REVIEW OF RELATED LITERATURE

- Review of Related Theory
- Review of Related Studies
REVIEW OF RELATED LITERATURE

Any worthwhile study in any field of knowledge requires an adequate understanding and familiarity with the work that has been already done in the same area. The review of related literature forms an important aspect to a research study. It gives the researcher an understanding of the research methodology and also it helps him to be familiar with the current knowledge in the area of his study.

According to Borg “the literature in any field forms the foundation upon which all future work will be built. If we fail to build the foundation of knowledge provided by the review of literature, our work is likely to be shallow and naive and will often duplicate work that has already been done better by someone else”.

The investigator surveyed a number of books, journals, dissertations and research reports besides searching the internet. The investigator also made efforts to meet experts and discuss with them the various aspects of the study. Consolidating the theory and pertinent studies, the present chapter is divided into

1. Review of related theory.
2. Review of related studies.
2.1 REVIEW OF RELATED THEORY

Since the present study is connected with Mastery Learning Strategy and Problem Solving Ability, the theoretical overviews of the two are to be given separately.

2.1.1 THEORETICAL OVERVIEW OF MASTERY LEARNING STRATEGY

2.1.1.1 Definition

Mastery Learning Strategy is an instructional strategy, which assumes that given sufficient time and appropriate instruction including alternative strategies, almost all of the students can master almost all of the content taught in the class. According to Anderson (1995), Mastery Learning is a philosophy that asserts that any teacher can help virtually all students to learn excellently, quickly and self confidently. The teacher can help "dumb", "slow", "unmotivated" students to learn like "smart", "fast" and "motivated" students.

2.1.1.2 Origin of Mastery Learning

Although the basic tenets of mastery learning can be traced to such early educators as Comenius, Pestalozzi and Herbart, most modern applications stem from the writings and research of Benjamin S. Bloom of the University of Chicago. Early attempts of using this concept can be traced to programmes developed by Washburne (1922) and Morrison (1926). Under Washburne's Winnetka Plan student learning was self-paced. Each student was allowed, all the time, he needed to master a unit. Under Morrison's method each student was allowed the learning
time his teacher required to bring all (or almost all) students to unit mastery. These characteristics are similar to the current scheme of mastery learning. While Morison's method was popular in the thirties, eventually the idea of mastery learning disappeared due to the lack of the technology required to sustain a successful strategy.

The idea of mastery learning resurfaces again in late fifties and early sixties as corollary of Programmed Instruction. A basic idea underlying Programmed Instruction was that the learning of any behaviour, no matter how complex, rested upon the learning of a sequence of less complex component behaviour (Skinner, 1954). Programmed Instruction worked very well for some students, but it was not effective for all (or almost all) students.

Recent discussion on mastery learning, however seem to go beyond these steps suggested by Washburne, Morrison and Skinner and refers to Carroll's Model of School Learning. Carroll's model was a conceptual paradigm, which outlined the major factors influencing student success in school learning and indicated how these factors interacted.

**Carroll's Model of School Learning**

John B. Carroll formulated a model of "learning for mastery" in 1963. His model was formulated on the following assumptions.

1. The model assumes that the work of school can be broken down to a series of discrete learning tasks.
2. Model applies to only one learning task at a time, but it should be possible to describe a student's success in learning a series of tasks (all the work of a certain school year) by summarizing the result of applying the model to each component task.

3. It is not intended (to be applied) to goals of schools that have to do with attitudes and dispositions (social and emotional goals of schooling). While Carroll acknowledges that learning tasks may play a role in support of attitude development. The acquisition of attitudes is postulated to follow a direct paradigm from that involved in learning task.

4. According to Carrol the model should not be confused with what is ordinarily called 'learning theory'. His model is intended a 'description of the economics of the school learning process', rather than as an exact scientific analysis of the essential conditions for process of learning itself.

The model proposed that under typical learning conditions, the time spent and the time needed were functions of certain features of the individual learner and the instruction he receives.

Carroll's model contains five elements. These elements act as variables that affect learning process in the classroom. The first three elements determine the time needed to learn a task, and the last two determine the time actually spent in learning.

(1) Aptitude, that is, the amount of time needed to learn the task under optimal instructional conditions, (2) ability to understand instruction related to his general intelligence and verbal ability, (3)
perseverance, that is, the amount of time the learner is willing to engage actively in learning, (4) opportunity, that is the time allowed for learning, and (5) quality of instruction judged by the degree to which it is optimal for every pupil.

Carroll’s definition of aptitude as the amount of time needed to learn a task at a given criterion level was his most significant contribution. Prior to him aptitude was defined in terms of the level of performance. He stressed that a student’s aptitude has traditionally been seen as an index of the level to which a child could learn in a given amount of time. From this perspective children tend to be viewed as either good or poor learners. The alternative perspective suggested by Carroll was to view aptitude as an index of amount of time required by a child to learn the subject to given level. Thus instead of being aptitude as a measure of ability to learn a particular subject, Carroll suggested that it could be viewed as a measure of learning rate. From this perspective children are seen as being fast or slow learners, rather than as good or poor learners.

In its simplest form his model proposed that if each student was allowed the time he needed to learn to some level and he spent the required learning time, then he could be expected to attain the level. However if the student was not allowed enough time, then the degree of which he could be expected to learn was a function of the ratio of the time actually spent in learning to the time needed.

This can be represented as

\[
\text{Degree of learning} = f \left( \frac{\text{Time actually spent}}{\text{Time needed}} \right)
\]
Carroll's model as the basis for Mastery Learning

The concept of mastery, as explained theoretically by John B. Carroll, was transformed into a learning strategy by Benjamin S. Bloom. Building upon Carroll's work Bloom took up the job of transforming this conceptual method of school learning into working model for classroom instruction. If aptitudes were predictive of the rate at which, and not necessarily the level to which, a student could learn a given task, it should have been possible to fix the degree of learning expected of students at some mastery level and so systematically manipulate the relevant instructional variables in Carroll's model such that all (or almost all) students attain it.

Use of the instructional variables in Carroll's model

Bloom focused on the major variables in the Carroll's model of school learning to suggest how these variables might be used in a strategy for mastery learning.

1. Aptitude for particular kind of learning

Carroll's view is that aptitude is the amount of time required by the learner to attain mastery of a learning task. Bloom believes that aptitudes for particular learning tasks are not completely stable and that they may be modified by appropriate environmental conditions or home and school learning experiences. In the opinion of Bloom the central task of educational programmes should be to produce positive changes in the student's basic aptitudes.
However, the key problem for Mastery Learning Strategy is to help students learn a subject to mastery whether or not changes are made in the aptitudes which are predictive of such learning.

2. Quality of Instruction

Carroll believes that individual student may need very different types and qualities of instruction to learn the same content and instructional objectives to mastery levels. He defines the quality of instruction in terms of the degree to which the presentation, explanation, and ordering of elements of the learning task approach the optimum for a given learner. Bloom observed that the quality of instruction must be developed with respect to the needs and characteristics of individual learners, rather than group of learners.

