1.8 Thinking and Problem Solving

Syllabus : Piaget's theory of cognitive development (*dealt in Ch-4*); Concept formation processes; Information processing, Reasoning and problem solving, Facilitating and hindering factors in problem solving, Methods of problem solving: Creative thinking and fostering creativity; Factors influencing decision making and judgment; Recent trends.

Previous Years' Questions

2016

Q. Cognitive psychologists often use computer as an analogy to explain the relation between cognition and brain. Discuss. (*this may even be placed in ch-14, not sure*) 10 marks [2016]

Q. Critically examine the metacognitive processes in problem solving. How do functional fixedness and mental set interfere in solving the problems effectively. 15 marks [2016]

Q. Distinguish b/w mundane and exceptional creativities and citing suitable research evidences, describe the confluence approach to creativity. 20 marks [2016]

2015

Q. What are the general strategies used in problem solving ? How do these differ from domain-specific procedures? 10 marks [2015]

2014

Q. What has been learned through experiments about the strategies and knowledge base of experts ? Discuss.10 marks [2014]

2013

Q. Critically evaluate the cognitive approach to the study of psychological phenomena. 10 marks [2013]

Q. How do novices differ from experts? 10 marks [2013]

2012

Q. Discuss various dimensions of thought process in relation to concept. 12 marks [2012]

Q. Critically evaluate the relation between intelligence and creativity. Cite experimental evidences in support of your answer. 20 marks [2012]

Q. Enumerate various methods of problem-solving. critically evaluate their advantages and limitations. 20 marks [2012]

2011

Q. Differentiate between inductive and deductive reasoning, and give reasons for the preference of scientist towards inductive reasoning. 10 marks [2011]

Q. What are the criteria to identify creativity? How can a teacher promote creativity in the classroom setting? 30 marks [2011]

2010

Q. Discuss the role of heuristics in reasoning. 10 marks [2010]

2009

Q. What is non directive thinking? Discuss different dimensions of thoughts processes in relation to concept and creativity? 20 marks [2009]

2008

No direct questions asked from these topics in 2008.

Concept formation processes

By **cognition** one refers to the mental representation of information which can be manipulated and used to solve problems.

Concept : Mental categories for objects, ideas, experiences and events that are similar to one another in one or more aspects.

Novices, Experts and Expertise

An expert is a person who has learned to solve problems or answer questions relating to a particular "problem solving domain" or area of expertise. Much problem solving involves domain-specific knowledge. That is knowledge relevant to a certain domain that is an environment or situation or class of problems. Domain-specific knowledge is what makes an expert an expert.

What distinguishes an expert? How does this relate to domain-specific knowledge?

Each environment requires its own sort of expertise. Living "on the street" as a homeless person in a big city requires a whole repertoire of behaviors and knowledge and assumptions that most of us lack. Same could be said of running a high-energy physics lab, or running a successful car dealership, or playing a musical instrument. Virtually any area of human accomplishment requires knowledge unique to that domain. Domain-specific knowledge allows the expert to do things that baffle or frustrate a beginner/novice. The expert makes it look easy, but the expert achieves this behavior only after long hours of practice.

How is expertise accumulated?

Experts may invest thousands of hours in developing domain-specific knowledge. **Chase and Simon (1973)** estimated that chess experts spend up to 50,000 hours learning to play chess. That works out to 4 hours of chess a day for over thirty years. Simon and Gilmartin (1973) estimated that, as a result of this experience, the chess expert can recognize between 10,000 and 100,000 distinct patterns of chess pieces on a chessboard.

What did **DeGroot** discover?

A huge "vocabulary" of chess configurations (knowledge of tactically important positions on a chess board) enables the expert to grasp the layout of a chessboard almost immediately. Some chess masters can play 20 chess games simultaneously, moving from board to board, winning almost all the games. In a classic study, DeGroot showed that chess masters had a fantastic memory for chess positions. Masters were able to reconstruct an entire chessboard full of positions after only about 5 seconds of inspection.

What did Chase and Simon show, in research following up on DeGroot's study?

Chase and Simon (1973) did follow-up research in which they tested experts and beginning players with randomly placed pieces. With random positions (those which did not make sense in chess) experts were no better at memorizing board positions than beginners. With meaningful positions, the experts were much better than beginners. If an actual mid-game configuration and a random configuration is shown to an expert, there is a big difference perceived by novices and beginners ! Only the configuration first is easy for the expert chess player to memorize, because it relates to the expert's accumulated schemas. To the non-player, neither picture relates well to past experience, so either can be memorized equally easily.

