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CHAPTER II

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CHAPTER II
THEORETICAL PERSPECTIVES

.0 Introduction

This chapter examines theoretical constructs as related to the present investigation. It outlines the theoretical perspectives of the selected variables and explores the theoretical relationship among the variables under study. It examines how the personal variables considered in the study could interact with problem solving ability, teaching aptitude and teaching competency of trainees in the colleges of education. A conceptual framework for the study is developed and presented.

.1 Content Knowledge

The most visible aspect of the revolution in science education has been the very subject matter of the programmes themselves – their content, organization and emphases. The crucial question for science educators is how it transmits a particular conception or structure of knowledge to students so that it becomes an enduring component of the learner’s cognitive structure (Novak, 1965).

Content knowledge or mastery in subject content consists of an understanding of key facts, concepts, principles and explanatory framework in the discipline. Teachers interpret experience through their existing knowledge and belief. A teacher’s knowledge and beliefs about a subject matter and teaching and learning thus are important determinants of how that teacher teaches the subject.
Research studies conducted in India and abroad establish strong influence of teacher’s content knowledge on his/her classroom performance and pupil achievement. (Ball, 1988; Smith and Neale, 1989; Carlson, 1991; Harbison and Hanushek 1992; Fennema and Franke, 1992; Shulman, 1996). Many research findings indicate that teachers often lack a strong foundation of subjects they teach. (Grossman, Wilson and Shulman, 1989; Shugart and Hounshell, 1995). Ball (1990) and Mosenthal and Ball (1992) observed that teachers have misconceptions and gaps in their knowledge domain. Teachers’ subject matter knowledge influences the way in which they teach and the teachers who know more about a subject will be more interesting and adventurous in the ways in which they teach. Teachers with only a limited knowledge of a subject may avoid teaching difficult or complex aspects of it and teach in a didactic manner with little scope for pupil participation and questioning. (Ball and Mc Diarmid, 1989; Mc Namara, 1991).

2.1.1 Content Knowledge: Meaning and Definition

Shulman and Sykes (1986) defined content knowledge as “that body of understanding and skill of dispositions and values, of character and performance that together underlie the capacity to teach” (p.5). Content knowledge refers to the amount and organization of knowledge per se in the mind of the teacher. It includes an understanding of best practice along with a depth of subject matter understanding. According to Shulman (1986) teaching subject matter knowledge means the ways of representing and formulating the subject that makes it comprehensible to others.
To think properly about content knowledge requires going beyond the knowledge of facts or concepts of a domain. It requires understanding the structures of the subject matter in the manner defined by such scholars as Schwab (1978). Schwab (1978) identified four components for subject matter knowledge as given below.

- Content knowledge (the facts and concepts of the subject matter)
- Substantive knowledge (the explanatory structures or paradigms of the field).
- Syntactic knowledge (the methods and processes by which new knowledge in the field is generated).
- Beliefs about the subject matter (learner’s and teacher’s feelings about various aspects of the subject matter).

2.1.2 Kinds of Knowledge

Shulman’s name is often associated with research on teacher’s subject matter knowledge and his seven categories of teacher’s knowledge are often linked to the development of a knowledge base for teaching. Shulman’s (1987) categories are: a) content knowledge b) general pedagogical knowledge c) knowledge about the curriculum d) pedagogical content knowledge e) knowledge of the learners f) knowledge of the educational contexts and g) knowledge of the educational ends, purposes and values.

Shulman (1986) defined three categories of content knowledge – i) subject matter knowledge ii) pedagogical content knowledge and iii) curricular knowledge. This concept has been extended by other writers (Shulman, 1987; Wilson, et.al., 1987). Subject matter knowledge refers to a teacher’s
2.2 Problem Solving Ability

Problem solving is a common experience in everyday life. The World Health Organisation (1997) has analysed all the life skills and grouped them into ten core sets of life skills of which problem solving and critical thinking are given priority over other skills. People are continually facing difficulties or perplexities for which there is no ready made ‘book answers’. Depending on the nature of the problem, individuals are stimulated to make first hand investigation to look for pertinent material and to give critical consideration to all circumstances in order to arrive at a satisfactory solution.

Besides its practical value in relation to everyday life, problem solving is of special value in the development of personality. There is indeed no better way to teach independence, initiative and self-reliance which can be achieved only through coping successfully with stimulating problems. Once an individual has gained self reliance in dealing with problems, he will attack new problems successfully. To develop problem solving skills one has to utilize one’s own thinking and reasoning powers and engage in serious mental work by systematically following some well organised steps for the removal of difficulties and obstacles.

A review of the stated goals of education reveals a consistent emphasis on problem solving. From the early writings of John Dewey to the Twenty sixth year book of the National Society for the Study of Education to the National Policy of Education (NPE, 1986) the goal of producing students who can think has been promoted. Whether it is called analytical, critical, productive, rational
or reflective thinking, the meaning is the same as problem solving, ie, an interpretation of knowledge, a use of reason and an evaluation of alternatives.

An analysis of problem solving models (Dewey, 1910; Johnson, 1944; Polya, 1945; Bayles, 1954; Oburn, 1956; Dressel, 1960; Kaufan, 1982) reveals that the basic steps associated with the problem solving are essentially the same as those given for the scientific method.