3. Ability to understand the instruction

This can be defined as the ability of the learner to understand the nature of the task, he is to learn, and the procedures he is to follow in its learning. In our school ability to understand instruction is determined by learner's verbal ability and reading comprehension. These two features are highly correlated with achievement. Therefore immediate modification needed is in dealing with ability to understand instruction. There are many instructional strategies, which teachers can use to fit their instruction to the differing needs of all their students. They are (i) small group study session; (two/three students) (ii) tutorial help; (iii) alternative textbook explanations, (iv) work book and programmed instruction on unit and (v) audio-visual methods and academic games.
4. Perseverance

Carroll defines perseverance as the time the learner is willing to spend in learning. Bloom believes that perseverance is not fixed. It can be increased by increasing the frequency of reward and evidence of learning success. Furthermore, the need for perseverance can be decreased by high quality of instruction.

5. Time allowed for learning

According to Carroll the time spent on learning is the key to mastery. His basic assumption is that aptitude determines rate of learning and that most, if not all students can achieve mastery, if they devote the amount of time needed to learn. This implies that the student must be allowed sufficient time for learning. According to Bloom it is not the sheer amount of time spent in learning that accounts for the level of students’ learning. He believes that the students should be allowed the time they need to learn a particular subject. The learning time needed will be affected by his aptitudes, his ability to understand the instruction, and the quality of instruction. If students’ use of time and instruction becomes more effective, it is likely that most students will need less time to master a subject, and the ratio of time required by the slower learners to that needed by the fast learners may be reduced.

2.1.1.3 The Mastery Learning Strategy

The Mastery Learning Strategy which Bloom proposed was designed to use in the classroom where the time allowed for learning is relatively fixed and mastery was defined in terms of specific set of
major objectives, the student was expected to exhibit by a subject completion.

The teaching learning strategy Bloom outlined to include the feedback and corrective procedures was labeled 'learning for mastery' and later shortened to simply 'mastery learning'. As conceptualized by Bloom and others mastery learning entails the following.

1. Material to be learned over a time period is divided into smaller units and performance criteria is established. 2. Following instruction on each learning unit, a test is administered. The result of which is periodically fed back to teacher and students regarding mastery of units and necessary corrective strategies. 3. The teacher provides corrective feedback until the student achieves mastery on the learning units. 4. The student then progresses to the next ability in the learning hierarchy.

Through this process of formative testing, combined with the systematic correction of individual learning difficulties each student receives appropriate amount of allocated quality instructional time and proportion of engaged learning time. Bloom reasoned that under these conditions virtually all students could achieve mastery of the school curricula.

2.1.1.4 Execution of Mastery Learning Strategy

In describing the steps for Mastery Learning Strategy, Block (1980) has pointed out that this strategy is accomplished through two distinct sets of steps. First the preconditions, which occur outside the classroom and prior to the instruction. Second the operating procedures, which take place inside the classroom during the instruction. These
steps contain four basic tasks. Preconditions contain two namely defining for mastery and planning for mastery. In the same way, operating procedures have two basic tasks. Teaching for mastery and grading for mastery. Each of these tasks is divided into several subtasks.

In this connection it is necessary to clear two points. First if mastery-learning programmes are to be as successful as they might be, all of the tasks and related subtasks must be accomplished. Second and somewhat related to the first point, how these tasks are accomplished is less important than that they are in fact accomplished. Each of the tasks and related subtasks serves as an important function within the context of mastery learning.

![Diagram of the Complete Mastery Model](image)

FIGURE 2-1 The Complete Mastery Model (Jacobsen, 1985)
In light of the above discussion the following section is focused on basic tasks and main steps involved in the development of successful mastery learning programme.

**Basic Tasks**

Block and Anderson (1985) have suggested four basic tasks and their related subtasks. They are as under:

1. Defining mastery
2. Planning for mastery
3. Teaching for mastery
4. Grading for mastery

Each of these major tasks is divided into several subtasks. They are described below.

**Defining mastery**

Mastery learning programmes are outcome based. Thus the first task is to define precisely what is meant by mastery. Defining mastery has the following related subtasks

1. Identification of course outcomes/objectives
2. Preparation of summative tests
3. Division of entire course into series of smaller units
4. Sequencing the units
5. Deciding what will constitute mastery of each learning unit
Planning for mastery

After defining mastery the next task is to plan for mastery. This plan must be consistent with the way in which mastery has been defined. Specially, the plan must include activities, material related to the unit objectives and materials for those students failing to attain the performance-standard on the unit formative test. The function of planning for mastery is to permit teachers to be proactive in their classroom situation. Proactive teachers are ready to tackle classroom situation as they arise. They can anticipate likely problems and respond in one of a variety of appropriate pre-planned ways.

In essence, planning enables teachers to monitor student learning on a unit basis. If the evidence gathered from the formative tests suggest that learning is not proceeding as well as expected or desired, then steps can be taken to intervene, so that, ultimately the desired degree of learning is attained. Planning for mastery involves the following related subtasks.

1. To design a general plan for helping all students to master unit objectives.
2. Presentation of methods to interpret and use the information gathered from formative tests.
3. Planning for time.

Teaching for mastery

Here the focus is on managing learning rather than managing learners. Inside the classroom, the function of the teacher is to specify what is to be learnt, to motivate pupils to learn it, to provide them with
instructional material, to administer these materials at a rate suitable for each pupil, to monitor students’ progress, to diagnose difficulties and provide remediation for them, to give praise and encouragement for good performance, and to give review and practice that will maintain pupils’ learning over long periods of time. Teaching for mastery has the following related subtasks:

1. Orientation of students
2. Teaching each learning unit in sequence using the original instruction plan
3. Administration of unit’s formative test
4. Enrichment activities for masters and corrective procedures for non-masters.

Grading for mastery

The final major task is grading for mastery. Grades are assigned to students based on their performance on the summative test relative to the predetermined performance standard, not based on their performance relative to the performance of other students. Such mastery grading is designed to engage students in competence motivation, that is the desire to compete against one self, and the objectives to be learned, and to disengage from competition motivation, that is the desire to compete against others. The sub task under grading for mastery is: administration of the summative test.

2.1.2 THEORETICAL OVERVIEW OF PROBLEM SOLVING

"Problem solving is an exciting area in psychology because it is a basic, universal characteristic of all humans. What person does not face
a number of problems each day? To understand how people solve problems is, to a large degree, to understand basic human behaviour, the goal of every psychologist. The importance of problem solving strategies and obstacles lie at the foundation of understanding humankind.” (Magill, 1996)

A comprehensive theory on Problem Solving is not available as the concept has very abstract roots in Psychology and Physiology. The intangible area of cognition - thinking and Problem Solving - is a less explored one with more of assumptions and hypotheses with no solid proof. Much of the theory, models and hypotheses are available on the different aspects of the process associated with Problem Solving mainly highlighting the steps and general nature of Problem Solving. Vaidya (1968) remarks that educational research on Problem Solving itself has so far been very little.

2.1.2.1 Definition for ‘problem’

A Problem arises when one has a goal - 'a state of affairs that one want to achieve' - and it is not immediately apparent how the goal can be attained. The conceptual framework for analyzing such situations has 3 components. (Newell and Simon 1972)

a) the initial problem state;
b) operators that transform problem states into new states
c) operators that test whether a problem state constitutes a solution.

The application of a sequence of operators to the initial states and the resulting states leads to a whole space of states.
A problem consists of a given state (i.e., a description of the current situation), a goal state (i.e., a description of the desired situation), and a set of operators (i.e., rules or procedures for moving from one state to another). A problem occurs when a situation is in one state, the problem solver wants it to be in another state, and there are obstacles to a smooth transition from one state to the other.

