With advancement in Science and Technological fields, the life of the individual is becoming more and more complex fraught with a number of problems which the individual and the society have to face in the near future. The responsibility of school becomes increasingly important to develop problem solving ability in students so that they may solve their problems independently for better adjustment.

Problem solving efforts have paved the way for all the advancement in Science and Technology. In recent years man has been successful to set his foot on the Moon and to stay in the sky. Psychologists, philosophers, parents and teachers, scientists and technologists are daily facing various types of problems. It is a well established fact that the problem-solving involves the process of thinking and reasoning; and it is also admitted fact that problem solving skill can be acquired.

It is quite difficult to define the process of thinking. According to Dewey (1910), "the act of thinking
involves the task of attaching meaning and then trying out them in order to determine whether a particular course of action satisfactorily solves a problem or not*.

The most complex form of adjustment of which human beings are capable is reasoning. Maier (1945) defined Reasoning as "Productive thinking in which previous experiences are reorganised or combined in new ways, to solve a problem".

**PROBLEM SOLVING:**

The process of Problem Solving has received much attention from research workers. Definitions of problem solving vary from Hazlitt's (1930) description of the simple findings of exceptions to Piaget's (1950) formal reasoning of a complex nature, from Maier's (1936) combining the essentials of two isolated experiences to Welch's (1947) "The integrated activity of perception, memory, recall, association, generalisations and reconstruction of ideas".

The problem solving is one in which certain initial information is given and some goal is more or less specified but the relationship between the given information and the goal, is not apparent, the individual is confronted by external conditions in which an obstacle or difficulty must be overcome to reach a goal.

Brownell (1942) puts it as, "what seems objectively
to be the same situation may constitute for one person a puzzle, for another a problem, and for a third a condition with which he is thoroughly acquainted.".

Problem solving is that activity by means of which a person tries to find the answer to a problem. Problem solving is a function of both the problem solver and the task.

Problem solving is the highest level of learning in the hierarchy proposed by Gagne which depends on the mastery of next lower types of learning. It involves the application of principles and facts to explain and solve new phenomena or predict consequences from known conditions. The task of problem solving requires prediction, analysis of facts and principles to develop cause-effect-relationship in physical phenomena or in the environment.

A key factor in problem solving is the application of past experience to arrive at a solution not previously known to the person at least in a particular situation. Thus the simple production of responses already in the person's repertory involves memory or use of training rather than problem solving. Further the fact that past experience supplies the requisite information or skill for solution distinguishes problem solving from learning.

If you want to do something but do not know how, then you have a problem. The problem is the gap.
which separates where you are from where you want to be. We can view problem solving as consisting of two major problem solving processes:

1. The understanding process: The procedure we use to comprehend the gap which separates us from the goal or the solution; and

2. The solving process: The procedures we use to bridge the gap.

Problem solving in the formal model requires finding a pathway from the initial stage to the goal state (or the reverse) from among a very large number of possibilities. The process of problem solving consists of generating the search space or a part of it and of evaluating the relative benefit or value of the alternative states and the possibilities that have been generated.

There are levels of problem solving ranging from those that involve only simple wants with the conditions for satisfaction available without much effort, to those of high level complexity requiring solution of intermediate problem, to reach the primary objective. The intermediate problem must be solved before the major wants can be satisfied. The following are the various main methods of problem solving behaviour:

a) Unlearned or Instinctive problem solving behaviour.
b) Habitual behaviour.
c) Trial and error behaviour.
d) Scientific method.

e) Insight problem solving behaviour.

f) Transfer of training.

g) Vicarious problem solving behaviour.

**Unlearned or Instinctive behaviour:**

Some lower animals appear to satisfy their needs blindly or by mechanical ways and not according to peculiar conditions of the environment, but by the inherited organic structure of the organism itself. The animal reacts to its needs in certain fixed ways which is termed as instinctive problem solving behaviour.

**Habitual Behaviour:**

In human beings, habits are generally mutable enough to be adjusted to peculiarities of each new problem. Habits that are learned in early life are often confused with those that are unlearned. They differ in origin but not in usefulness in solving problems, that vary from those for which they are originally intended. This method of problem solving is not very much useful for solving new problems.

**Trial and Error Problem Solving Behaviour:**

When the problem which confronts the individual is such that no readymade response is adequate for solution
or is so complex that one cannot solve the problem by integrating already learned reactions then one tries to solve the problems by making certain responses, one of which may lead to successful solution of the problem.