There are two well-known models which have a relationship to the cognitive complexity of problem solving which appear useful to science instruction. One model is Gagne’s model of learning hierarchy (Gagne, 1977) and the other is Bloom’s Taxonomy of Cognitive Objectives (Bloom, 1956). Gagne’s model classifies problem solving as the highest form of learning in his hierarchy. In discussing problem solving, he contends that the more complex forms of learning depend upon the processes which have been previously acquired in the simpler forms in a hierarchical fashion (Gagne, 1966 p.313). Gagne typifies problem solving as the formulation of a new higher order rule. Relevant rules previously learned are recalled and applied in a novel manner.

According to Bloom’s model, problem solving corresponds to application level of thinking. As described by Bloom, students operate at the application level when they select an abstraction (principle, law or theory) from their learned repertoire and use it to solve a problem. This description of application level learning is similar to Gagne’s explanation of problem solving whereby Bloom’s abstraction corresponds to Gagne’s higher order rule. In both models, there is an
emphasis on transfer of learning to new and different situations rather than repetition and drill.

A review of the related literature indicates that a significant amount of classroom activity is conducted at the lower levels of Bloom’s Taxonomy. (Airasian, 1970; Albright and Ridky, 1974; Fast, 1974; Atwood and Stevens, 1975; Monk and Stallings, 1975). Consequently there is a great deal of room for problem solving and application instruction in science teaching.

2.2.1 Problem Solving Defined

Problem solving has been defined differently by many authors. International Dictionary of Education (1979) defines problem solving “as term given in Gagne’s theory of learning which represents the highest category of intellectual skill. The characteristic of problem solving is the combination of two or more rules in a novel way inorder to solve a problem” (Terrypage and Thomas, 1979, p.273).

Lester (1982) defines problem solving as a process of co-ordinating previous experience, knowledge and intuition in an effort to determine an outcome or a solution for which a procedure for determining the outcome is not known. Thus previous knowledge and experiences play a significant role in determining a solution to the problem. However problem solving is not merely applying previously learned rules and principles. As Woodworth and Marquis (1948) observes, “Problem solving behaviour occurs in novel or difficult situations in which a solution is not attainable by the habitual methods of
applying concepts and principles derived from past experience in very similar situations.” (p. 263).

According to Risk (1965), problem solving may be defined as a planned attack upon a difficulty or perplexity for the purpose of finding a satisfactory solution. Risk further elaborates that problem solving procedure is a process of raising a problem in the minds of students in such a way as to stimulate purposeful reflective thinking in arriving at a rational solution. Three elements seem to be involved here: a situation which presents some difficulty, perplexity or doubt requiring a solution, a goal or an end involving some aspect of situation for which no ready made answer can be given and a desire or motive that stimulates an attempt to find the answer. Therefore problem solving may be said to be a deliberate and purposeful act on the part of individual to realize the set of goals or objectives by inventing some novel methods.

Problem solving takes place when a problem solver accepts to solve it as well as where his previous knowledge or patterns of behaviour are insufficient and inappropriate to enable him to provide an acceptable solution. In such a case, solutions become possible only when he acquires new knowledge or capitalizes upon relationships which have not been seen earlier. In general, problem solving is bridging the gap or overcoming the barrier or obstacle that exists between problem and its solution (Fadnis, 1994).

2.2.2 Problem Solving: General or Domain Specific?

Some psychologists believe that effective problem solving strategies are specific to the problem area. That is, the problem solving strategies in science
are unique to science, strategies in mathematics are unique to mathematics, strategies in art are unique to art and so on. Becoming an expert problem solver in an area requires that one masters the strategies of that area. The other side of the debate claims that there are general problem solving strategies that can be useful in many areas.

There is evidence for both sides of the argument. In fact it appears that people move between general and specific approaches, depending on the situation and their level of expertise. When we know little about a problem or domain, we may rely on general learning and problem solving strategies to make sense of the situation. As we gain more domain specific knowledge (particularly procedural knowledge about how to do things in the domain), we need the general strategies less and less. But if we encounter a problem outside our current knowledge, we may return to relying on general strategies to attack the problem (Perkins and Salomon, 1989; Shuel, 1990; Alexander, 1992).

2.2.3 Steps in Problem Solving

“Educational programmes have the important ultimate purpose of teaching students to solve problems” (Gagne, 1977. p. 177). A problem has an initial state, the current situation, a goal – the desired outcome and a path for reaching the goal. Problem solvers often have to set and reach sub-goals as they move toward the final solution (Schunk, 1991). Problem solving is usually defined as formulating new answers, going beyond the simple application of previously learned rules to create a solution.
Problem solving strategy usually encompasses five stages. (Gick, 1986; Derry and Murphy, 1986; Derry, 1991; Gallini, 1991). Bransford and Stein (1984) use the acronym IDEAL to identify the five steps.

I Identify the problem
D Define and represent the problem
E Explore possible strategies
A Act on the strategies
L Look back and evaluate the effects of activities

i) **Identify the Problem**

Identifying that a problem exists which needs to be solved begins the process. The individual must be faced with some obstacle or interference in the path of the realization of his goals, needs or motives. Consequently, he must be conscious of the difficulty or problem.

ii) **Define and Represent the Problem**

Defining and representing a problem often requires finding the relevant information and ignoring the irrelevant details. The task in representing a problem is to assemble all the sentences into an accurate understanding or translation of the total problem. Interpretation of the problem is called a translation because when one translates the problem into a schema, then one understands the same. When students use proper schema for representing a problem, there is less chance for getting confused by irrelevant information.

