face of difficulties; achievement motivation is regarded as the central human motivation”. He mentioned three types of motivational needs, namely:-

- Achievement motivation (n-ach)
- Authority/power motivation (n-pow)
- Affiliation motivation (n-affi)

The need for achievement (n-ach) - The n-ach person is ‘achievement motivated’ and therefore seeks achievement, attainment of realistic but challenging goals, and advancement in the job. There is a strong need of feedback as to achievement and progress, and a need for sense of accomplishment.

The need for authority and power (n-pow) - The n-pow person is ‘authority motivated’. This driver produces a need to be influential, effective and to make an impact. There is a strong need to lead and for their ideas to prevail. There is also motivation and need towards increasing personal status and prestige.

The need for affiliation (n-affi) - The n-affi person is ‘affiliation motivated’ and has a need for friendly relationships and is motivated towards interaction
with other people. The affiliation driver produces motivation and need to be liked and held in popular regard. These people are team players.

The n-ach is characterized by a desire to attain a high standard of excellence and to accomplish the unique objectives. In such a situation an individual shows concern with competition with a standard of excellence. Such a concern may be stated explicitly or may have sufficient evidence of such a competition. The self imposed requirement for good performance and the description of instrumental acts, form the quality of the work. Sometimes they are involved in long term goals of achievement or in the accomplishment of some unique work. These may be called as need for accomplishing something worthwhile, unique or excellent, or need for mastery.

David Clarence McClelland said that most people possess and exhibit a combination of these characteristics. Achievement motivated individuals set goals which they can influence with their effort and ability, and as such the goal is achievable. He suggested various characteristics and attitudes of achievement – motivated people:

- Achievement is more important than material or financial reward.
- Achieving the aim or task gives greater personal satisfaction than receiving praise or recognition.
- Financial reward is regarded as measurement of success, not an end in itself.
- Security is not prime motivator, nor is success.
- Feedback is essential, because it enables measurement of success, not for reasons of praise or recognition (the implication here is that feedback must be reliable, quantifiable and factual).
- Achievement- motivated people constantly seek improvements and ways of doing things better.
- Achievement-motivated people will logically favour jobs and responsibilities that naturally satisfy their needs, i.e. offer flexibility and opportunity to set and achieve goals.

Achievement motivation is based on reaching success and achieving all of our aspirations in life. Various investigators have attempted to explain how difference in the need for achievement affects the performance of an individual. Achievement goals can effect the way a person performs a task and represent a desire to show competence (Harackiewicz, Barron, Carter, Lehto and Elliot. 1997).
1.11 TEACHING APTITUDE

An **aptitude** refers to potential to acquire skills; a natural tendency to do something well, especially one that can be further developed or quickness in learning; quickness or ease in learning. In other words, an aptitude is defined as the specific capacity to do a certain job which is promoted by training in that field. Aptitude is a combination characteristics indicative of an individuals capacity to acquire (with training) some specific knowledge, skill or set of organized responses, such as the ability to speak a language, to become a musician, to do mechanical work. An aptitude is an innate, acquired or learned or developed component of a competency (being the others: knowledge, understanding and attitude) to do a certain kind of work at a certain level. Aptitudes may be physical or mental. The innate nature of aptitude is in contrast to achievement, which represents knowledge or ability that is gained. The term ‘aptitude’ is generally used in either of the two ways: (a) when we say that a man has a great deal of aptitude for art, meaning that he has in a high degree many of the characteristics which make for success in artistic activities; or (b) when we say that a person lacks spatial aptitude, meaning that he lacks this specialized ability which is of varying importance in a number of different vocations. In the former instance, the word is used not to denote a unitary trait, or even an entity of any sort, but rather a combination of traits or abilities which result in a person being qualified for some type of occupation or activity. In the latter case, the word ‘aptitude’ is intended to convey the idea of a discrete, unitary characteristic which is important, in varying degree, in a variety of occupations and activities. Both these concepts of aptitude are important in vocations; however the meaning intended should be clear.

Cronbach and Snow (1969) defined aptitude as “aptitude is defined as any characteristic of the individual that increases (or impairs) his probability of success in a given treatment”. They also said that aptitude is, essentially, whatever makes a person ready to learn rapidly (or to adapt effectively to his environment).

Caroll (1973) stated that aptitude reflects not a predilection for proficiency but rather a potential rate of acquisition by older learners, under optimal conditions of motivation, opportunity, and quality of instruction. He said that although aptitude remains constant, the role aptitude plays in achievement can vary as the other variables vary.
According to Snow (1991), “aptitude should refer to any measurable personal characteristic hypothesized to be needed as preparation for response to treatment to successful goal achievement in the treatment(s) studied”.