**Definition for 'problem solving'**

Let us now consider the following three definitions of problem solving.

1. It may be defined as a planned attack upon a difficulty or perplexity for the purpose of finding a solution. There is then recourse to reflective thinking which is a process of careful conscious consideration of facts, beliefs or other elements of mental experience for the purpose of arriving at rational conclusions relevant to some problem or perplexity.

2. It is the process of raising a problem in the minds of students in such a way as to stimulate purposeful reflective thinking arriving at a rational solution. Three elements seem to be involved here

   - a situation; which presents some difficulty, perplexity or doubt requiring solution,

   - a goal or an end involving some aspect of the situation for which no ready answer can be given

   - and a desire or motive that stimulates an attempt to find the answer.
3. Problem solving takes place when a problem solver accepts to solve it as well as when his previous knowledge or patterns of behavior are insufficient or inappropriate to enable him to provide an acceptable solution. In such a case solutions become possible only when he acquires new knowledge or capitalizes relationships, which have not been seen earlier.

Polya (1981 p.ix) defined problem solving as "finding a way out of a difficulty, a way around an obstacle, attaining an aim that was not immediately attainable.

Mayer (1992) summarizes three major aspects of a definition of problem solving:

a) Problem solving is cognitive, because it occurs internally within the problem solver's cognitive system. b) Problem solving is a process, because it involves manipulating or performing operations on the problem solver's knowledge and c) Problem solving is directed, because the problem solver is attempting to achieve some goal.

Different approaches towards the study of Problem Solving

1. Experiment: The behaviour of actual subject is studied under controlled conditions.
2. Factor Analysis: This type of studies has led to identify a set of operations involved in Problem Solving.
3. Task analysis: This type of studies are performed independently or in combination with various empirical research methods and has resulted in the formulation of several different sets of steps involved in Problem Solving.
4. Mass Observation Method: It is used in the study of concept formation in children, which depends upon interview, cross-questioning etc.

5. Psychological Test: This type of tests yield a certain amount of information about the factors involved in thinking and their operational availability in testing situations.

6. Cross sectional and Longitudinal studies: Such studies were used by J. S Bruner in identifying and classifying the enactive, iconic, and symbolic modes of representing experience and also in explaining facts of cognitive growth, language and strategies of learning.

7. Introspection and Self knowledge: Although liable to error, one can get considerable stimulus from observing something of one's own reaction and those of one's family and friends.

2.1.2.2 Historical Over-view

The history of scientific research on thinking and problem solving dates back to 1901, when researchers at the University of Wourzburg began publishing their findings concerning the thought processes involved in making free associations concerning words or pairs of words (Humphrey 1951, Mandler and Mandler 1964).

Most of the subsequent research on thinking and problem solving falls within three categories: associationist, Gestalt and cognitive. The associationist approach, which dominated psychology through out the first half of the twentieth century, views problem solving as the production of a series of responses until one works. A major criticism
of this approach concerns how it can account for creative problem solving.

The gestalt approach, developed in Germany in the 1920 s and 1930 s, view problem solving as mentally reorganizing the elements of the problem so that they fit together in a new way. Thus the major task in problem solving is to achieve structural understanding, that is to see how the given elements mesh with the requirements of the goal. A major criticism of this approach concerns the need for clearly testable theories.

The cognitive view, which began in the late 1950 s and evolved into the cognitive science approach by the 1980 s, provides for an integration of the positive features of both approaches (Gardner 1985, Mayer 1992). According to this approach, problem solving involves a series of mental computations, so a theory of problem solving must specify the specific mental processes used to solve a problem as well as the methods that problem solvers employ for selecting and controlling their cognitive processes.

**Theoretical Formulations**

Problem Solving is combining what we had known with various aspects of problem situation to arrive at a desired solution. A variety of basic thought processes like perceiving, remembering, reasoning, inferring are involved while solving a problem. The ability to formulate creative solutions to problem is considered as the central aspect of thinking. Various theoretical formulations by the exponents in the field are detailed below.
1. Wallas’s Classic Description of Creative Problem Solving

Wallas’s (1926) considered that Problem Solving process covers a number of stages and strategies in progressing towards a final solution. His classic description included:

- Preparation – defining the problem, making first attempts to solve it.
- Incubation – where the problem is left aside to develop
- Illumination – where the solution comes in a sudden and
- Verification – in which the solution is evaluated to make sure that it really works.

Eysenck and Keane, however considered that this approach is rather too general and remarked that the stages incubation and illumination are vague.

2. Dewey’s Description Theory of Problem Solving

Dewey (1933) characterise thought as a Problem Solving behaviour. This conception emphasizes that thought may have grown out of man’s need to adopt himself to a difficult and often hostile environment. Dewey remarks that reflective thinking begins when there is doubt that leads to a search for material that will resolve the doubt and dispose the perplexity. The first phase is the pre-reflective which establishes the nature of the problem to be solved. The last phase is the post-reflective which result in a feeling of mastery and satisfaction, between these two phases are the states of thinking which include suggestions in which the mind anticipates possible solutions, recognition of the nature of the problem, use of hypothesis to initiate and guide the
search for relevant material, mental testing of the hypothesis and actual testing of hypothesis.

3. Cognitive and Gestalt views on Problem Solving

   Gestalt psychologists and other wholistically oriented psychologists have pointed to the integrative aspects of thought, the ways in which our understanding of a problem, and of the tools that may lead to its solution is more than a sum of the parts. It can be restructured by the interactions among the parts and by the unique whole, including attention, set and expectations and even by the whole past experience and personality of the person attempting a solution.

4. Duncker's Funneling theory of Problem Solving

   Duncker (1945) brought forth a new explanation on the nature of Problem Solving. According to him, Problem Solving consists of series of restatements of the problem – each funneling into a more narrowly defined statement until the final solution is reached. Duncker's description is based on observation of what people actually do and say as they go about solving a problem that has been set up in the laboratory. His analysis shows that when an individual starts solving problem, his concepts can be described as progressing through three major stages – from the general range, through a functional solution to a specific solution.

5. Gagne's theory of hierarchy of learning

Verbal association 5. Multiple Discrimination 6. Concept learning 7. Principle learning and 8. Problem Solving. Gagne considers Problem Solving as the highest form of learning, the accomplishment of which demands the ability to deal successfully with the pre-requisite principles that are in turn preceded sequentially by necessary concepts, multiple discriminations, verbal associations, chain and stimulus-response experiences (with the possible exception of the signal type).


Bransford et al. (1984) list the 5 steps that they believe lead to effective Problem Solving: Identify, Define, Explore, Act and Look and Learn. It may be noticed that the first letters of the steps spell “ideal”. To apply this thinking strategy one should identify the problem, define it clearly and then explore the possible solution and relevant knowledge. Next he should act by trying a possible solution or hypothesis. Finally he should look at the result and learn from them. Of course each attempted solution may identify sub problems. These can again be tackled with the ‘ideal’ steps until a final satisfactory solution is found.

7. Marzano’s model for the process of Problem Solving.

Marzano (1997) believes that providing a model is a good way to help students feel comfortable with the Problem Solving process. The steps in the process are stated as follows: 1. Identify the goal you are trying to accomplish. 2. Identify the constraints or limiting conditions. 3. Determine exactly how these constraints or limiting conditions are preventing you from reaching your goal. 4. Identify different ways of overcoming the constraints or meeting the limiting conditions. 5. Select
and try out the alternative that appears to be the best. 6. Evaluate the effectiveness of the alternative you have tried.