Figure 2.1 shows the schematic representation of the problem solving process. There are two main outcomes of the problem representation stage of problem solving as shown in the figure 2.1. If the representation of the problem
suggests an immediate solution, one has activated the right schema and the solution is apparent because it is part of the schema. This has been called schema driven problem solving, a kind of matching between the situation and one’s store of systems for dealing with different problems. (Gick, 1986). In terms of the figure 2.1, one has taken the schema activated route and have proceeded directly to a solution. But if no schema is available, searching and testing may become the path to a solution.

![Diagram of Problem Solving Process](image)


**Figure 2.1**

Diagramatic Representation of the Problem - Solving Process

### iii) Exploring Possible Solution Strategies

There are two possible solution strategies. i) Algorithms and ii) Heuristics. An algorithm is a step by step prescription for achieving a goal. It usually is domain specific as it is connected to a particular subject area. A
heuristic is a general strategy that might lead to the right answer. Heuristic represents such problem solving strategies in which we make use of some mental short cuts for restructuring a problem to arrive at a quick solution.

iv) Acting on the Strategies and Looking Back

After representing the problem and selecting the approach, next step is to execute the plan. All the possible solutions thought out in the first step are closely analysed and evaluated, by checking for evidence, that confirms or contradicts the solution.

2.2.4 Information Processing and Problem Solving

Current research on problem solving in science education involves information processing theory – the idea that solving a problem requires two processes: retrieval from memory of the pertinent information and proper application of the information in the problem (Blosser, 1988).


Figure 2.2
The Information Processing System
Figure 2.2 shows the diagramatic representation of information processing system. The three stages of information processing system are the sensory register, short-term memory and long-term memory. Information is encoded in the sensory register where perception determines what will be held in short-term memory for further use. Thoroughly processed information becomes part of long-term memory and can be activated at any time to return to working memory.

According to Duncker (1945) a problem is present when one has a goal but does not know immediately how this goal can be reached. The goal cannot be reached without a ‘search process’. (Gilhooly and Green, 1989). To solve problems, learners must search for long-term memory for relevant principle, knowledge and strategies that might apply to this problem. In doing so, they begin to clarify the ‘problem space’. The problem space (Anderson, 1985) includes the goal state (ie the desired end state of the situation: what conditions would be like if the problems were solved), the given state (current situation including its restrictions and obstacles) and intermediate state to move from the given state to the goal state. Thus in arriving at a solution, it is necessary to select out of the previous experiences those which are particularly relevant to the present task and to organize these phases of previous learning into a new pattern of response.

2.2.5 Cognitive Requirements of Problem Solving

To solve the problems in a domain, learners must possess and apply three kinds of knowledge: principles, declarative knowledge and cognitive strategies.
(Gagne, 1980, 1985; de-Jong and Ferguson – Hessler, 1986). The ability to apply seems to be most critical component to problem solving. However, it is clear that without declarative knowledge and cognitive strategies, the learner may not be able to adequately identify or search the problem space. These types of knowledge are used in varying degrees to support four components of cognitive processing in problem solving: knowledge representation, solution planning, solution implementation and solution evaluation.

The following phases often occur in problem solving conditions (Smith and Ragan, 1999).

- Clarify the given state (conditions) including any obstacles or constraints.
- Clarify the goal state including the criteria for knowing when the goal is reached.
- Search for relevant prior knowledge and declarative principle or cognitive strategies that will aid in solution.
- Decompose the problems into sub problems and sub goals.
- Determine a sequence for attacking sub problems.
- Consider possible solution paths to each sub problem using related prior knowledge
- Select a solution path and apply production knowledge (principles) in the appropriate order
- Evaluate to determine if the goal is achieved.

These nine paths can be used in analysing specific problem solving tasks within content domains helping the designer to find and structure the primary tasks.
2.2.6 Factors Affecting Problem Solving

Factors which affect problem solving behaviour may be broadly classified into two categories: i) Factors which are directly linked with the nature and type of the problem; ii) Factors which have a direct relation with the nature and capacities of the problem solver.

a. Factors Inherent in the Nature of the Problem

The factors of problem solving depend to a great extent on the nature of the problem as given below:

- The simplicity or complexity of the problem
- Size and shape of the problem
- Appropriate or inappropriate definition of the problem
- Its similarity or analogy with the problems experienced or solved in the past.

b. Factors Associated with the Problem Solvers

- Past Experience : The level of proficiency gained through some learning or training of one or other types of problems always works as a deciding factor for the problem solving.

- Motivational Level : The interest and motivation are known as the key factors or moving forces behind any activity carried out by the individual. These factors in terms of seeking the desired goals, motives, satisfaction of needs etc induce him to find a solution to his problem.
Role of Memory: One of the powerful strategies in solving problems is the efficient use of memory. Appropriate strategies depend on the level of material involved and the conditions under which the information must be remembered.

Creativity: Creative pupils are sensitive to problems. They also learn strategies needed to solve the problems, they inevitably encounter. If one solution does not work, they immediately work for new combinations or new ways of attacking the problem.

Mental Set: Mental set may be regarded as a way of perceiving things in the light of mental images already fixed in one’s mind on past experiences. Consequently influenced by one’s mental set, he/she tries to solve a problem.

2.2.7 Reflective Thinking and Problem Solving

The Online American Heritage Dictionary of English Language (2000) defines thinking as ‘a way of reasoning; judgement’. A good thinker welcomes problematic situations. He looks for alternative possibilities and goals; seeks evidence on both sides. He is reflective and deliberative, believes in the rationality and thinking can be effective.