Thorndike (1898) used the word "trial & error" behaviour for studying the problem solving. He preferred to call it "learning by selecting and connection". After performing experiments on rats and cats under different learning situations, he tried to derive certain laws and propagated his theory of connectionism or trial and error learning. The characteristic feature of this type of learning in problem solving is that perception of relations between means and end, is either vague or almost entirely lacking. In these trials, the individual accepts those which take him nearer to the success and rejects or corrects those which are not profitable. Trial and error type of problem solving behaviour finds, favours with lower animals and with very small children.

Scientific Method of Problem Solving Behaviour:

It is not the language that helps a man in problem solving in life but the way he uses the language in problem solving. Scientific method of problem solving is used by intelligent persons when they solve difficult and complex problems. The man confronted with a problem tries
to solve the problem in a scientific manner and does not make irrelevant movements as are made in trial and error method. Dewey has suggested the following steps of scientific method of problem solving:

I) Awareness of the problem and defining the problem.
II) Collecting the information/data.
III) Formulating hypothesis.
IV) Evaluating hypothesis.
V) Forming conclusions/application.

Insight Problem Solving Behaviour:

Gestalt Psychologists say that problem solving is not due to trial and error or stimulus-response mechanism. They were of the view that trial and error method was limited to lower animals only, on the other hand human beings while solving their problems involve insight.

Kohler, W. (1913-17) performed problem solving experiments with Chimpanzees, using hunger as the motive and found as a goal to satisfy that motive. In one experiment, a bunch of bananas was suspended from the ceiling of a room which had smooth walls and a box was lying in one corner. All the animals made repeated attempts to reach the lure by jumping, but Sultan the most intelligent of the group, soon ceased jumping, paced up and down and suddenly went near the
box and used the box as a jumping platform by placing it just below the hanging bananas. In another experiment, banana was placed outside the cage and two sticks, one longer than the other, were placed inside the cage. The banana was so hung that it could not be picked up by anyone of the sticks. The Chimpanzee first tried the sticks one after the other but failed. Suddenly he got a bright idea. The animal joined the two sticks together and reached the banana. These experiments indicate the importance of perception in problem solving and they probably identify the critical factor in perception which correlates with a sudden solution. Kohler (1925) from his experiments emphasised the presence of perceptual field and minimised the role of past experience.

Transfer of Training:

It has been observed that knowledge of solution of one problem does have an effect upon solving another similar problem, i.e., positive transfer.

Many experiments have been conducted on transfer of training and they showed slight amount of positive transfer - not enough certainly to justify the idea that sheer practice in learning gave one a superior mind. Thorndike (1898) noticed that experience with one puzzle box sometimes facilitated the solution of another one. A cat that had learned to pull a loop hanging in one part of the box
readily mastered a similar loop hanging in another part.

In Roger's (1954) experiments on human puzzle solving there were many instances of negative transfer effect. The ability to transfer what has been learnt leads to intelligent and seemingly purposeful solution of problem.

**Intelligence and Problem Solving**

Trial and error method, past experiences or learning does not always account for all the variances between individuals in solving problems. People differ in respect of abilities and it can be said majority of them who get a high score on a test of general intelligence do better in solving problems than those who get low score on intelligence.

Wechsler, D. (1944) defined intelligence as "is the aggregate or global capacity of an individual to act purposefully, to think rationally and to deal effectively with this environment."

**Vicarious Problem Solving Behaviour:**

Lower animals cannot respond to abstract situations as though they are present. Only man can recreate the past, extend his sensory range from beyond nature's limitations and accurately predict consequences that have yet to occur. Lower animals cannot use language
whereas man can use it and the value of language in problem solving is fundamental to all civilization.

**Methods of Problem Solving:**

Several methods may exist for a single problem formulation, representing alternative ways to attain the goal. With the set-predicate formulation of problem solving, we can associate a generate-and-test method; with the search formulation, a heuristic search method.

The basic structure of a problem solver is disjunctive: it selects one method; and so on. Each method has a chance of solving the problem. Thus we might write:

\[
\text{Probability-of-solution} = 1 - (1 - \text{probability(method)})^N \\
\text{Time-to-solution} = \text{Set up - time} + N(\text{Selection-time} + \text{Execution-time})
\]

Where \(N\) is the number of methods tried.

The **Recognition Method** (Universal method of a solving problem - by recognizing the answer): If one is asked "what is the value of pi?" and immediately answers "3.1416", it is probable that the answer to the question was recognized. The problem is not easy for all solvers.