Teaching is the leading of valuable experiences in a specific way to provide the most learning and growth in a positive direction as described by Dewey (1938). Dewey argued that “every experience should do something to prepare a person for later experiences of a deeper and more expansive quality”. Teaching refers to the action of a person who teaches; profession of a teacher; something taught; precept, a doctrine that is taught, or instruction. Teaching has an influence in developing one’s mind and character and also gives the satisfaction of having sparked the light of knowledge and dispelled the clouds of ignorance. "Teaching is imparting knowledge or skill”. It is undertaking certain tasks or activities the intention of which is to induce learning". A teacher can anticipate that certain activities will result in learning. In short, successful teaching cannot be reduced to a set of general rules, or a prescribed pattern of behavior.

Teaching is a tri-polar process; since the teacher, the learner and the subject matter (learning experiences) encompassing the teaching learning cannot be excluded. All the aspects play an equally important role. Any teaching learning devoid of any of these aspects cannot be called good teaching. Through teaching the learner is enabled to exist successfully in his environment and play his unique roles in the process of teaching-learning. The learner benefits the most from an effective teaching-learning process.

Figure 1.4 Teaching as a tri-polar process
A prospective teacher needs an intellect capable of grasping not only the subject matter and its place in curriculum, but also the aims, objectives and instructional strategies involved in education. Teaching aptitude of an individual is a combination of various factors like word fluency, interest in the subject, scholarly ability, interest in children, clarity of presentation, techniques of classroom management, tolerance, urges to share knowledge and pedagogical knowledge. Teaching aptitude is a capacity to acquire proficiency or skill, with a given amount of training. Teaching aptitude is necessary for the teachers to do their holy job a successful one. Without having considerable amount of teaching aptitude, no teacher can make teaching learning process effective. In a modern classroom, for teachers the objective is to strive for promotion of educational progress equally and fairly for all of our students. Teachers are expected to devise courses and lesson plans to reach instructional goals for the class as a whole, and to carry these plans forward as best as they can each day with evenhanded classroom management. Sometimes these goals mean that teachers are to find a style of presentation or forms of participation that fits the particular character of a given class and differs from they have done in previous years. Often they also mean recognizing student differences within the class group, looking for individual strengths to capitalize on and weaknesses to remove or avoid. They develop alternatives - different approaches to a topic or activity, different organizations of content, different explanations, different representations and examples - and provide a variety of media and materials from which students can choose, in the hope of connecting with each student's learning strengths and interests. And they are always expected to respect and respond to individuality - each student is in various ways and degrees unique. The focus of testing for teaching Aptitude is to determine/select students who genuinely want to teach they possess qualities, such as open mindedness, curiosity, and love for children and have some basic knowledge about teaching as a profession and people (thinkers and educational psychologists) who have contributed to the field of education.

1.12 OPERATIONAL DEFINITIONS OF THE TERMS USED

The terms used in the present study are operationally defined as under:

1. Mathematical Exit Competencies: Mathematical Exit competencies are knowledge, skills and attitudes, a prospective mathematics teacher must be able to demonstrate prior to completion of mathematics teacher training program.
The following three mathematical exit competencies were identified and selected; and are operationally defined as below:

a. **Mathematics Content Competencies:** This mathematical exit competency includes sub-competencies specifically related to mathematics content, giving illustrations with examples, selection and organization of mathematics content and making mathematical connections. In the present study, Mathematics Content Competencies means the exit competencies as measured/assessed by the rating scale prepared by the investigator.

This Mathematical Exit Competency included the following four Mathematical Exit Sub-Competencies:-

i. **Mathematics Content Knowledge:** - Mathematics content knowledge deals with the teaching process, including the most useful forms of representing and communicating content and how student’s best learn the specific concepts and topics of mathematics. In the present study, Mathematics content knowledge means the Mathematical Exit Competency as measured/assessed by the observation schedule developed by the investigator.

ii. **Illustrating with Examples:** - The act of illustrating refers to the act of making clear and distinct; also, that which illustrates using a comparison or example intended to make clear or apprehensible, or to remove obscurity. In a subject like mathematics, concrete examples will really help students to understand the concepts to be taught in class. In the present study, Illustrating with Examples means the Mathematical Exit Competency as measured/assessed by the observation schedule developed by the investigator.

iii. **Selection and Organization of Mathematics Content:** - Mathematics content builds coherently from grade-to-grade; students have the opportunity to build upon their learning year-to-year; each year, the content increases in complexity and is appropriately challenging. In the present study, Selection and Organization of Mathematics Content means the Mathematical Exit Competency as measured/assessed by the observation schedule developed by the investigator.