Good problem solvers have reflective mode of thinking which aims at solving complex rather than simple problems. It requires reorganization of all the relevant experiences and finding the new ways of reacting to a new situation. Good problem solvers do not involve the mechanical trial and error type of
efforts. There is an insightful cognitive approach in reflective thinking. It takes all the relevant facts arranged in a logical order into account inorder to arrive at solution of the problem at hand.

With proper instructions, human thought processes could become more spontaneously generated. The teacher training institutions must focus on efforts and resources for developing the attributes of the ideal thinking person – a reflective thinker and problem solver.

2.2.8. Creative Thinking and Problem Solving

Gardner (1993) defines the creative individual as a person who regularly solves problems, fashions products or designs new questions in a domain in a way that is initially considered novel but that ultimately becomes accepted in a particular cultural setting. National Curriculum Framework for School Education developed by NCERT (2000) observes that learning science in school augments the spirit of inquiry, creativity and objectivity along with aesthetic sensibility. Also one of the objectives for organization of curriculum at secondary stage has been suggested as ‘to promote problem solving abilities and creative thinking in the citizens of tomorrow’.

According to Bloom (1956), creative thinking is a synonym to divergent thought processes or the competency to find unique multiple and elaborate solutions to problems which can be solved in more than one way. To be proficient enough in various types of thinking helpful for creative problem solving, critical thinking is required. It means acquisition of various
competencies such as understanding the nature of problems, comprehending the ideas contained in the problems, analysis of concepts based on scientific principles by integrating them to the line of reasoning till the solution is obtained (Jain, 1996; 2000).

Torrance (1962) defined creative thinking as a process of becoming sensitive to problems. When an individual is sensitive to problems, it leads him to think creatively for the solution. For a solution of the problem, the individual sees new relationships among the things or ideas and rearranges the ideas or concepts. The essence of creativity is in forming new combinations out of existing things or attributes. The educational process therefore should be aimed at developing creative abilities among children, which would stimulate and sharpen the creative mind which is vital for effective problem solving.

2.2.9 Critical Thinking and Problem Solving

To Budmen (1967) critical thinking is problem solving or an act of inquiry. Dressel and Mayhew (1954) reduced a long list of critical thinking abilities to five central ones, which also follow a problem solving format.

- The ability to define a problem which includes the abilities to break complex elements into simpler familiar workable parts, identify central elements and eliminate extraneous elements.
- The ability to select pertinent information for the solution of a problem, including the ability to recognize unreliable and biased sources of information as well as information that is relevant and irrelevant to the solution of the problem.
➢ The ability to recognize stated and unstated assumptions and unsupported and irrelevant assumptions.

➢ The ability to formulate relevant hypotheses and check the hypotheses against the information and assumptions.

➢ The ability to draw valid conclusions and inferences, detect logical inconsistencies and judge the adequacy of a conclusion.

Activities in which students are taking an active role and sharing information with each other encourage critical thinking and create knowledge that is lasting, transferable and useful (Carr, Jonassen, Litzinger and Marra, 1998). Schools must focus on efforts and resources in developing the attributes of ideal thinking person – a critical thinker and a problem solver.

2.3 Teaching Aptitude

The word aptitude is derived from the word ‘aptos’ which means ‘fitted for’. An aptitude is a composite of different component abilities that together make for success in performance in a particular field. The higher the aptitude, the higher are the chances of success; the lower the aptitude, the lower the probability of achievement.

In Warren’s Dictionary, aptitude has been defined as a condition or set of characteristics regarded as symptomatic of an individual’s ability to acquire with training some knowledge or skill or set of responses such as the ability to speak language, to produce music etc. A more general definition of aptitude has been proposed by Hahn and Machean (1962). They pointed out that aptitudes are correctly referred to as latent potentialities, undeveloped capacities to acquire
abilities and skills and demonstrate achievements. Aptitudes thus may be briefly regarded as potentialities which can be trained into special skills. Intelligence, interests, aspects of personality such as emotional make up and moral character, subject to varying degrees of favourable and unfavourable environment, mould and shape the aptitude of an individual.

Thus aptitude may be defined as a specific capacity or special ability distinct from the general intellectual ability of an individual, indicative of his probable success in a particular field after receiving appropriate opportunity for learning or training. Like many other personality traits, aptitudes have been adjudged to be the product of both heredity and environment.

Aptitude differs from ability and achievement in that it is forward looking in nature. i.e., it gives an indication of the future success of an individual where as ability limits itself to the present performance of an individual. Achievement with its past oriented nature, merely indicates what an individual has learned or acquired. Aptitude is different from interest. One may show interest into a particular act or job but one may not have the aptitude for it. To achieve the desired success in a task, one must have both interest as well as aptitude.

Teaching aptitude refers to the traits and abilities that constitute success in teaching. A person with teaching aptitude is one who has a good proportion of the traits and abilities required for becoming successful in teaching. The magnitude of these traits may differ from individual to individual or even the number of traits possessed by individual to individual may differ.
Corno and Snow (1986) have explained the meaning of teaching aptitude as 'a complex capability; it includes such aspects as alertness, 'witness', a propensity to check students' understanding continuously in a variety of ways, knowledge about how to use what is observed. They are also the features of intelligence broadly defined.

Thus the teaching aptitude may be described as a special ability or specific capacity distinct from the general intellectual ability which helps an individual to acquire the required degree of proficiency or achievement in teaching field. The knowledge of teaching aptitude of an individual helps us to predict his future success in the teaching field.