Recognition processes are important for solving problems but not because they can be used directly for hard problems. They are important because problem solving often
proceeds by reduction.

The Generate and Test Methods:

The method makes use of the information available in the problem formulation. First, a process generates potential solutions from the set U. Then, as each is generated, it is tested to see if it is also a member of set G. Let us consider one example.

An extra chair is needed from the living room to seat an additional guest at dinner. Here the set U is small (say four chairs) and accessible (simply step into the living room and look at each chair in turn); furthermore the test is rapid (reject large stuffed chairs, reject tacky chairs, and others will do). Generate-and-test is an excellent method for solving the problem.

Heuristic-Search Method:

The basic cycle involves selecting an element in the problem space from which to work next, selecting an operator, attempting to produce a new element of the space, and testing whether it is a solution to the problem. The basic cycle completes itself with a three-way choice: to continue applying operators to the current element, to replace the current element by the new element; or to abandon the path defined by the current and new elements and go back to untried problems.
STRATEGIES OF PROBLEM SOLVING

People working on multi-step problems, employ a variety of strategies. Means and end analysis (According to Duncker (1935), the essence of it, is to find points of contact between the goal and the problem state which can serve as cues for devising or selecting a method of solution. In addition it is also important to know or discover for which purposes the available means are suitable), Protocol analysis (Verbal protocols are used to externalize a subject's internal problem-solving strategies. Such protocols result from asking the subject to 'think aloud' while solving a problem. These verbalizations plus whatever actions a person takes in solving a problem, are recorded and analyzed phrase by phrase. Each phrase represents an assertion about the task or a single act of task-specific behaviour). A balance strategy, focusing and scanning strategy. Bruner (1956) uses the term strategy to refer to the sequence of thinking as they tackle each problem for its solution. Obviously strategies employed by people are not fixed things. They alter with the nature of the problem being sought, with the kinds of pressures that exist in the situation, with the consequences of behaviour and the like.

These pure strategies provide only a partial account of human thinking. People generally shift from one strategy
to another one during the solution of the same problem. When they find that a particular strategy does not lead further towards the solution, they alter strategies. At any point in a multi-step complex problem, a person must choose among several "next steps". Two components of this overall decision process can be distinguished, scanning among the various alternatives and searching down (Focusing) the path leading from any alternative. Bruner has identified four strategies of selection of an alternative or next step:

1. **Simultaneous Scanning**: in which subjects attempt to deal with the task of solving a problem by generating and evaluating all possible hypotheses at once and at each presentation of new information.

2. **Successive Scanning**: in which subjects work on a single hypothesis at a time and examine subsequent presentations only in terms of that hypothesis.

3. **Conservative Focusing**: in which subjects find a similar problem and tries to apply the same solution to the new problem.

4. **Focus Gambling**: in which subjects use a positive instance as a focus and change more than one attribute at a time.

The two reception strategies are:
1. **Wholist** (akin to focusing)'s strategy is to take the first positive instance of the concept and use it toto as a guide, comparing all the attributes of the first instance to those of subsequent instances and modifying the hypotheses accordingly.

2. **Partist** (akin to scanning), here, the choice of a hypothesis is based on only part of the initial example. If the initial hypothesis is not confirmed, the partist refers back to all previous instances and changes the hypothesis.

In the use of problem solving as a method of teaching, three conditions are required: (a) the problem to be solved is adapted to the students' maturity and experience; (b) the students have had analogous previous experience and must possess related information needed for the solution, or they must know how to proceed to get this information; and, (c) the students are interested in solving the problem.

**Logical Steps involved in Problem Solving:**

Various steps have been made to break down the process as well as products of thinking. Dewey (1910) by various subjective and introspective observations formulated his five well-known steps in the process of thinking and problem solving (a) a felt difficulty, (c) its location and definition, (c) suggestion of possible solution, (d) development
of reasoning, (e) further observation and experimentation leading to its acceptance or rejection.

Wallas (1926) using similar methods has broken down the process of problem solving as (1) preparation stage - during which the problem is investigated from all directions, (2) incubation - when the individual is not consciously thinking about the problem, (3) illumination - the stage during which idea for solution occurs, (4) verification - in which validity of the idea for solution is tested.

Burack (1950) put in the necessary steps for the method of attack as (a) clear formulation of the problem, (b) preliminary survey of material, (c) analysis into major variables, (d) location of crucial features, (e) application of past experiences, (f) varied trials, (g) control, (h) elimination of sources of error, (i) visualization.