8. Mayer’s Design for Teaching Problem Solving

Mayer (1992) has summarised three major issues in the design of an effective program for teaching Problem Solving: what to teach, how to teach and where to teach. First, Problem Solving can be taught as a single, monolithic ability that can be strengthened through training and exercise (eg., mathematical problem-solving skill or language skill), or as a collection of smaller, component skills that can be specifically taught (eg., how to represent problems, how to devise solution plans, or how to monitor one’s comprehension). Second, Problem Solving can be taught by emphasizing the product of Problem Solving (namely, getting the right answer), or by emphasizing the process of Problem Solving (that is the method or steps that one goes through to arrive at an answer). Third, Problem Solving can be taught in a general, domain-free context in hopes of promoting transfer across many domains or within the context of specific subject domains such as mathematics, social studies, or writing, with the expectation that students are generally able to apply a problem-solving strategy only within a particular domain. Mayer suggests that Problem Solving is most effectively taught when the focus is on teaching the component skills rather than a single general ability, on process rather than product, and on domain-specific rather than context-free settings.

**Strategies for Problem Solving**

Decomposition - If a problem is too complicated a strategy called
decomposition can be used. This is done by dividing the problem into smaller more manageable sub problems.

Working Backward – Many problems are like trees. The trunk is the information you are given; the solution is a twig on one of the branches. If you work forward by taking the ‘givens’ of the problem and trying to find the solution, it is easy to branch off in the wrong direction. Sometimes the more efficient approach is to start at the end, working backward from your goal.

Finding Analogies – To take advantage of analogies, one must first recognize the similarities between current and previous problems. Then it becomes easier to recall the solution that worked before for an earlier but similar problem. Surprisingly, most people are not very good at seeing the similarities between new and old problems.

Allowing to Incubate – In the case of a difficult problem a helpful strategy is to allow it to ‘incubate’ by laying it aside for a while. A solution that once seemed out of reach may suddenly appear when you engage in unrelated mental activity. The benefits of incubation probably arise from forgetting incorrect ideas that may have been blocking the path to a correct solution.

Research on Problem solving in Real situations

Research on every day problem solving reveals that people rarely use school-taught methods to solve problems encountered outside of school (Lave1988, Rogoff and Lave 1984).
An important area of research involves comparing of how experts and novices solve problems in domains such as medical diagnosis, computer programming and Physics (Chi et al. 1988) as well as in the game of chess (De Groot 1965). For example when Larkin (1983) asked experts and novices in Physics to think aloud as they solved physics problems, she found that experts were more likely to describe the problem in terms of its physics concepts (such as forces and weights), whereas novices focused on the surface features of the problems (such as pulleys and ropes). Similarly when Chi et al. (1981) asked experts and novices to sort physics problems into groups, experts sorted problems based on their underlying physics principles (such as conservation of energy) whereas novices sorted the problems based on their surface characteristics (such as inclined planes or springs). Results of expert- novice studies suggest that experts represent and solve problems differently from novices, and so instruction can focus on helping novices to think more like experts.

Another important area is the study of human problem solving within subject matter areas such as reading, writing, mathematics and science, that is psychologies of subject matter (Mayer 1987). Instead of studying how people think in general, psychologists of subject matter investigate how people think scientifically or mathematically or how people think within the process of reading or writing a passage. For example in scientific problem solving, the problem solver must overcome preconceptions that he or she brings to the situation. This approach suggests that instruction in subject matter areas should focus on helping students learn the cognitive process and strategies required for successful problem solving.
Relation between Problem solving, Thinking and Reasoning

Problem solving is a common and pervasive type of thinking, namely directed thinking in which the thinker is attempting to achieve some goal; in contrast, non directed thinking in which the thinker is not attempting to achieve some goal, includes daydreaming and the abnormal thinking of autistic and schizophrenic people. Reasoning can be viewed as a type of problem solving.

Types of Problems

Well - defined problems and ill - defined problems

A distinction based on the clarity of the problem statement, can be made between well - defined problems and ill - defined problems. A well - defined problem has a clear given state, a clear goal state and a clear set of allowable operators. For example, finding the value of 'x' in an algebraic equation such as \(x^2 + x + 4 = 0\) is a well-defined problem. In contrast an ill - defined problem has a poorly specified given state, goal state and/or operators. For example, giving a persuasive speech is an ill - defined problem because the goal and the allowable operators are not clearly specified. In school, students often work on well - defined problems whereas most of the crucial problems in everyday life are ill defined.

Routine and non - routine problems

Another important distinction is that between routine and non- - routine problems, and is based on the knowledge of the problem solver. Routine problems are identical or very similar to problems that the
problem solver has already solved, and therefore require reproductive thinking, reproducing responses that have been produced previously. For example, routine problems for most high school students are of the type: ‘5 + 5 = __’. In the strictest sense, routine problems do not conform to the definition of problems, since they do not include an obstacle between the given and goal states. In contrast non-routine problems are different from any problems that the problem solver has solved previously, and therefore require productive thinking (Wertheimer 1959), that is, creating a novel situation. In school, students often work on routine problems called ‘exercises’, however most important problems in everyday life are non-routine.

Problems requiring convergent and divergent thinking

A third distinction can be made between problems requiring convergent and divergent thinking. Convergent thinking problems have a single correct answer that can be determined by applying a procedure or retrieving a fact from memory. Example includes arithmetic computation problems and typical multiple-choice items. Divergent thinking problems (Guilford 1967) have many possible answers, and so the problem solvers' job is to create as many solutions as possible. Classic examples include 'uses problems' such as "List all of the possible uses of a brick", and 'consequences problems' such as "List all of the consequences of humans having six rather than five fingers". Originality and fluency in producing answers to divergent thinking problems are measures of creativity and are taught in instructional programs in critical thinking. Although divergent thinking is the
hallmark of creativity, most school-based problems emphasize convergent thinking.

Rigidity in Thinking

A major obstacle to effective problem solving is rigidity in thinking. For eg., in some problem solving situations, the problem solver must use an object in a new way, such as using a brick as a doorstep or using chewing gum as an adhesive. When a problem solver can only conceive of using an object in its most common function, the problem cannot be solved. Duncker (1945) used the term "functional fixedness" to refer to such a situation. Another example of rigidity occurs when a problem solver uses a well-learned procedure on a problem for which the procedure is inappropriate.

The distinction between meaningful and rote learning

Max Wertheimer (1959) suggested that there are two ways of learning. Learning by rote leads to reproductive thinking. Such problem solvers would perform well on retention tests but perform poorly on transfer tests. In contrast learning by understanding leads to productive thinking as measured by transfer tests.

2.2 REVIEW OF RELATED STUDIES

Since, Mastery Learning Strategy, Problem Solving and Physics are the key terms used in the present study, the investigator has classified the entire studies as under:

2. Studies related to problem solving and related cognitive processes.
3. Studies conducted in Physics.

2.2.1 STUDIES RELATED TO MASTERY LEARNING STRATEGY

Yadav (1984) studied the effect of Mastery Learning Strategy on pupils’ achievement in Mathematics, their self concept and attitude towards Mathematics. After the experimental treatment, the group taught through Mastery Learning Strategy exhibited a significantly higher achievement in Mathematics, evinced a more positive attitude towards Mathematics and showed improvement in self concept than the control group.