The same is true in any domain of expertise. The expert learns to recognize significant patterns and remember them easily. A person who lives in the arctic circle develops a specialized vocabulary for describing different types of ice and snow and probably can memorize the type of snow easily. An expert auto mechanic develops a huge repertoire of patterns to look for when examining an engine, and so forth.

An expert not only learns thousands of patterns and rules; the expert also knows when to break the rules. The expert knows about odd cases that come up "once in a blue moon" or which might not be what they appear to be. The ability to recognize situations where normal rules should not be applied is almost as important as knowing the rules themselves.

In addition to learning thousands of patterns and rules, the expert must learn... what?

Because expertise results from long-term accumulation of experience, there is no quick and easy road to expertise of any kind. Children do not automatically understand this. They may become frustrated when they find out they cannot become skilled at something right away. They must be encouraged to persist in accumulating relevant experience so that someday they might be experts who make it look easy.

Problem Solving

Types of Problems

Problems vary from ill defined to well defined. In a well defined problem such as a mathematical equation or a jigsaw puzzle both the nature of the problem and the information needed to solve it are available and clear. Thus, one can make straightforward judgments about whether a potential solution is appropriate. With an ill defined problem, such as how to bring peace, not only may the specific
nature of the problem be unclear, the information required to solve the problem may be even less obvious.

Greeno (1978) suggested one method of classifying well defined problems based on the general kinds of psychological skills and knowledge needed to solve different problems. Typically, well defined problems falls into one of the three categories viz.,

(i) Arrangement Problems
problem solver must rearrange or recombine elements in a way that will satisfy a certain criteria. Usually, several different arrangements can be made but only one or few arrangements will produce a solution. e.g., Anagram problems, jigsaw puzzles etc.

(ii) Inducing Structure
Existing relationships among the elements presented need to be identified. Then a new relationship needs to constructed among them, so that the problem could be solved. In such a problem, the problem solver must determine not only the relationships among the structures but also the structure and size of elements involved. e.g. no. series completion and analogy problems.

(iii) Transformation.
An attempt is made to change the initial state to a goal state. e.g. Like the first time trying to tie your shoes, baking a cake, **Tower of Hanoi problem (aka Tower of Brahma or Lucas' Tower)**, water jar problem. According to **Greeno 1978** solving transformation problems primarily requires skills in planning based on a method called **means end analysis.** Means end analysis requires identifying differences that exist between the current state and the goal state and selecting operations that will reduce these differences.

16 Characteristics of a difficult problem

- In-transparency (lack of clarity of the situation)

- Commencement opacity. (confusion regarding how to start stating the problem)

- Continuation opacity (Continuing confusion in regard to the problem as there is no clarity)

- Polytely (The problem has multiple goals and so reaching and selecting a particular goal is difficult)

• Inexpressiveness (inability to express the problem clearly)

• Opposition

• Transience (the problem keeps changing)

• Complexity (The problem is in large numbers of items, too many interrelationships and decisions)

• Enumerability (It is not possible to list it or quantify it)

• Connectivity (There are hierarchy of problems w.r.t. to relationship, communication and allocation)

• Heterogeneity (The problem is not homogeneous and so difficult to handle)

• Dynamics (time considerations)

• Temporal constraints (There is limitation to time factor as it has to be got done within a time period)

• Temporal sensitivity (The problem is influenced and affected by time factor)

• Phase effects (There are changes in different phases of the problem and these affect the problem from being solved)

• Dynamic unpredictability (The problem is complex and consists of high degree of unpredictability)

Nature of Problem Solving

Considered the most complex of all intellectual functions, problem solving has been defined as higher-order cognitive process that requires the modulation and control of more routine or fundamental skills.

Various psychologists have defined problem solving.

Problem Solving According to **Baron (2001)** : problem solving involves efforts to develop or choose among various responses in order to attain desired goals.

Witting and Williams III (1984) : problem solving is the use of thought processes to overcome obstacles and work towards goals.

There are several methods of studying problem solving: introspection, behaviourism, simulation, computer modeling, experiments etc.

Beginning with the early experimental work of the Gestaltists in Germany and continuing through the 1960s and early 1970s, research on problem solving was typically conducted in relatively simple, laboratory tasks that appeared novel to participants (e.g. Mayer, 1992).