Heiss, O'bourn and Hoffmann (1951) analyzes the problem solving objectives as (a) sensing significant problems, (b) defining problem solutions, (c) studying the situation for all facts and clues bearing upon the problem, (d) manipulating and laboratory equipment needed in solving a problem with understanding of its function, (e) making the best tentative explanation of hypotheses, (f) testing hypotheses by experiment or other means, (g) accepting tentatively or rejecting the hypothesis or testing other
Vinacke (1952) thinks that the process of problem solving involves (a) recognition of the problem, (b) manipulation or exploration of some kind, (c) analysis, (d) partial solving, (e) emotional responses.

Gray, J.S. (1956) thinks these steps as methods of problem solving (a) unrelated and habitual behaviour, (b) blind trial and error behaviour, (c) insight behaviour, (d) vicarious behaviour, (e) scientific method.

1.1 REVIEW OF RELATED STUDIES:

Many research studies concerning different problem solving strategies and their effectiveness in relation to various process, psychological and support variables have been conducted in the past. Some findings of the studies having relevance to the present study are given below:

Heidbreder (1928) has investigated problem solving in children and adults by exposing them to puzzle type problematic situations. She concluded that reactions and sensitivity to problems increased with age, a gradual change with age from a more subjective attitude to a more objective attitude and characteristics and individualistic reactions to the problems apart from the fact that "the general pattern of the solution became more general or definite but new rigidity
set as the age increased*1.

Lazerte (1933) reported a study of the solving of arithmetical problems. Lazerte studied the problems into a series of steps of solutions so that two alternative procedures typed on two envelopes were offered to subject after he had read the problem. Within each of the two envelopes, two additional envelopes, each offering choice of two further alternatives that might be chosen. In the final stage eight possible alternatives were available for choice. Lazerte was able to describe objectively the process of thinking followed by the problem solver.

Mumford (1937) has also investigated thinking processes as they occur when normal individuals are engaged in working out puzzles of various types. Training, experience and practice influence thinking if thinking is regarded as a mental skill based upon innate capacity. School subjects can develop and promote problem solving if they are properly approached.

Sutherland (1947) analysed the one step, two steps and three steps verbal problems in Arithmetic. She showed that these problems can be broken into 38 one step patterns. It suggested the error of considering all problem solving as a single pattern and to the need for a mode of attack which will analyse specifically just what a problem is?
Bloom and Broder (1950) attempted to analyse the difficulties students had with variety of achievement and intelligent test problems.

The study of Benjamin Burrack (1953) dealt with the nature and efficiency of methods of attack on reasoning problems involving induction, deduction and geometrical analysis carried on a highly select group of 25 psychology undergraduates.

Prof. Guy T. Buswell (1956) reported a study on "Patterns of Thinking in Solving Problems". He studied the thinking process on the basis of different tests to help answering the following questions:

1. In solving problems to what extent do students first structure their thinking in terms of relevant, irrelevant and needed facts?
2. Can students estimate what would be reasonable answer before proceeding to the solution of problem?
3. How far is the pattern of thinking affected by the verbal sequence of the different parts of the problem?

Wheeler (1958) has investigated the development of reasoning in children. From her studies she concluded that children possess logical reasoning at much earlier age than hitherto assumed by teachers and most of the
elementary schemata necessary for valid reasoning are already within the capacity of the 7-year old children. It is only their subsequent development that helps children attack the complex problems later on.

Simon and Paige (1966) have developed computer programmes which are capable of problem-solving situations in algebra and in other fields. This work represents an attempt to explain and analyse human behaviour in problem-solving situations through comparison with computer processes which will make some of the same errors as human beings at various stages in the learning process.

Kent, B.R. (1974) investigated that the achievement of students taught verbal problem solving by consensus method was significantly greater than the achievement of the students taught by the Expository method.

Barnett, J. Charles (1975) suggested that structural variables can be used effectively as a basis for instruction designed to improve student problem-solving ability and no significant change was taken place in the amount of variance accounted for by the structural variables as a result of the four instructional units.

Felen, B.K. (1975) examined problem-solving attempts among male and female students confronted with a complex task situation, the overt manipulation of variables in
an electric circuit problem. The findings indicated that males tended to exhibit more overt, exploratory response behaviours than did females. Successful males appeared to achieve the desired state of affairs by focusing attention onto a limited number of response sequences while successful females were more inclined to shift their attention from one variable to another. Results further indicated that among the unsuccessfuls selected information processing behaviours could be associated with maturity of the problem solver.

Webb, N.L. (1975) concluded that Mathematics achievement had the highest relation to the problem solving process.