Koul (1986) compared the effects of Bloom’s Mastery Learning Strategy and Keller’s personalised system of instruction with the traditional method on achievement motivation and test anxiety of socially disadvantaged group. It was found that both Bloom’s Mastery Learning Strategy as well as Keller’s personalised system of instruction was effective to promote achievement motivation.

Salim (1988) tried to determine the effects of a Mastery Learning Strategy on the achievement of secondary school chemistry students in Sabha, Libya. The results suggested that the mastery learning students had significant achievement gains in Chemistry across all achievement tests. It was also concluded that although all students benefited from mastery learning, high and average aptitude students benefited more than low aptitude students.
Mathur (1988) studied the effect of the mastery learning programme on the achievement, self concept and attitude of undergraduate and postgraduate pupils towards Statistics. It was found that mastery learning programme is an effective strategy in terms of achievement, self concept and attitude. Mastery learning programme also reduced the gap between repeaters and non-repeaters.

Aranha (1988) showed the utility of mastery learning approach for slow learners. They gained in scores on final tests along with strong academic motivation and self concept habits as result of mastery learning programme.

Malini (1988) studied the effectiveness of Mastery Learning Strategy in the achievement of Mathematics at secondary school level. The results revealed that the mean achievement scores obtained using the Mastery Learning Strategy are greater than the mean achievement scores obtained using traditional classroom teaching methods. Also it was noted that Mastery Learning Strategy is effective irrespective of the three levels of intelligence (high-, average-, low-).

Prasad (1988) studied the effectiveness of Mastery Learning Strategy on achievement in English of secondary school pupils. The study revealed that pupils taught through Mastery Learning Strategy achieved significantly higher than the pupils taught through Conventional Strategy of teaching.

Monger (1989) examined the effects of a mastery learning instructional strategy on student achievement and on student’s subject related attitudes. Bloom had predicted that mastery learning
instructional strategy would result in the majority of students reaching superior levels of cognitive achievement and positive subject related affect. But the results did not confirm the underlying theory of mastery learning as there was no significant difference in the achievement, subject related affect, mathematics problem solving and mathematics computations. Also in a specific case of the quasi-experimental design, the control group out performed the experimental group in mathematics concepts and total mathematics, disconfirming Bloom’s theory in this case.

Divakaran (1989) studied the effectiveness of Mastery Learning Strategy on the achievement in Malayalam of low cognitive entry behaviour secondary school pupils. The study revealed that there exists a real difference in the mean achievement scores in Malayalam between experimental group and control group. Therefore it can be concluded that Mastery Learning Strategy is more effective than Conventional Strategy of teaching for low cognitive entry behaviour students.

Odud (1989) investigated the effects of strategies of instruction on mastery learning. It was found that there was no significant difference among different strategies of instruction on the criterion of immediate attainment of mastery.

Arredondo, et al. (1990) comments that in recent research, when teachers focus on higher mental processes (problem solving, application of principles, analytical skills, and creativity) within a mastery learning format, students' thinking skills and knowledge levels improve. Baltimore County (Maryland) and East Islip (New York) School Districts have programs integrating process and content.
Kulik et al. (1990) analysed the findings from 108 controlled evaluations and showed that mastery learning programs have positive effects on the examination performance of students in colleges, high schools, and the upper grades in elementary schools. Effects of mastery programs on student attitudes, instructional time, and college completion rates are discussed.

Malini (1990) determined the effect of certain cognitive variables namely Verbal Intelligence, Nonverbal Intelligence and mathematical creativity and Mastery Learning Strategy on achievement in Mathematics of secondary school pupils. The results showed that irrespective of the ability level of the pupils, Mastery Learning Strategy has significant advantage over traditional method of teaching. The study also indicated that the formative evaluation can be conveniently done after the completion of three or four lessons instead of giving at the end of each lesson with the effect of Mastery Learning Strategy kept intact.

Slavin (1990) evaluates that findings of positive effects of mastery learning on experimenter-made measures can be interpreted as supporting the view that this technique may help focus teachers on a given set of objectives. The claim that mastery learning can accelerate achievement, in general, in elementary and secondary schools is still awaiting evidence.

Maurer (1991) evaluated the effectiveness of a Mastery Learning Strategy in enhancing student’s cognitive achievement, problem solving abilities and retention of these concepts in an introductory Chemistry program. Those students who received the Mastery Learning Strategy
had a significantly better cognitive achievement than those students that did not receive the treatment. However, the Mastery Learning Strategy did not significantly improve the cognitive retention of the treatment group.

Verma (1991) analysed the effect of personalized system of instruction and Bloom's Mastery Learning Strategy on the achievement and certain non-cognitive variables of students promoted by adopting lenient promotion criteria at school stage. The study revealed that the pass groups of students achieved higher on summative criterion test after receiving instruction through Keller's personalized system of instruction and through Bloom's Mastery Learning Strategy in comparison to the pass group of students taught through the Conventional Strategy.

Patadia (1991) tested the effectiveness of mastery learning in a group-oriented classroom to meet the conflictive demands of a classroom situation. The study revealed that the mastery in initial units facilitated the learning of subsequent units in terms of time. Remedial measures used had a positive effect on achievement. The role of IQ in learning was considerably reduced with the use of mastery learning.

Abadir (1992) examined the effects of two different mastery learning instructional strategies and the effect of the lecture strategy on community college student's achievement in Mathematics. In this study, mastery learning students were able to achieve academically. But there was no significant difference, among the instructional methods for students' attitude towards Mathematics.
Chen (1992) used selected masterly learning techniques in Mathematics for non-disabled, learning disabled and educable mentally retarded children. The results suggested that the mastery learning strategies promoted the learning outcomes of Mathematics for non disabled children, for learning disabled children, and for educable mentally retarded children, but the effects on the latter were not so significant as the use of the mastery learning strategies for the non disabled and learning disabled children.

Abadir et al. (1993) studied the effects of mastery learning strategies, interactive video mathematics (IVM), individualized instruction (IND), and the lecture method on mathematics achievement of community college students. Interactions among instructional methods, gender, and age were examined; and the grade success rate was determined for each instructional method. The IND and IVM methods were characterized by mastery learning principles. Pretest and posttest components determined the mathematics achievement of college freshmen. IVM and IND methods had a positive educational influence on students' achievement on mathematics basic skills posttest scores, but, because many of these students did not complete the course in 10 weeks, grade success rate was significantly lower for these methods than for the lecture method. No significant difference was found for gender on the main effects, but a significant difference for simple effects shows that males favor the IVM method.

Nichols (1993) determined if differing ability levels will affect the acquisition of problem-solving skills and self-esteem as a result of participation in two approaches to teaching problem-solving skills, a
study was conducted with sixth graders in a posttest-only control group experimental design. Results suggest that thinking-skills instruction does impact the development of creative and critical thinking and that the acquisition of these skills has a positive effect on self-esteem. The study also provides evidence that the length of training is an important consideration in providing thinking-skills instruction, and that such instruction should be an integral part of the curriculum rather than a supplementary or isolated program. In addition, thinking-skills instruction is appropriate for students at all ability levels.