In these tasks, they had clearly defined optimal solutions which were solvable within a relatively short time frame, and researchers could trace participants' problem-solving steps, and so on. The researchers made the underlying assumption that simple tasks such as the **Tower of Hanoi** captured the main properties of "real world" problems, and that the cognitive processes underlying participants' attempts to solve simple problems were representative of the processes engaged in when solving "real world" problems. Thus researchers used simple problems for reasons of convenience.

Simple laboratory based tasks can be useful in explicating the steps of logic and reasoning that underlie problem solving. However, they omit the complexity and emotional valence of "real-world" problems. In clinical psychology, researchers have focused on the role of emotions in problem solving, demonstrating that poor emotional control can disrupt focus on the target task and impede problem resolution (**Rath, Langenbahn, Simon, Sherr, & Diller, 2004**).

Human problem solving consists of two related processes

(i) problem orientation : deals with the motivational/attitudinal/affective approach to problematic situations

(ii) problem-solving skills : deal with the actual cognitive behavioural steps. If cognitive skills are successfully implemented, it will lead to effective problem resolution.

Problem solving is a mental process and is part of the larger problem process that includes **problem finding** and **problem shaping**.

Stages of PS

4 components of any problem solving activity are:

• The initial state: How the starting conditions are defined : It is critical to problem solving and some problem's initial state may lead to efficient problem solving while another may end up in high complexity.

• The Operators: Moves or operations to move from one state to another

• Intermediate Problem States: Any states that are generated by applying an operator to a state on the way to final goal.

• The goal state: How the final state or goal conditions are described.

Problem Space : The internal representation (or mental model) of these four states of a problem.

Each individual's problem space is unique and depends also on the nature of the problem.

Effective PS

According to **Wertheimier (1959)** effective problem solving requires:

i) Productive thinking : For productive thinking there is a need to have a grasp of the general principles that apply in the particular problem situation. Since individuals do have a tendency
to reproduce thinking appropriate for other situations, they need to think beyond that solution and look for unique solutions. It is important to keep in mind the structure of the problem without which solutions may not come about.

ii) Being sensitive and open to structural requirements

iii) Going beyond the knowledge learnt from previous problem solving tasks

Kinds of thinking processes in PS

1) **Analytical Thinking :** In analytic thinking, there is nothing more in solution than in the premise. e.g. if the problem is a simple question like "how many doors are there in your house", then the answer is simple counting of the doors and adding it up. There can be no other answer and there can also be no other solution.

2) **Synthetic Thinking :** In contrast, Synthetic Thinking does not contain the conclusion in the premise itself because the solution is not needed in the construction of the mental object. e.g. we know that 2 is a divisor of 4, 4 is a divisor of 8, and 2 is also a divisor of 8. In general, it is true that a divisor of a divisor of a number is a divisor of that number. Such solutions are best reached by constructing mental model like images like number lines.

The importance of synthetic thinking is that you can get out more than you put into it. After you construct a mental model, you can see relationships that were not evident before you constructed it. Seeing these new relationships is what comprises problem solving through synthetic thinking. In other words, one is synthesizing the available information and facts to derive new solution. This is also termed as developing insight.

Insight and Metacognition

Insight - Occurs when people suddenly discover the correct solution to a problem after struggling with it for a while.

Sometimes, solutions to problems are classified as

(i) Insightful solutions

(ii) solutions without involving insight.

The essential characteristics of an insight solution to a problem is that the solution appears suddenly, without warning. By contrast, problems solved without insight are solved gradually rather than suddenly. The solution process here involves a stepwise progression towards the solution. e.g. arithmetic and algebraic problems fall into the category of problems solved without insight.

In this, the subjects themselves must be able to distinguish between these two types of solutions. As the subjects solve a non insight problem, they should be able to tell that they are getting closer to the solution. For non-insight problems subjects generally have a greater feeling of warmth as they get closer and closer to the solution. This is because non-insightful problems are solved step by step and with each step the subject gets closer to the solution and thus warmer in each step.

As for insight problems there is no gradual approach to the solution and so subjects do not feel warmer until the solution actually appears. Feeling of knowing and feeling of warmth reflect judgments that subjects make about their own knowledge. Such judgments are examples of **metacognition.**

Metacognition : refers to what one knows about the technique of how accurately one can assess one's own cognitive processes. It is the "cognition about cognition", "thinking about thinking", or "knowing about knowing" and higher order thinking skills. There are generally two components of metacognition:

1. knowledge about cognition,
2. regulation of cognition.