Whitelaw, S. (1975) investigated that the use of mathematical models in organisational problem solving is an effective way of describing the major phases of implementations, is a solution to a problem dependent on and is useful in predicting potential "trouble spots" in isolating and identifying the critical aspects.

Snethen, C.O. (1976) investigated that Peer support as presented in the study neither appeared to result in improved achievement nor appeared to result in higher retention of problem solving skills in arithmetic.

Cohen, M.P. (1977) reported that problem solving was most successfully based on the knowledge of students' interest and arithmetical reasoning.
Schenck, W.E. (1973) investigated the necessity of improving methods of instructing students in solving problems in detecting inappropriate strategies and the usefulness of the recognition procedure used by many EMR children.

Smith, R.L. (1973) reported in his studies that though the figure type problem solving achievement helped the performance of the high ability students but it is not beneficial for the low ability students.

Ward, D.E. (1979) reported in his studies that reading ability has much greater effect on problem solving ability of the students than the use of calculations.

Alan Handel! (1980) investigated problem solving strategies of 6th grade students who are superior Problem Solvers and found the subjects possessing the following characteristics in common: (i) they were quick to identify the nature of problem, (ii) they were able to use all four abilities included in Piaget's INHC group as needed, (iii) they were not dependent upon physical manipulations or calculations for most of problem, and (iv) they could express their reasoning and procedures with ease.

Gabel (1981) compared the effects of four instructional treatments on problem-solving achievement, and also examined was the interaction of instructional treatment with reasoning
ability, mathematics anxiety, and verbal-visual preferences among students. It was reported that students exhibiting high mathematics anxiety performed lower than other subjects and students of high proportional reasoning ability outperformed other subjects.

Russell and Chiappetta (1981) studied the effects of a problem solving strategy on the achievement of Earth Science students and found that eighth grade students who received problem-solving procedures achieved significantly higher scores on earth science content tests than did students in control classes.

Devaney, R.F. (1982) reported in his study that there was no significant difference in achievement in mathematical problem solving between students who are taught heuristic processes and those who are taught a conventional text book approach to problem solving, and found no significant relationship between basic computational skills and problem solving ability.

Donahue, G.M. (1982) analysed and compared problem solving strategies used by second-grade and fourth-grade children in solving routine and non-routine word problems in mathematics. Children solved ten problems aloud. It was found that second-grade means for use of aids and calculator were significantly higher than fourth-grade means on the routine problems. Fourth-grade means for mental and written calculations
were significantly higher than second-grade means. On the nonroutine problems, the differences were the same except for written calculations. But there appeared differences in other areas when the children's use of procedures on the routine problems was compared with procedure on nonroutine problems. Some children were very explicit in stating what they were thinking. In solving nonroutine problems, they exhibited strategies which were not ordinarily taught in elementary schools. It is suggested, that formal presentation of problem-solving techniques should be introduced into the curriculum at the second-grade level.

Singh, Santokh (1982) analysed the processes (skills and strategies) involved in problem solving of grades seven, nine and eleven. The subjects were asked to "Think aloud" while doing problems and their verbalizations were cassette-recorded. Strategies used by successful and unsuccessful subjects at each level did not differ much. The differences were in the lack of concern for accuracy in calculations, in determination, and persistence to get at the answer.

Finkel (1983) examined three methods of teaching problem solving which had been adapted to group presentation in an ongoing physics course. The methods were (1) standard, guessing a formula and substituting numbers; (2) heuristic, using stepwise planning and evaluation; and (3) information
The performance criteria used here indicated that the three approaches to teaching problem solving were equally successful.

Lawiripaiboon, P. (1983) studied the effects of a problem solving strategy on 9th grade students' ability to apply and analyze physical science subject matter and concluded that the Problem Solving strategy seems to be an effective means for improving the overall achievement of Physical Science students particularly achievement at the application and analysis levels.

McGuire, S.Y. (1983) investigated the relationship between cerebral dominance (determined by dichotic listening, techistoscopic viewing and solat (questionnaire), and Problem Solving strategies used by Chemistry students and indicated that students should receive instruction in algorithmic and heuristic problem solving methods. The method that is best for a particular student depends on the success attained from using each method as well as the individual preferences of the students.

Moore, W.C. (1983) concluded that instruction emphasizing the qualitative aspects of physics produced problem solvers as good as those produced by a traditional quantitative approach. Students receiving the qualitative instructions were found less likely to drop the course than did the control group before the semester ended.
Roth, D.D. (1983) conducted an experimental study to investigate the effects on achievement of 6th graders in Mathematical Problem Solving using Text Book problems compared to problems constructed by the teacher, and reported no significant differences on the pre-tests administered, and post-tests in the following: achievement in computation, attitude in Maths and achievement of Problem Solving ability.