Deshpande et al. (1994) attempted determining the effectiveness of mastery learning strategies across socio-economic levels in terms of VIII standard students’ chemistry achievement and modification in their self concept. It was found that the students with high Socio-Economic Status achieved significantly higher than the students of low Socio-Economic Status. MLS was used more effective for above average and average intelligent students even though the below average students were also benefited. The self concept of all students enhanced significantly as a result of MLS.

Lai et al. (1994) compared data from 95 educationally disadvantaged Hong Kong students placed in mastery-learning classes with 64 control students in expository-learning classes. Results indicate that under mastery learning, deep- and surface-biased learners increasingly diverge in performance and attitude, with surface learners doing better unit-to-unit, and deep learners worse. Implications for mastery learning are discussed.
Ritchie et al. (1994) used a fifth-grade videodisc fractions program to examine accountability in mastery learning programs. Four classes were randomly assigned to two treatments (those who were and were not aware of participation in mastery learning). Results revealed standardized mean differences for achievement favoring knowledge of being in the mastery-learning program.

Whiting et al. (1995) investigated the cognitive and affective student learning outcomes of 36 semesters (equivalent to 18 years) using the mastery learning approach in high school distributive education classes (n=7,179 students). Student achievement in the cognitive area is reported by increasing grade point averages, and test scores are presented to show the consistent high level of academic achievement of students. Affective information (attitudes toward school and learning) has also been elicited from the entire sample and is presented to show positive changes.

Laney et al. (1996) examined economic concept learning and retention in 121 first and second graders who were randomly assigned (stratified by grade) to 1 of 4 instruction conditions: cooperative learning, mastery learning, cooperative-mastery learning, or control treatment. Found on posttest and delayed posttest that cooperative-mastery method was superior to other methods in promoting learning and retention.

Su (1996) attempted to determine whether low ability students in a mastery-learning program could attain the same level as high ability students in a traditional program. The result revealed that mastery
learning strategies are effective with low learning ability students to attain the same level as high ability students.

Vaidya (1997) attempted to study the effect of Mastery Learning Strategy on pupils' achievement, pupils' self concept and attitude towards Hindi. Mastery Learning Strategy was found more effective in facilitating learning and raising the achievement of the learners than either concept attainment model or the traditional method. Mastery Learning Strategy was more potent in bringing about improvement in the self concept as well as attitude towards Hindi of the pupils when compared to either concept attainment model or the traditional method.

Jaffer (2000) determined the effectiveness of Mastery Learning Strategy on achievement in geography of secondary school pupils. The study revealed that Mastery Learning Strategy was more effective than the traditional method in teaching Geography at the knowledge, understanding and application level.

Lee et al. (2000) evaluated the effect of using the mastery learning techniques of self-directed feedback, reinforcement, and remediation of knowledge on the performance of a work-related task involving transfer of training. The study supports the hypothesis that mastery learning would have a positive effect on transfer of knowledge from the classroom to a work-related task.

2.2.2 STUDIES RELATED TO PROBLEM SOLVING AND RELATED COGNITIVE PROCESSES.

Bloom and Broader (1950) studied the problem solving processes of college students and found that successful problem solvers differed
from unsuccessful problem solvers in respect of: (1) ability to use rather than possess the total fund of uniformed knowledge. (2) Extent of thought brought forward on a problem. (3) Attitude towards reasoning, confidence in the problem and the introduction of extraneous considerations into the problem situations.

Mealings (1961) studied some aspects of problem solving in science and found that problem solving is more related to intelligence than to chronological age. It appeared that there was a minimum mental age of 13 years before a child can reason formally about a problem. Children should not be expected to solve abstract problems below the mental age of 16.

Vaidya (1964) investigated the problem solving behaviour among certain groups of adolescent children in science. It was found that though adolescent pupils are in a position to state hypotheses, most of them were not in a position to test them.

Newell and Simon (1972) in their study on human problem solving understood that logic contributes to information processing through the presentation of ideas by symbols. The consequent alteration in meaningful ways by precisely defined, process symbol manipulation can refer to a much wider range of phenomena than simple deductive logic. The problem solver can be described and understood as an information processing system.

Linn and Levine (1976) studied adolescent reasoning and found that when the results were stressed and the procedure was hidden from view, the performance of the younger adolescent pupils was impaired
when compared to that of the older ones. The gap between the two was as wide as four years. Both groups of subject performed similarly on the problem when the results were not shown,

Mathur (1981) studied the growth of the experimental mind during adolescence and found that performance on piaget-type tasks shows an increasing trend with grade with some fluctuation in certain tasks. It was also found that the capacity of the adolescent pupils to grasp the essence of the problem increases with grade.

Raizada (1981) investigated the relationship between Problem Solving Ability and some relative personality traits using Piagetian tasks. The study revealed that Problem Solving Ability increases with age, grade and intelligence. Sex differences favouring girls existed in problem solving. Personality traits like persistency, erogenic tension, conformity and tender heartedness influenced problem solving.

Jain (1982) studied the problem solving behaviour in Physics of adolescent pupils and found that a large number of students who initially failed to solve problems correctly were able to solve most of the problems completely correct or partially correct after providing hints in relation to the strategies for problem solving. The hints were presented systematically and logically. It was also found that the problem solving scores differed significantly among the three groups of I.Q levels and also among the three groups of the level of intellectual development.

Shreshta (1983) conducted a study on the acquisition of problem solving processes during adolescence. The study revealed the following: 1. Each problem which inheres in a continuous chain of
reasoning has its own distinct factorial structure. 2. Processes of thought underlying the problem can be predetermined. 3. These processes of thought across the problem constitute distinct schemes of thought on appropriate grouping.

Jain (1984) carried out a study of Piagetian logical thinking among certain groups of adolescent pupils. The study revealed that the majority of adolescent pupils aged 11+ to 14+ are not in a position to reason formally. The mean performance of individual tasks, schemes of thought, and total adolescent thoughts show an increasing trend with age. The mathematical structures of tests and tasks showed the existence of six factors – combinatorial reasoning, grasping sense of the problem, supper ego strength, probability reasoning, classification-reasoning, and using constant differences.

Banerji (1987) used the programming language, LOGO, in its graphic mode as a method of teaching Mathematics and problem solving. The results suggested the new method had significant positive effect on students' application of problem solving strategies and ability to understand problem statements. Qualitative observations seemed to suggest improvements in some of the components of Problem Solving Abilities, but not in all.

Rekha (1988) studied the effect of piagetian model of teaching for the development of Problem Solving Ability in secondary school students. It was understood that the piagetian model of teaching is significantly capable of developing Problem Solving Ability over the traditional method of teaching, even though intelligence and achievement in the subject are controlled.
David (1988) carried out a comparative study of problem solving behaviour and found that the incidence of concrete thoughts favour boys rather than girls. There was a significant relationship between scores on concrete thought and measures of creativity. Directed observation or keenness of observation did not appear as a separate factor.

Suri (1989) studied the structure of the reasoning ability of rural and urban students. The study revealed that for the rural group, cognition of semantic classes, cognition of semantic relations and convergent production of semantic implications emerged as factors accounting for reasoning ability. And for the urban group, convergent production of semantic classes emerged as the only factor to account for reasoning ability.

Haridasan (1989) conducted a study of the Problem Solving Ability in biological science of high-, average-, and low- biology achievers at secondary school level. It was found that there is a significant relation between the Problem Solving Ability and achievement.