It has been shown that people's metacognitive assessments of their performance on non-insight problems are quite accurate. However, their metacognitive assessments of their performance on insight problems are not accurate, because an insight is not something that can be planned. An insight is something that happens to the person, not something that a person decides to have. In insight solution, the problem is solved by the sudden illumination characteristic of insight. Insight is preceded by a gradual process whereby relevant parts of the problem are identified. However, solvers may not be aware that this process is leading toward an insight.

Another aspect of insight problems is that the source of difficulty in some insight problems is the inability to see that something we already know is needed for the solution. Hints given within the context of the problem are fairly effective in facilitating subsequent insight.

Sagacity

As the **Gestalt psychologists** often observe, people are generally not efficient at realising that a new problem can be solved with information already at their disposal. People differ in their ability to select information that is relevant to the problem at hand. **Sagacity** is the ability to discover what is essential about situation is important as well as the ability to remember information that is relevant to the problem. It is the ability to see into the situation and to discriminate the important aspects of it. It differs from learning in that it involves a sensitivity to detail, a discernment of what is important in a situation.

Effect of format of problem presentation on PS

The format in which the information is presented makes a difference in insightful problem solving. That is, one can give the information in

i) a puzzle format or in
ii) a declarative format.

The information given in the puzzle format leads the subject to discriminate the relevant information better than when the information is in declarative format. This is so because, the puzzle format leads the subject to process the relevant information in a way that makes it accessible for later use.

On the other hand the declarative format leads to the acquisition of the relevant information, but in a way that makes it less possible for the person to see its relevance for subsequent problem solving.

Select a word that can be interpreted in different ways. e.g. the word lake can refer to a frozen or unfrozen body of water. Most people interpret the word to refer to an unfrozen body of water. A riddle can be constructed by requiring the problem solver to come up with the less accessible meaning in order to make sense of what is being described. e.g. If the subject is presented with a clue that the stone rested on the surface of the lake for 3 months, after which it sank to the bottom some 10 meters below, this would provide the solution that lake here
refers to frozen one for 3 months and then running water lake afterwards.

Approaches to PS

Imp. theoretical models include

- Traditional models of PS
- Gestaltists Theories
- Information processing and computer simulation
- The General Problem Solver (GPS)
- Wickelgren's general problem solving strategies
- Newell's approach to understanding Problem Solving.

Traditional Approaches to PS

Traditional approaches explain problem solving in terms of principles of associative learning derived from the studies of classical and instrumental conditioning. According to some theorists an individual enters a problem situation with an existing complex of stimulus response associations as a result of prior experience. The problem is more likely to elicit some of these associations than others, with a clear implication that problem difficulty will depend on the strength of the correct association relative to the strength of other incorrect associations.

In the course of PS, the associative complex gets rearranged as some tendencies are weakened through extinction (failure) and other strengthened through reinforcement (success). This viewpoint stresses the transfer of prior learning to the problem situation and to the learning which takes place during PS.

Gestalt Approaches

A different view of problem solving was proposed by the gestalt psychologists. These theorists emphasised the importance of the structure of the problem situations and the formation of new combinations of old ideas. They were particularly interested in how people solve problems by rearrangement of objects. A well known example is the problem described by **Kohler (1925)** in his book, **The Mentality of Apes**. Kohler hung some fruits from the top of a cage to reach it. The cage contained several sticks and crates. The solution depended on finding a correct way to rearrange the objects.

According to the Gestalt analysis, solving the problem required the reorganisation of the objects into a new structure. Gestaltists argued that discovering the correct organisation usually occurred as a flash of insight. Insight is the sudden discovery of the correct solution following a period of incorrect attempts based primarily on trial and error. Insightful solutions seem to occur in a flash.

Gestalt psychologists distinguished between **reproductive** and **productive thinking** (**Wertheimer, 1959**). Reproductive thinking entails the application of tried and true paths to solution. The thinker reproduces a series of steps that are known to yield a workable answer by using rote memory. Productive thinking on the other hand, requires insight and creativity. According to gestalts view the thinker must see a new way of organising the problem, a new way of structuring the elements of thought and perception. A classic problem calling for productive insightful thinking is the **nine dot problem.**

The task (problem) is to connect the nine dots with just four (or less) straight lines, without lifting your pencil from the paper in drawing the lines. To think productively in this problem situation one must restructure the problem, to throw off the unnecessary assumption that the lines must lie within the visual boundaries.