2.3.1 Characteristics of Aptitude

Aptitude is a present condition with a forward reference. It is not a developed competence, rather it is a potential ability to do something. It is a condition or set of characteristics regarded as symptomatic indicative of potentialities. According to Kochar (1984), the following are the characteristics of aptitude.

- It is symptomatic or indicative of one's ability for a particular work or job.
- It connotes more than potential ability in performance and implies fitness and suitability for the activities. A person who cannot develop a liking for an occupation along with the proficiency in it, cannot properly be said to have an aptitude for it because he lacks the necessary drive.
Aptitude is the result of the interaction between heridity and environment. The individual is born with certain potentialities and begin to learn and thereafter everything that he learns enables him to learn still more.

Aptitude predisposes learning including intelligence, achievement, personality, interests and special skills.

One’s readiness to acquire proficiency in an occupation is not the sole measure of one’s aptitude for it. Readiness to develop an interest in exercising his potential ability along this line and ability to a genuine absorption in the work and satisfactory competence are all required in an aptitude.

2.4 Performance in Science at Degree Level

Performance in science at degree level is a significant factor that could contribute towards teaching science in high school classes. Teacher trainees who have acquired upto date knowledge of specific concepts and an understanding of the complex relationships within the subjects at the degree level can successfully communicate the same to the students. Performance in science at degree level can facilitate, constrain or transform teaching learning process.

Vyas, 1982 has reported performance in science as a significant predictor of teaching success of the prospective teachers in Rajasthan. Smith (1989) has established strong relationship between teachers’ performance in science and ability to implement conceptual change lessons. Research evidence shows that student teachers’ performance in science at degree level is significantly related to academic performance of B.Ed. students (Pradhan, 1989). Thonguchumnam (1999) found that performance in science could make predictions for teaching
competency of fourth year students in science under the faculty of education. It seems that student teachers with their academic excellence can foster the effective use of teaching skills in the classroom that could enhance the retention of subject matter knowledge among the learners.

2.5 Teacher Competency, Teacher Competence, Teacher Performance and Teacher Effectiveness Differentiated

Teacher competency, teacher competence, teacher performance and teacher effectiveness are the terms often treated as synonymous (Reddy, 1998).

Teacher competency can be defined as any single knowledge, skill or professional value which a teacher may be said to possess and the possession of which is believed to be relevant to the successful practice of teaching. Competencies must be defined in terms of process or what the teacher does, not in terms of product. Any competency must be assessed directly in terms of what a teacher knows, does or believes.

Teacher competence on the other hand is conceived of as a matter of degree. Some teachers are more competent than others. Teachers grow in competence with training and experience. Minimum competence is the lowest level of competence at which a teacher can practice the teaching profession safely. Teacher competence depends on the repertoire of competencies he or she possess.

Teacher performance refers to what the teacher does on the job, rather than what he or she can do. It is therefore specific to job-satisfaction. Teacher performance can be expected to differ in different situations. The quality of the
performance depends on the competence of the teacher and context in which the teacher works.

Teacher effectiveness refers to the effect that the teacher performance has on the pupils. Teacher effectiveness differs from competence or performance in what it cannot be measured in terms of the behaviour of the teacher. Effectiveness must be assessed in terms of the behaviour of pupils, more precisely in terms of changes in their behaviour.

2.6 Teaching Competency

According to International Board of Standards for Training, Performance and Instruction (IBSTPI), a competency involves a set of knowledge, skills and attitudes that enable a person to effectively perform the activities of a given occupation in such a way that it meets the standards expected in a particular profession (Richey, et. al., 2001). Typically a competency is divided into specific indicators describing the requisite knowledge, skills, attitudes and context of performance. They are demonstrated in a job context and as such are influenced by an organizational culture and work environment (Denver, 2003).

Applied to teachers, competency means the right way of conveying units of knowledge, application and skills to the students (Rao, 1998). The right way includes knowledge of content as well as processes, methods and means of conveying them in an interesting way and involving the activities of the students. Competencies identify a single level of proficiency, or range of levels determined through theoretical and empirical processes at which a teacher should perform.
Five classes of competencies have been identified and defined (Houston, 1987) as given below.

i) Cognitive based competencies: These competencies refer to the knowledge and intellectual skills of the learner.

ii) Performance based competencies: The learner demonstrates that he or she can do something rather than simply know something: skills and overt actions.

iii) Consequence based competencies: To demonstrate such competence, a person is required to bring about a change in others. Teacher competence is measured by the achievement of the pupils.

iv) Affective competencies: These competencies include expected attitudes and values.

v) Exploratory competencies: These competencies include activities like working 30 hours in a community centre, discuss schooling with parents or act as a teacher aide for four weeks. Such activities are exploratory, they provide opportunities for student teachers to learn about teaching. Exploratory competencies have also been referred by educators as experience objectives or expressive objectives.

Teaching competency refers to professional ability including both the abilities to perform specific teaching functions and the ability to demonstrate acquired knowledge and higher level conceptualisations. Its measurement involves identifying all the teaching skills constituting the entire teaching task and making observations regarding the effectiveness of each of those teaching skills.
2.6.1 Teaching Skills

Teaching skills are a group of teaching acts and behaviours intended to facilitate pupils’ learning directly or indirectly. The adequate processing of any content or subject matter depends on an efficient use of teaching skills. Effective use of teaching skills reflects the competency of a teacher. A teaching skill can be defined as “a set of teacher behaviour which are specifically effective in bringing about desired changes in pupils.” (Sampath, et. al. 1981, p.74). Singh (1988) defined a teaching skill as “a set of teacher behaviours which together achieve a specific teaching act” (p.103).