Darchingpui (1989) examined the relationships among variables such as achievement in science, attitude towards science and problem-solving ability under certain conditions such as location, socio-economic status, parental condition, occupation and typology of school among secondary school children. The study indicated significant relationship between scientific attitude and achievement in science. Significant sex differences in achievement in science and Problem Solving Ability existed. High socio-economic status, family facility and type of school
attended favoured achievement in sciences, scientific attitudes and Problem Solving Ability.

Dutt (1989) investigated the effect of problem solving strategies on Problem Solving Ability in science and examined its relationship with certain cognitive and personality variables. The study used tools of Problem Solving Ability test in science developed by the investigator; the group embedded figure test (GEFT) by Witkin, Oltman and Raskin; the General Mental Ability Test by S. Jalota and the comprehensive anxiety test by Sinha & Sinha. Data were analysed using mean, median, S.D, ANOVA and multiple regression analysis. It was found that strategies of problem solving significantly affect Problem Solving Ability of students. The focusing strategy was found to be superior to the scanning strategy. High intelligent students, irrespective of the strategies of training scored high on Problem Solving Ability test than low intelligent students.

Gill (1990) studied the effect of training strategies on creative Problem Solving Abilities and cerebral dominance in relation to intelligence, personality and cognitive style. The study showed that right brain- training strategy was superior to the left-brain training strategy, so far as creative Problem Solving Abilities in Mathematics were concerned. The group having the field independent cognitive style scored higher on originality than the field dependent group on creative Problem Solving Ability test.

Goel and Agbebi (1990) attempted to compare the relative effectiveness of the individualized method and the lecture-demonstration method of laboratory instruction of student acquisition of
psychomotor and related cognitive abilities when the specific behavioural objectives of five physics experiments in the subject area of light were pre-disclosed to students before instruction. The group of students who followed the individual lab method achieved significantly better on the psychomotor abilities whereas students who followed the lecture-demonstration method achieved higher level of cognitive abilities related to their respective counterparts.

Kanevsky (1990) experimented with forty children who were divided into four groups and administered the Tower of Hanoi puzzle using static and dynamic approaches. The benefits of age and ability were indicated by significant improvement from the general failure of the four- to five-year olds to the success of the majority of the high ability seven- to eight- year olds.

Parasnis (1990) constructed a test for Marathi medium students of standard IX to measure their Problem Solving Ability. Four hundred boys and girls drawn randomly from standard IX were used subjects for item analysis. For the study of reliability and validity an additional sample of 100 students was used. Percentages, t test and correlation were used for the analysis.

Pickering (1990) analyzed the performance of students on numerical versus conceptual chemistry problems in their freshman general chemistry course and their sophomore organic chemistry course. Data indicated that the ability to solve a problem did not necessarily imply an understanding of the concepts involved. ERIC Identifier: EJ409411
Sawrey (1990) compared in this research the performance of students on numerical versus conceptual chemistry problems at the introductory college level. Separate analyses were done to compare high and low achievers. It was shown that even the upper group of achievers had difficulty with concept questions. ERIC Identifier: EJ409410

Kumari (1991) studied the problem solving strategies and some cognitive capabilities of 10-12 year old children. The study revealed that the Problem Solving Ability and success on different types of problems were significantly and positively related to each cognitive capability separately as well as globally. There was some evidence for some sequential steps in problem solving at different forms or levels of responses to be associated with the tactics used by children.

Funkhouser (1992) administered Pretests measuring problem-solving ability to 71 students in a high school mathematics class. One group was given computer-augmented instruction; the other group was given instruction augmented by mathematics laboratory activities. Posttest results for problem-solving ability were mixed, but the group receiving computer-augmented instruction scored significantly higher on tests of mathematics content.

Shah (1992) examined the effectiveness of an educational programme on decision-making and intellectual abilities. The effect of the decision making programme was found to be more highly placed among girls than boys in the samples characterized by a lower intelligence. The creative thinking abilities development programme led to the development of fluency and originality of abilities in all the groups.
Granier (1992) investigated the effects of learning computer programming on the Problem Solving Abilities of community college students. Based upon the findings it was concluded that computer programming does provide an effective avenue to the development of Problem Solving Abilities in community college students.

Fischbach (1993) attempted an alternative method of instruction, called cognitive apprenticeship that utilizes the results of research in how students learn to solve problems in community college technical mathematical classes to improve student problem solving. But the results did not suggest the new method to be superior to the traditional method.

Nichols (1993) determined if differing ability levels will affect the acquisition of problem-solving skills and self-esteem as a result of participation in two approaches to teaching problem-solving skills, a study was conducted with sixth graders in a posttest-only control group experimental design. Results suggest that thinking-skills instruction does impact the development of creative and critical thinking and that the acquisition of these skills has a positive effect on self-esteem. The study also provides evidence that the length of training is an important consideration in providing thinking-skills instruction, and that such instruction should be an integral part of the curriculum rather than a supplementary or isolated program. In addition, thinking-skills instruction is appropriate for students at all ability levels.

Sumathy (1994) studied the hemisphericity, divergent thinking and Problem Solving Ability in Physical Science of the plus two students in Salem and found that boys and girls did not show any
difference in the deductive thinking skill, Inductive thinking skill, analytical thinking skill, convergent thinking skill, Divergent thinking skill and symbolic thinking skill and that girls were better than boys in solving problems involving recall/recognition and in problems involving more than one principle skill and synthetic skill.

Sherzer (1995) compared two groups of Israeli College preparatory students in their ability to solve algebra-rate problems using a computer program. One group received combined meta cognitive/meta affective abilities training. The second group received only meta cognitive training. It was predicted that the first group would out perform the second group on algebra-rate problems, meta-strategy knowledge, feelings of self-control and transfer. The results showed no significant difference between the groups in algebra – rate problems. Inconsistent with the hypothesis, the group which had meta cognitive abilities training only showed significant superiority over the group with combined abilities training for level of meta strategy knowledge.

Armstrong (1995) developed a high school physics laboratory manual designed to develop critical thinking, problem solving and creativity. The students are required to not only determine what information is needed for the data sheet, but they also must develop this data sheet. The final component of this manual is the in depth analysis the students must do.

Curtis (1995) investigated through a case study approach problem solving instruction occurring within a vocational technical school in Oklahoma. Problem solving was a planned and powerful part of the instruction. Instructors taught the following Problem Solving Abilities:
using problem solving steps, drawing parts of a problem, using different technologies and troubleshooting. Instructors encouraged the following characteristics of good problem solvers: intrinsic motivation, informal cooperation and creativity. Instructional strategies used to facilitate problem solving were questioning, coaching, scaffolding, modeling, articulation, exploration and reflection.

Dyer, James E.; Osborne, Edward W. (1996) In their study a group of Illinois secondary agriculture students was taught using a problem-solving approach (PSA), the other with a subject-matter approach (SMA). A problem-solving posttest and Group Embedded Figures Test showed significantly higher problem-solving ability in the PSA group. Field independent learners in the PSA group significantly increased their scores. There were no score changes for other learning styles or for the SMA group.

Oughton (1997) studied the effect of hypermedia development on high school students’ knowledge acquisition, problem solving and general design abilities. The results indicated that the students increased their declarative and procedural knowledge and could use the knowledge in more complex ways at the end of the treatment. In addition, the students’ general Problem Solving Abilities increased and the general design abilities emulated a cognitive framework.