Information Processing and Computer Simulation Approach

A number of researchers have tried to program computer to perform tasks that human beings do. Such computer simulation research has had a profound influence on psychology of human cognitive processes. The method consists of programming a computer to work in a specified manner and comparing its performance to that of human subjects given the same tasks. Researchers employing computer simulation have made major contributions to the development of **information processing view** of PS.

Information Processing View of PS

A problem requires a person not only to register information from the environment but also to operate on, modify, or transform that information in some way in order to reach a solution. Solving problem also requires the retrieval of both factual and procedural knowledge from LTM. Especially for longer problems, reaching a solution might involve repeated storage and retrieval of information generated early in the problem for use in later stages.

Problem solving is not a single cognitive process but rather involves a number of activities which need to be properly executed and organised to be successful. The most promising kind of theory in the early 1980s involves computer simulation. In the last couple of decades a number of computer simulation theories of problem solving have emerged e.g. **The general problem solver (GPS)** developed by **Newell, Shaw and Simon (1958), Wickelgren's GPS Strategies** and the **Means and Analysis Approach**.

The General Problem Solver (GPS)

GPS introduced a way of looking at PS which has influenced virtually all problem solving theories. **Newell, Shaw and Simon (1958)** made this program which was equipped with the equivalent of:

- A limited capacity working memory characterised by rapid storage and retrieval
- A large capacity long term memory characterised by relatively slow storage and retrieval
- A serial processor that performs one operation at a time
- A reliance upon heuristics, rather than algorithms that would require a large number of high speed calculations.

Newell and his colleagues collected verbal protocols that were used and kept as a record of people talking aloud as they solved problems. Then they transcribed these lengthy records carefully to see if they could find general heuristics that emerged. It introduced a way of conceptualising problem that is adopted in most contemporary theories of problem solving.

The General Problem Solver (GPS) assumes that the problem solver represents a problem as a problem space which consists of a set of nodes, each node corresponding to a state of knowledge about the problem. The problem

solver begins at the initial state of knowledge and seeks to convert it into the goal state by applying operators, which are actions that are permitted in order to move from one state of another.

Problem solving, then, requires a constructive search during which the solver builds up a problem space, which leads from the initial to goal state using a set of allowed operators.

Means End Analysis

This was recognised as a general problem solving heuristic which involves a search for operations that will reduce the difference between present state of knowledge and the goal state. In particular, means-end analysis involves the following steps:

1. Set up a goal
2. Look for a difference between the current problem state and the goal state.
3. Look for a method to decrease or eliminate the difference between the two stages.
4. Set as a sub goal which is the application of that method.
5. If necessary apply means- ends analysis to apply to the sub goal.
6. Keep doing it till the goal state is achieved.

Thus, the main heuristic used in GPS involves setting up goals and sub goals. In fact, this strategy can be expressed very precisely as a production system, i.e. as a set of if-then pairs stored in the computers memory as production.

Wickelgren's General Problem Solving Strategies

Wickelgren's view of PS is based on information processing theories such as GPS. According to this view, a formal problem contains three types of information:

- A statement of the initial state.
- Description of the goal state.
- Description of set of operation or transformations.

A solution can be defined as a sequence of state or actions which helps to represent in a diagram called the **State Action Tree**. The nodes or branch points on the tree represent all the possibly different problem states that could result from all the different action sequences.

The branches on the tree represent the possible actions that could be made at the particular state of knowledge. The given state is represented by the single node at the top level of the state action tree, and the goal state is represented by the indicated node in the lowest level of the tree.

For this schematic tree, we assume that from the goal state there are only two possible actions that the person can take. One of which starts the person on the path toward the goal, the other of which does not. Having chosen one of these (thereby leading the person to state level 1), the person is then faced with a new set of possible actions. Here, we arbitrarily assume that there are three possible actions that could be taken at either of the state level 1 nodes.

This successive making of choices goes on and on until the person either reaches the goal state or finds himself at a dead end. Thinking about state action trees is the fact that as you get further into a problem (i.e. lower and lower levels in the tree) the number of possible action sequences increases rapidly.

Wickelgren argues that there are 7 GPS techniques for searching the state action tree.