iv. **Mathematical Connections:** - A mathematical connection helps students recognize how ideas in different areas are related. Mathematical Connections can relate mathematical topics to students’
daily lives and to other mathematical topics but are probably most important in relating mathematics to other curriculum areas. In the present study, Mathematical Connections means the Mathematical Exit Competency as measured/assessed by the observation schedule developed by the investigator.

b. **Mathematics Process Competencies:** This Mathematical Exit Competency includes sub-competencies specifically related to communication in mathematical language, technique of questioning and dealing with responses given by students, problem solving ability in mathematics, and evaluation. In the present study Mathematics Process Competencies means the Mathematical Exit Competencies as measured/assessed by the rating scale prepared by the investigator.

This Mathematical Exit Competency included the following four Mathematical Exit Sub-Competencies:-

i. **Mathematical Communication:** - Through Mathematical Communication, mathematical ideas become objects of reflection, refinement, discussion and amendment. The communication process in mathematics helps build meaning and permanence for ideas and makes them public. In the present study, Mathematical communication means the Mathematical Exit Competency as measured/assessed by the observation schedule developed by the investigator.

ii. **Questioning and Response Management:** - Asking questions in mathematics is a fundamental part of finding information and for subtle (and otherwise) persuasion. Responses given by students may be complete, partially correct or null responses. The effective management of such responses in a mathematics classroom can make the teaching-learning process in mathematics more effective. In the present study, Questioning and Response Management means the Mathematical Exit Competency as measured/assessed by the observation schedule developed by the investigator.

iii. **Mathematical Problem Solving:** - Problem solving forms part of thinking. Problem solving is an integral part of all mathematics learning. Teachers play an important role in developing students' problem-solving dispositions. In the present study, Mathematical Problem Solving means the Mathematical Exit Competency as
measured/assessed by the observation schedule developed by the investigator.

iv. **Evaluation:** - Evaluation serves as the basis for the improvement of the way activities are carried out in a classroom. Evaluation is also an effort at discovering whether certain activities have led to desired effects or outcomes. In the present study, Evaluation means the Mathematical Exit Competency as measured/assessed by the observation schedule developed by the investigator.

c. **Mathematical Pedagogical Competencies:** The Mathematical Exit Competency Mathematical Pedagogical Competencies includes Exit Sub-Competencies specifically related to black-board writing and multiple instructional strategies. In the present study Mathematical Pedagogical Competencies means the Mathematical Exit Competencies as measured/assessed by the rating scale prepared by the investigator.

This Mathematical Exit Competency included the following two Mathematical Exit Sub-Competencies:-

i. **Black Board Writing:** - The Blackboard is a teacher’s best visual aid when question arises that involves the whole class. A mathematics teacher can organize discussions on it, emphasize major points, makes note of page numbers for assignments, and work with examples by writing problems. In the present study, Black board writing means the Mathematical Exit Competency as measured/assessed by the observation schedule developed by the investigator.

ii. **Multiple Instructional Strategies:** - Instructional strategies are the methods that are used in the lesson to ensure that the sequence or deliveries of instruction help students learn. A mathematics teacher understands and uses a variety of instructional strategies i.e. multiple instructional strategies to encourage student’s development of critical thinking, problem solving and performance skills. In the present study, Multiple Instructional Strategies means the Mathematical Exit Competency as measured/assessed by the observation schedule developed by the investigator.

➢ **Mathematics Teaching Competency** refers to the competency of a mathematics teacher in a classroom situation. In the present study Mathematical Teaching Competency is as measured/assessed by
Mathematical Teaching Competency Assessment Scale (MTCAS), developed by the investigator.

2. **Achievement Motivation**: Achievement Motivation is a task-oriented behaviour that allows the individual's performance to be evaluated according to some internally and/or externally imposed criterion. It involves the individual in competing with others at some standards of excellence. In the present study, Achievement Motivation means the scores obtained by prospective mathematics teachers on Achievement Motive Test (ACMT) by Bhargava (1994).

3. **Teaching Aptitude**: Teaching Aptitude is a capacity to acquire proficiency or skill, with a given amount of training. Teaching Aptitude is necessary for the teachers to do their holy job a successful one. Without having considerable amount of teaching aptitude, no teacher can make teaching learning process effective. In the present study, Teaching Aptitude means the scores obtained by prospective mathematics teachers on Teaching Aptitude Scale (TAS) by PSY-COM SERVICES.