To be skilled is to enable to perform a learned activity well and at will (Cottrell, 1999). Skill is associated with performance with a way of using knowledge and experience in action. Argyris and Schon (1974) defined skills as dimensions of the ability to behave effectively in situations of actions. Cottrell (2001) remarks “a skilled performance does not arise by chance, by mere fluke, but through an act of will, by an application of previous knowledge and experience” (p.9). Skilled teaching is a guided tour through the world of experience.

Skills are sensitive to practice and strategy and improve when there is time for rehearsal. Skills refer to a quality of performance which is developed through practice, training or experience. However inorder to acquire a skill, personal qualities are also required including motivation, commitment, perseverance and ability to manage set backs.
Skills of teaching are specific aspects of teaching behaviour that are considered to be particularly effective in facilitating desired learning in students. The concept of specific teaching skills seems first to have been implemented in teacher education in microteaching programme at Standford University. With the subsequent widespread acceptance of microteaching as a technique for training teachers, the concept of technical skills of teaching became relevant in the field of teaching.

Since teaching competency is defined in terms of what the teacher knows, believes and can do, it would seem to make more sense to evaluate teacher competency by looking at what the teacher does, rather than at what the pupils do, ie by observing teacher performance rather than measuring the pupil learning or outcomes. Its measurement involves identifying all the teaching skills constituting the entire teaching task and making the observations regarding the effectiveness of performance of each of those teaching skills.

The activities that are performed by a teacher in the classroom have been classified by different researchers and some of which are listed below.

According to Allen and Ryan (1969) the first technical skill used in teaching at Stanford University was “how to begin a lesson”. List of teaching skills developed by them is given below.

- Stimulus variation
- Set induction
- Closure
- Silence and nonverbal cues
• Reinforcing student participation
• Fluency in asking questions
• Probing questions
• Higher order questions
• Divergent questions

Other skills to become incorporated in the Stanford list were “recognizing attending behaviour”, “illustrating the use of examples”, “lecturing”, “planned repetition” and “completeness of communication”.

The researchers in the Centre of Advanced Study in Education M.S. University of Baroda have identified the following skills in Indian Context (Mohanty, 2003).

• Skills in writing instructional objectives
• Introducing the lesson
• Fluency in questioning
• Explaining
• Illustrating with examples
• Stimulus variation
• Silence and non-verbal cues.
• Reinforcement
• Increasing pupil participation
• Using black board
• Achieving closure
• Recognizing attending behaviour
These inter-related teaching acts which are observable, measurable, controlled and helpful in achieving teaching objectives are called teaching skills. The analytical approach to teaching assumes that teachers can be purposefully trained to develop these teaching skills and use them judiciously in their teaching process.

2.6.2 Teaching Skills and their Components

The following table is a representation of the component skills, comprising the complex act of teaching (Janjira and Sing, 1984).

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Skill</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Writing instructional objectives</td>
<td>Clarity, relevance to the content with reference to the domains and level of objectives, attainability in terms of pupil's outcome.</td>
</tr>
<tr>
<td>2.</td>
<td>Organizing the content</td>
<td>Logical organization as per need of the pupil.</td>
</tr>
<tr>
<td>3.</td>
<td>Creating set for introducing the lesson</td>
<td>Greeting, accepting, securing attention and giving instruction, establishing rapport, ensuring facilities like chalk, duster, aids etc.</td>
</tr>
<tr>
<td>4.</td>
<td>Introducing the lesson</td>
<td>Linking the previous knowledge of the pupils with the main parts, through questions, the teacher may elicit what the pupils have learnt in previous classes, and the current topics which the pupils might be aware of or the teacher may create situations in the class and then refer to the relevant knowledge.</td>
</tr>
<tr>
<td>5.</td>
<td>Structuring class room questions</td>
<td>Structuring questions at different levels which are grammatically correct, precise and relevant to the content.</td>
</tr>
<tr>
<td>6.</td>
<td>Questions delivery and distribution</td>
<td>Questions delivered with appropriate speed, allowing pause for thinking and questions well distributed.</td>
</tr>
<tr>
<td>7.</td>
<td>Response management (probing questions)</td>
<td>Management of pupil responses using techniques like prompting, refocusing and eliciting further information, accepting, asking critical awareness questions, rejecting and redirection.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clarity, continuity, relevance to the content, covering essential points.</td>
</tr>
<tr>
<td>---</td>
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</tr>
<tr>
<td>8.</td>
<td>Explaining</td>
<td>Simple, interesting and relevant to the point being explained.</td>
</tr>
<tr>
<td>9.</td>
<td>Illustrating with examples</td>
<td>Relevant to the content, appropriate to pupils level, proper display and appropriate use.</td>
</tr>
<tr>
<td>10.</td>
<td>Using teaching aids</td>
<td>Body movements, gestures, change in intonation and pitch, change in interaction pattern and pausing.</td>
</tr>
<tr>
<td>11.</td>
<td>Stimulus variation</td>
<td>Use of praise words and statements, accepting and using pupil ideas, repeating and rephrasing pupil ideas, use of pleasant and approving gestures and expressions, writing pupil answers on black board.</td>
</tr>
<tr>
<td>12.</td>
<td>Reinforcement</td>
<td>Adjusting the speed of the lesson to the level of the pupils and difficulty level of the content.</td>
</tr>
<tr>
<td>13.</td>
<td>Pacing the lesson</td>
<td>Providing opportunity to pupils to increase participation through asking questions, creating climate of participation.</td>
</tr>
<tr>
<td>14.</td>
<td>Promoting pupil participation</td>
<td>Legible, neat, adequate with reference to the content covered.</td>
</tr>
<tr>
<td>15.</td>
<td>Use of black board</td>
<td>Summarization, establishing link between the present learning with their previous knowledge and linking the pupil's new knowledge gained in the lesson with their future learning.</td>
</tr>
<tr>
<td>16.</td>
<td>Achieving closure of the lesson</td>
<td>Relevant to the content covered and level of pupils.</td>
</tr>
<tr>
<td>17.</td>
<td>Giving assignments</td>
<td>Relevant to the instructional objectives, use of appropriate questions and observations.</td>
</tr>
<tr>
<td>18.</td>
<td>Evaluating the pupil's progress</td>
<td>Identifying learning difficulties along with causes, remedial measures suited to the type of the learning difficulties and level of pupils.</td>
</tr>
<tr>
<td>19.</td>
<td>Diagnosing pupil learning difficulties and taking remedial measures</td>
<td>Attention behaviour reinforced and directions given to eliminating non-attending behaviours, clarity of directions, appropriate handling of pupil's disruptive behaviour.</td>
</tr>
<tr>
<td>20.</td>
<td>Management of the class (recognizing attending behaviour)</td>
<td></td>
</tr>
</tbody>
</table>
2.7 Reforms in Science Education