Ross and Maynes (1983) described an instructional program based on expert-novice differences in experimental problem-solving performance. Between-group comparisons using pretest scores as a covariate, showed that treatment condition students consistently out-performed controls; similar results were found in the within group comparisons.

Cunnion, M. (1984) investigated sex differences in problem solving strategies. Out of 16 problems (13 problems from progressive Matrices and three experimental problems), the girls rated only the experimental problems, those without one correct answer, as more difficult than did the boys, which meant that girls tend to employ an exhaustive approach to problem solving, utilizing as many problem variables as possible in order to reach an "ideal" solution. Boys, on the other hand, using a streamlined approach, may not attend to problem variables that would indicate their answer is not the best one.

Greenbowe, T.J. (1984) investigated various variables
involved in Chemistry Problem Solving. The subjects individually solved chemical stoichiometry problems using the think-aloud technique. It was found that successful problem solvers had exhibited more effective problem solving skills (organization, persistence, evaluation, heuristics and formal operations) than unsuccessful problem solvers. Both content and process variables were found important for successful Chemistry problem solving.

Kelly, M.G. (1984) studied the effect of the use of hand-held calculators on the development of Problem solving strategies and reported that the calculator could enhance, (a) the increased use of deductive reasoning, (b) the ability of students to explain their strategies in retrospect, (c) effectively implement strategies that increase the understanding of the problem.

Keys, S.G. (1984) assessed the effect of problem-solving training on problem solving skills and found that problem-solving training had a significant impact on the set of dependent variables. It also suggested that social problem-solving ability could significantly affect the adjustment of third-grade children.

Payne, H.E. (1984) investigated the effects of three instructional techniques on the Problem solving ability of General Education Mathematics students at the junior
college level and reported that all three treatments were effective in significantly improving problem solving ability on typical verbal problems and in retention of that problem.

Roberts, G.D. (1984) reported in his study that creative problem solving is a skill requiring longer periods of time to learn than is allowed in this study. No significant differences were found in the post means of verbal reasoning, numerical ability, or algebra between the control and experimental groups.

Shinatrakool, S. (1984) studied the relationships between verbal and situational problem solving and found significant differences in overall achievement with real life situational problem solving performance slightly higher than achievement in verbal problem solving.

Rice, R.B. (1985) studied the analysis of the effectiveness of an instructional strategy to teach selected problem solving skills to nursing students and found that the selected problem solving skills of the treatment groups were significantly improved by the instructional strategy but there was no difference in the means of the control group and the treatment group which received both outcome and process feedback.
Cognitive Style and Problem Solving:

Quickenton, A.J. (1980) investigated hypothesized relationships between an individual's cognitive style (i.e. field-dependence/independence) and their mathematical problem solving ability, reported no significant aptitude treatment Interaction when criterion scores for the total groups were regressed on a measure of cognitive style and general reasoning. Anglo-American males score significantly higher on GEFT than the Mexican-American males score significantly higher on GEFT than the Mexican-American males and females. The performance of the Mexican-American females on the GEFT and the criterion test is interesting but un-explainable.

Swanson, E.J. (1980) studied the influence of Field-dependence/independence on Problem Solving ability and on Problem Solving performance and cognitive learning following a video or written instructional model and reported no difference in problem solving efficiency between these groups found by multivariate ANOVA. No interaction effect between cognitive style and media was found on any set of scores. Main effects for cognitive style demonstrated superior performance of FI groups.

Cagley, C.E. (1984) studied field dependence/independence as a predictor of inferencing and problem solving
abilities in community college students and found cognitive style as a minimal predictor of both. Results of ANOVAs indicated significance (p < 0.05) between highly field dependent and independent regarding problem solving but non-significance (p > 0.05) regarding inferencing ability among same students.

Dugger, C.R. (1985) compared the effects of two contrasting instructional approaches representing the field-dependence/independence cognitive dimension on the mathematical problem-solving performance and found statistical differences in the math problem-solving post-test and gain scores of the two treatment groups, receiving field-dependent and field-independent instruction, over the control group. The conclusions supported the assumption that the field-dependence-independence cognitive dimension applied to teaching improved the student's performance in math problem solving.