Babarasc (1997) determined the effect of parenting style, and social Problem Solving Abilities on the ability of sixth graders to cope with the transition to middle school. The study revealed no significant relationships between social problem solving and parenting style.
Savelsbergh et al. (1997) identified the reasoning mechanisms that available the problem solver to achieve the transformation to a physics structure of the problem situation. Elaboration is explored as a mechanism in fulfilling this transformation by providing beginning problem solvers with elaborations that they failed to infer. Findings of the study provide evidence that that the reasoning processes in weak students may be qualitatively different from the reasoning processes in proficient students, and that the major problem for weak-problem solvers is not that they do not know problem types but rather that they fail to elaborate on a giver situation properly.

Neto and Valente (1997) explored the possibility of developing classroom strategies that would encourage Physics teachers to put greater focus on a more qualitative, meta cognitive approach to problem solving. This research was carried out with students approximately 16 years of age in physics classes at two Portuguese high schools with both qualitative and quantitative procedures being used. The results suggest that a meta-cognitively oriented problem solving approach might be a suitable means to assure a synergetic interaction between the scientific concepts and the thinking abilities.

Hong (1998) set forth to test the theory that the problem abilities used for well structured problems are necessary but not sufficient for solving ill structured problems in the context of an open minded, multimedia problem solving environment. The results of this study verified past research conclusions that well structured and ill structured problems require different components for reaching successful solutions. Cognition, including domain-specific knowledge and structural
knowledge and justification abilities were critical components in well-structured problem solving whereas Meta cognition, non-cognitive variables, justification abilities as well as cognition were essential components needed to solve ill structured problems.

Kelley (1998) compared the computer aided drafting (CAD) problem solving abilities of students taught with two different teaching methodologies via; cooperative learning and traditional individualistic form of teaching. The results of the study showed that both teaching methodologies were equally as effective at developing CAD problem solving achievement in students.

Kota et al. (1998) hypothesizes that the incidence of process-oriented thinking increases with the syntactic complexity of the problem presentation. Presents data confirming students' arithmetic preferences in the form of left-to-right translation along with evidence to show the effects of the ordering of data presentation in the problem statements on the problem-solving abilities of students.

Noh et al. (2000) studied the effects of Visual Organization and Cooperative Learning in Problem-Solving Strategy. The study examined participating students' multiple-choice problem-solving ability, strategy performing ability, anxiety about chemistry learning, perception of involvement, and motivation to learning science and reported a significant main effect in strategy performing ability. ERIC Identifier: EJ656441

Lin et al. (2002) investigated the efficacy of promoting 8th grade students' problem-solving ability through history of science teaching.
After one year of teaching, with the statistical procedure of the analysis of covariance, finds that the experimental group students outperformed their counterparts in the chemistry conceptual problem-solving ability. Initial results revealed that students benefited from the introduction of development of scientific concepts. ERIC Identifier: EJ649512

Chang et al. (2002) explored the interrelationship between students' problem-solving ability and their science-process skills in earth science. Statistical analyses indicated that a significantly moderate correlation existed between students' problem-solving ability and their science process skills. Results of a t-test also revealed that there were significant mean differences in students' skills of observation, data interpretation, and hypothesis formulation between higher-level and lower-level problem solvers.

Reid and Yang (2002) investigated Open-Ended Problem Solving in School Chemistry using a new set of 14 open-ended problems to gain some initial insights into the way pupils solve open-ended chemistry problems. The study emphasizes how concepts and linkages between concepts influence success in solving such problems and suggests that creating links between "islands" of knowledge is an important skill in Problem solving. ERIC Identifier: EJ659919

Sriraman (2003) studied Nine freshmen in a ninth-grade accelerated algebra class who were asked to solve five non routine combinatorial problems. The four mathematically gifted students were successful in discovering and verbalizing the generality that characterized the solutions to the five problems, whereas the five non gifted students were unable to discover the hidden generality.
Fawcett, L. and Garton, A.F. (2005) investigated the effect of collaborative learning on children's problem-solving ability and whether differences in knowledge status or the use of explanatory language were contributing factors. It was found that children who collaborated collectively obtained a significantly higher number of correct sorts than children who worked individually. However, post-testing indicated that only those children of lower sorting ability who collaborated with higher sorting ability peers showed a significant improvement in sorting ability from pre-test scores. In addition, it was found that when analysis was limited to this particular group, only those children who were required to explain the sort for their partner to carry out improved significantly from Pre to post test.

2.2.3 STUDIES CONDUCTED IN PHYSICS

Anantha ramaiah (1980) compared activity method with the lecture method to develop science talent among a few high school children in Banglore city. The study revealed that activity method was better than the lecture method in Physics.

Vijaya kumari (1985) investigated the effectiveness of problem solving method in terms of behavioural change in teaching physics to IX standard students. The problem solving method had a positive effect on the learning of students. This was pronounced in the area of understanding, application and drawing abilities.

Murthy (1989) tried to develop creative thinking abilities among eighth standard students through teaching of Physics using synectic
model and found a positive effect. The synectic approach also
developed fluency, flexibility and originality when taken separately.

Gurumurthy (1990) tried to compare the effectiveness of a guided
discovery approach of carrying out physics experiments versus
instructed performance approach at pre university level. Significant
differences were observed between the students of the guided discovery
group and instructed performance group I mean scores of 1.
comprehensive achievement and its components such as knowledge,
understanding and application and practical ability abilities.

Devi (1991) studied the effectiveness of multimedia approach in
learning Physics and found that the multimedia package was effective in
improving the achievements of students. It was found that the high
intelligence group and high socio-economic status group performed
better.

Usman (1991) studied the effectiveness of concept attainment
model in teaching Physics at secondary school level and found that it
was an effective method for developing concepts. Concepts like wave
motion, wave length, transverse wave etc. were difficult to follow in
spite of the teaching through concept attainment model.

Conclusion

Research studies (Pickering 1990, Sawrey 1990) indicated that
numerical problems and conceptual problems had different impacts on
students. It was shown that even the upper group of achievers with high
numerical Problem Solving ability had difficulty with conceptual
problems. These researches indicated that the ability to solve a
numerical problem did not necessarily imply an understanding of the concepts involved in it.

Alternative methods of instruction like cognitive apprenticeship that utilizes the results of research in how students learn to solve problems did not improve student problem solving. In one research it was found that girls were better than boys in solving problems involving recall/recognition and in problems involving a combination of principle skill and synthetic skill. Statistical analyses indicated that a significantly moderate correlation existed between students' problem-solving ability and their science process skills.

The studies on Mastery Learning Strategy show that this strategy definitely increases achievement and retention. Only very few studies are conducted to study the effect of Mastery Learning Strategy on higher order cognitive abilities. Certain research studies (Arredondo and Block, 1990; Mevarech, 1985; Soled, 1987) show that Mastery Learning Strategy increases high-level outcomes such as problem solving, drawing inferences, deductive reasoning and creative expression.

Nevertheless, what is known about the effect of Mastery Learning Strategy on higher order cognitive abilities is only on the basis of studies undertaken in the west, which may not be completely true in our state, with a different curricular approach, a different curriculum-transaction pattern and a different curriculum.