Science education in its traditional form does not adequately prepare future citizens to understand science and technology issues in a rapidly evolving society (Millar and Osborne, 1998). In an attempt to change this situation, a series of influential publications in the United States (Rutherford and Ahlgren, 1989; AAAS, 1993; NRC, 1996) have advocated a nation wide reform of science education with the following aims.

❖ To achieve scientific literacy as the central goal of science education (Science for ALL Americans). In this respect, it is considered particularly important to focus on students’ understanding of the nature of science.

❖ To achieve science standards for all students implying both excellence and inquiry (NRC, 1996).

❖ To design science education to reflect the premise that science is an active process so that both hands as well as mind on activities should constitute the core of educational process.

❖ Focus on inquiry as a central element of the curriculum to promote students along with reasoning and thinking skills.

From a teaching perspective, these reform efforts describe some implications for teaching science

➢ Instead of transmitting the content knowledge in a rigid manner, the emphasis in teaching will be on designing situations and a variety of activities which enable students to learn actively. In this respect, the teacher needs to investigate what students already know, identify
possible misconceptions and then design an appropriate educational setting. In any case, teachers need to be able to respond to situations what they might not have anticipated (Kennedy, 1998).

➢ In general a shift toward reflection on science rather than focusing solely on the content of scientific ideas is implied.

➢ Teachers will be confronted with the challenge of teaching in a way which appeals to all students both from a cognitive and an effective perspective.

➢ A shift towards the teaching of inquiry skills which is definitely more complex than the traditional training of practice skills.

➢ To develop competence in an area of inquiry, students must (a) have deep foundations of factual knowledge (b) understand facts and ideas in the context of a conceptual framework and (c) Organize knowledge in ways that facilitate retrieval and application.

➢ Teachers of science must provide their students with inquiries that mentally and physically engage their students with the content and evidence. It may facilitate students’ understanding as well as provide opportunity for students to apply and transfer their knowledge to new situation.

The implications of educational reforms suggested by National Science Education Standards (NSES, 1998) given above recommends a substantive change in how science is taught.

National Curriculum Framework for School Education (NCERT, 2000) that responds to the new societal and pedagogical changes which remains within
the broad parameters of N.P.E (1986 revised in 1992) is more relevant for science classrooms in Indian context.

- A shift of emphasis should be from information based and teacher centred education to process centred and learner centred curriculum.

- Science education should nurture the ability to explore and seek solution to the problems related to environment and daily life situations.

- Emphasis would shift from factual knowledge to the process of understanding, thinking and problem solving.

- Instructional strategies may assume a variety of classroom activities such as discussion, debate, problem solving, discovery learning etc.

The National Science Education Standards (NSTA, 1998) and National Curriculum Framework for School Education (NCERT, 2000) have guided the researcher to prepare the conceptual framework for the present study.

2.7  Conceptual Framework for the Present Study

The task of building an enlightened, strong and prosperous nation rests on the shoulders of its teachers who are unfolding the potentialities of the learners and transforming their interests, attitudes and values. Teachers must have a solid understanding of pedagogical practices that make content vivid and memorable, as well as practices that will motivate the learner’s interest, relate their background experiences and encourage them to learn. They need to know how to help students, understand how concepts are related, how to make difficult concepts comprehensible and how to help students transfer knowledge to novel
situations. In short, teachers must apply their knowledge of content using an array of strategies to help students acquire the basic knowledge and think critically about the content areas.

Competent teachers of science integrate their knowledge of content and methods of teaching through the effective use of teaching skills. These teaching skills relate to good interpersonal relationship, better human understanding and make teaching effective. A sound programme of teacher education is essential to maintain high level of professional efficiency and teaching skills which are especially effective in bringing about the desired changes in pupils. Many researchers (Rajameenakshi, 1988; Verma, 1988; Singh, 1989; Mishra, 1992; Sharma and Kumar, 1993) reported that microteaching based practice teaching during teacher training programmes contribute significantly towards sharpening the teaching skills of teacher trainees. The professional education which demands a great deal of creative work and skills along with indepth subject matter knowledge could help teacher trainees to master several teaching skills. Thus pedagogical practice given during teacher training programme helps teacher trainees to become competent in their profession.