Koessler-Jacoby, V.G. (1985) investigated the role of field independence using an Analogy-based problem solving method and found that field independent subjects scored significantly higher on the problem solving task than the field dependent. Field independent subjects using an analogy scored significantly higher on the problem task than field independent subjects who did not use an analogy. Results from the study indicated that the cognitive style of subjects may influence successful use of analogy-based problem solving.
strategies in the solution of new paradigm problems.

**Intelligence and Problem Solving:**

Sodhi, G.S. (1970), studied the relationship between problem solving and intelligence in Physics and reported that above average students were better in recognising relevant and irrelevant facts than average and below average students and added also that individuals differ in their thinking patterns.

Mishra, B.C. (1986) studied the relationship between creativity and problem solving ability at different levels of intelligence, and found positive correlation between (i) high intelligence and problem solving ability but insignificant correlation between low intelligence and problem solving ability, (ii) intelligence and creativity, and (iii) creativity and problem solving ability.

**Anxiety and Problem Solving:**

Castaneda et al. (1956 b) reported a study which was concerned with the performance of 21 high and 16 low anxious fifth-grade children on very easy V/S difficult components of a complex learning task. The main finding of the study was a statistically significant interaction between anxiety and task difficulty. This interaction was based on the fact that the high anxious children in comparison with the low anxious children tended to perform better on the easy components and at an inferior level on the difficult components.
However, further statistical tests indicated that only the difference between anxiety groups on the difficult combination was statistically significant. Since there is a reason for assuming that there are sex differences in various types of problem solving tasks, it is important to note that 12 of their 21 high anxious children and 10 of their low anxious children were girls. Unfortunately, the hypothesis that the performance of their girls accounted for some part of their difference cannot be checked since the authors reported no data on sex differences. In addition, the fact that the authors failed to control for intelligence becomes crucial in view of the fact that the difference between anxiety groups were statistically significant for the hard items but not for the easy items.

Thomas F.G. and Matthew Mastenbrook (1980) conducted a study to examine the influence of state anxiety on memory and the use of logical rules during problem solving. College students were required to solve simple problems presented in a blank-trials format with and without memory aids. It was found that high state-anxious subjects solved fewer problems than middle or low state-anxious subjects under no memory aid conditions, and all anxiety groups performed comparably with memory aids. High state-anxious subjects tended to use less focusing strategy when memory aids were unavailable.

Druwa, C.A. (1984) examined the comprehension skills
that math-anxious individuals bring with them to a maths problem-solving situation. The high-math-anxious did better on non-computational, visual type problems than did non-math-anxious individuals. There was no difference between the lower ability high- and low-math-anxious groups on problem solving steps indicating a similar instructional sequence for both levels of math anxiety.

Anxiety and Intelligence:

Kerrick, J.B. (1956) reported in his study that the effect of increased anxiety on the high I.Q. group was to make them less discriminating whereas the reverse was true of the low I.Q. group. The conclusion was that the anxious, intelligent subjects in responding to the discriminating task were either impulsive or did not respond at all, whereas the less intelligent anxious subjects were generally cautious and uncertain in their judgements.

Sarason, Lighthall, Davidson, Waite and Ruebush (1960), in their study of anxiety on elementary school children, noted a decrease in measured I.Q. following increase in anxiety and an increase in measured I.Q. following reduction in anxiety.

Spielberger (1966), using college students, found that among the very brightest students, those who were highly anxious obtained slightly higher grades than those who were low anxious.
Cognitive Style and Anxiety:

Rastegarpour, H. (1983) investigated the relationship of the field dependence-independence dimension of cognitive style to self esteem and anxiety and found low correlations between the field-dependence-independence, self esteem and anxiety. The correlations between self esteem and anxiety were negatively related and significant.

Phuvipadawat, S. (1985) investigated the effects of goal structure and cognitive style on the mathematics achievement and test anxiety and reported significantly higher achievement on the mathematics achievement test by field independent subjects than did the field dependent subjects. No interaction effect of goal structure (cooperative, competitive and individualistic), and cognitive style on the mathematics achievement was found. In addition, test anxiety was shown to be affected by the different goal structures and cognitive styles. Field dependent students had a significantly higher level of test anxiety than field independent students regardless of the goal structure.

Cognitive Style and Achievement:

Thumann (1983) investigated that students who exhibited reflective reasoning patterns achieved higher science achievement scores and studied interaction between two methods of teaching science and student cognitive style.
Mrosla (1934) investigated that low achieving Mathematics students were more field dependent than high achieving Mathematics students in both traditional high school and in the high school for dropouts and that there would be a significant interaction on the achievement variable and the sex variable with respect to field dependence in both schools.