Recent research has brought out increasing attention to the importance of subject matter knowledge (Sapre, 1993) as well as performance in science at degree level on teacher trainees' classroom performance (Bridget, 2001). These achievement variables may significantly contribute towards instructional practices in science class rooms. Kennedy (1990) asserts that student teachers
must be fluent in their subject. This fluency includes up-to-date knowledge of specific concepts and understanding of the complex relationships within the subject. Unless teacher trainee has indepth knowledge of his/her subject, coupled with communication skills, transmission of knowledge cannot take place. Teacher trainees have to integrate their knowledge of content and methods of teaching through the effective use of teaching skills.

Teachers' knowledge of subject matter content is particularly an important issue in science education, as national studies consistently report that many science teachers in secondary schools need adequate training in science disciplines. (NPE, 1986; Acharya Ramamurti Committee, 1992). Reynolds (1995) found that teachers with content knowledge in their discipline choose better metaphors for explanations, but those who lack subject matter knowledge have difficulty in selecting appropriate explanations. There are empirical evidences to show strong influence of teacher's content knowledge on his/her classroom performance. (Carlson, 1991; Harbison and Hanushek, 1992; Fennema and Fanke, 1992; Shulman, 1996). Teachers' knowledge of subject matter has been reported as an important correlate of teacher success. (Smith, 1989; Brophy, 1991; Kukretti, 1992; Ebert, 1994; Khourey-Bowers, 1995). Performance in science at degree level is significantly related to teacher competence of B.Ed students (Pradhan, 1989; Thonguchumnam, 1999; Bridget, 2001). Barba and Rubba (1992) argue that the ability to reorganise information for instruction requires an indepth understanding about the subject. And hence
both content knowledge and performance in science at degree level may be good predictors of teaching competency.

Teaching aptitude and problem solving ability could contribute directly or indirectly towards teaching competency of the teacher trainees. Every science teacher to be successful in his/her classroom performance should have readiness to develop an interest in exercising his/her innate ability and skills. Many studies have reported teaching aptitude as a significant correlate of teaching success. (Bhasin, 1988; Kukretti, 1992; Jain, 1992). Jain (1992) reported positive and significant correlation among teaching aptitude, teaching skills and creativity of student teachers. Teaching aptitude could even help in achieving a better performance in science at degree level which contributes toward enhancing mastery in subject content of high school Biology. There are empirical evidences which indicate teaching aptitude as an important correlate of performance in science at degree level (Kahlow, 1979; Vyas, 1982; Kahlon and Saini, 1989; Diwan, 1991). Michael and Chiapetta (1980) and Visser (2003) reported problem solving ability of student teachers is related to performance in science at degree level. Bucalos (2003) found problem solving ability as a determinant of knowledge acquisition of student teachers. Thus teaching aptitude and problem solving ability of student teachers may contribute towards mastery in subject as well as performance in science at degree level and could be significant predictors of those two variables and thus contribute indirectly towards teaching competency.
Travers (1981) contends that teaching competence of student teachers depends on many basic personal variables outside the control of the institution or teacher educators such as qualification of the teacher trainees, socio economic status, family environment, peer group of the student teacher and above all his/her personality make up. Qualification of the teacher trainees is found to be a powerful determinant of teaching success. (Shah, 1991; Bridget, 2001; Kagathala, 2002).

Socio economic status is an important correlate of achievement in science (Sarah, 1983; Misra, 1986; Darchingupui, 1989 and Alexander, 1990). For the same reason, it may interact with content knowledge, problem solving ability and teaching competency of the student teachers. Socio economic status has significant impact on the teaching competency (Rajameenakshy, 1988; Singh, 1988) and problem solving ability (Darchingupui, 1989). Father’s education is found to have significant influence on achievement in science of the learner (Menon, 1973; Ojah, 1989; Sophiani, 1992).

To maximize the effects on teaching and learning process, student teachers select colleges where they get better training. There are empirical evidences to show that type of management influenced the teaching competency of the teacher trainees. (Rajameenakshy, 1988; Shah, 1991). Research evidences establish significant gender difference among teacher trainees in their performance in the class (Rajameenakshy, 1988; Verma, 1988; Singh, 1988), problem solving ability (Darchingupui, 1989; Singh, 1992; Bridget, 2001),

Better facilities available in the colleges of education in urban areas may contribute towards better results. Research studies indicate that teacher trainees hailing from urban areas are superior to teacher trainees from rural areas in their teaching competency (Verma, 1988; Prakasam, 1988), problem solving ability (Singh, 1992), teaching aptitude (Diwan, 1991; Kumaran, 1997) and academic achievement (Diwan, 1991).

Therefore while seeking for the interaction among mastery in subject content of high school Biology, performance in science at degree level, teaching aptitude, problem solving ability and teaching competency, it is pertinent to seek systematic and up-to-date information on the interactive effects of personal variables, such as qualification of the teacher trainees, socio economic status, gender, region, college management type, parental education, parental occupation and parental income. These basic personal variables could interact with teaching competency of the teacher trainees directly or indirectly.

On the basis of the theoretical constructs discussed, and interrelationship among the selected variables, a schematic representation of the conceptual framework for the present study is developed and presented in Fig.2.3.
Figure 2.3

Schematic Representation of the Interpretive Frame Work