Randolph, C.F. (1984) investigated the relationships among cognitive style, achievement in Science, selected personality variables, and the sex of students and found significant correlations among field independence and science achievement; and self reliance and science achievement; no significant differences between the performance of males and females on the science achievement test.

Walker, A.J. (1984) reported in his study that field independent students performed at higher levels of initial learning, retention, and time on task behaviour, irrespective of methodology. He suggested a significant main effect for cognitive style for the initial learning variables. For the retention variable, there was also a highly significant main effect for cognitive style but no main effect for methodology.

Atang, C.I. (1985) reported in his study that individuals' field dependence/independence was not a
significant factor in their performance in the pre-test and the post-test. Both the color and black and white subjects proved superior to the control group subjects in post-test scores. There was a significant relationship between pretest and post-test time.

Fritz, K.M. (1985) reported in his study that neither locus of control nor field independence/dependence was related to academic achievement in samples of gifted students; there were no differences in locus of control and field independence/dependence between male and female gifted students; and there were grade level differences in locus of control and field independence/dependence among 4th, 6th and 8th grade gifted students.

Nelson, P.A. (1986) studied the effects of field independent-dependent cognitive style on achievement in a telecourse and found no significant difference between the attitude of field dependent and field independent students enrolled in a telecourse. Students with a field independent learning style scored higher grades than students with a field dependent style. There was no association between field independence/dependence and course completion.

1.2 EMERGENCE OF THE PROBLEM

The most of the modern curricular designers for school curriculum have stressed the need for the development of
problem solving skill among the students. This is based upon the fact that the main aim of education is to prepare the individual for later life. In complex society, every individual will be facing a huge number of problems daily and his adjustment will depend upon his capabilities to solve the problems successfully. The main stress of the educator is to provide such opportunities to the students so as to develop the skill of problem solving. This emphasis has motivated the investigator to take the present problem which involve some problem solving strategies for effective science instructions.

Very little research has been done in the field of problem solving to determine the most effective problem solving strategy in developing problem solving ability in Science. Different people think in different ways and there is not always one way or one solution to a problem. The present study is aimed at finding relationship between problem solving strategy in Science and the effects of anxiety level, cognitive style and intelligence on problem solving ability.

1.3 STATEMENT OF THE PROBLEM:
"THE EFFECT OF PROBLEM SOLVING STRATEGIES ON PROBLEM SOLVING ABILITY IN SCIENCE OF HIGH SCHOOL STUDENTS IN RELATION TO ANXIETY LEVEL, COGNITIVE STYLE AND INTELLIGENCE".

1.4 RESEARCH QUESTIONS:
1. Do different strategies of Problem Solving affect problem solving ability in Science differentially?
2. Will a particular strategy of problem solving favour a particular level of intelligence?

3. Is a particular strategy of problem solving more suited to a particular anxiety level subjects?

4. Is cognitive style of learners related to problem-solving ability?

1.5.1 **HYPOTHESES:**

The present study was conducted to test the following hypotheses:

1. There will be significant difference in mean scores on problem solving ability in respect of groups trained through different strategies of Problem Solving.

2. There will be no significant difference between mean scores of high and low anxious students.

3. Cognitive style does not significantly effect problem solving ability in Science.

4. Intelligence does not account for differential problem solving ability in Science.

5. The independent variables namely strategies of problem solving, cognitive style, intelligence and anxiety will significantly contribute towards the total variance in problem solving ability.
1.5.2 **INTERACTIONAL HYPOTHESES**

**First Order:**

(a) There is no significant interaction between intelligence and strategies of problem solving.

(b) There is no significant interaction between anxiety level and strategies of problem solving.

(c) There is no significant interaction between cognitive style (field-independent/dependent) and strategies of problem solving.

(d) There is no significant interaction between intelligence and anxiety level.

(e) There is no significant interaction between intelligence and cognitive style (field-independent/dependent).

(f) There is no significant interaction between anxiety level and cognitive style (field-independent/dependent.)

**Second Order:**

(a) There is no significant interaction between cognitive style (field-independent/dependent), intelligence and strategies of problem solving.

(b) There is no significant interaction between cognitive style (field-independent/dependent), anxiety level and strategies of problem solving.

(c) There is no significant interaction between intelligence, anxiety level and strategies of problem solving.
Third Order:

There is no significant interaction between cognitive style (field-independent/dependent), intelligence, anxiety level and strategies of problem solving.