1. Inference: Deducing from the explicitly stated goals givens, and operations stated in the problem

2. Classification of action sequences: organising possible sequences of actions (or operations) that are equivalent as far as the problem is concerned. These are called equivalence classes.

3. State evaluation and hill climbing: state evaluation involves defining a quantitative evaluation function that can be calculated for all possible problem states and hill climbing involves choosing the action to be taken next that will have an evaluation that is closest to the goal.

4. Subgoals: This stage involves searching for sub goals involve breaking down the problem into sub goals to make it simpler.

5. Contradiction: deriving some inference from the givens that is inconsistent with the goal state to narrow down the state action tree in a systematic fashion by eliminating possibilities that could possibly not work.

6. Working backward: It involves beginning with the goal state and working backward from it.

7. Finding relations between problems: finding relations between the new problems and problems solved previously.

Newell's appraoch to PS

Newell is one of the most influential cognitive psychologists who made computer stimulation approach to the study of problem solving. Newell stated that the goal is to construct a mental model. From this model, one will find answers to a problem by inspecting that model itself. To do this, one writes parts of the problem mentally on the model. Once the model has been constructed one can read the results of what has been written. It is important to note that in order to read these results one needs the **"mind's eye".**

The mind's eye has traditionally been a controversial issue in cognitive psychology. Another word for it is **"homunculus"** meaning **"little man in the head".** Most cognitive psychologists disapprove of this concept of Mind's eye on the premise that it reflects nonscientific theories of behaviour that were largely based on soul.

It is very natural to think of problems as being solved through the exploration of different paths to a solution. Take maze for example. In this, you start from a point outside the maze and then progress through it to the centre. On your way, you reach junctions where you have to choose between going straight on, turning to the left or right, or turning back. Each of these alternative paths may branch again and again so that, in the maze as a whole, there are hundreds of alternative paths (only some of which will lead to the centre).

Different strategies can be used to find one's way through a labyrinth. The strategies provide you with a systematic method for searching the maze and help you to select one from among the many alternative paths.

Newell and Simon used parallels to these basic ideas to characterise human PS behaviour. They suggested that the objective structure of a problem can be characterised as:

i) a set of states, beginning from an initial state (e.g. standing outside the maze)

ii) involving many intermediate states (e.g. moving through the maze)

iii) ending with a goal state (e.g. being at the centre of the maze).

The application of these operators (turn left, go straight etc.) results in a move from one state to another. In any given state there may be several different operators that apply (e.g. turn left, turn right, go back) and each of these will generate numerous alternative states. Thus, there is a whole space of possible states and paths through this space, and only some of these will lead to the goal state. This problem space describes the *abstract structure* of a problem.

Summary of The Problem Space Hypothesis

For any given problem there are a large number of alternative paths from an initial state to a goal state; the total set of such states, as generated by the legal operators, is called the basic problem space. People's PS behaviour can be viewed as the production of knowledge states by the application of mental operators, moving from an initial knowledge state to a goal, knowledge state. Mental operators encode legal moves that can be made. There are also restrictions which disallow a move if certain conditions hold.

People use their knowledge and various heuristic methods (like means-end analysis) to search through the problem space and to find a path from the initial state to the goal state. All of these processes occur within the limits of a particular cognitive system i.e. there may be working memory limitations and limitations on the speed with which information can be stored and retrieved from LTM.

Newell's approach, which is based on this problem space hypothesis, propounds that the knowledge level rationalises behaviour in terms of the reasons that an agent has to believe that certain actions will lead to achieving certain goals. In this sense knowledge is a means to an end, a resource for behaviour. The goal of PS is to select one of the possible actions.

Problem Solving as Modeling

More recently, a different view is being explored, namely the view of problem solving as modeling. The idea is that PS is the construction of situation specific model or case model. From a knowledge level perspective the person's perception of the world is through knowledge alone. A goal therefore must correspond to the desired state of ones knowledge about the world.

Consequently this knowledge must refer to the specific systems that the goal is about. The case model thus summarises the person's understanding of the problem, and allows it to eventually conclude that the goal has been reached. The actions are the means by which the person interacts with the world. Since at the knowledge level the person's perception is through knowledge, the interaction must be viewed as a way of obtaining knowledge about the reality. Thus one may say that actions of perception and interactions fit in this scheme.

In the problem solving as modeling, the actions are not the goal of PS but are themselves a means to an end. That end is the construction of a model which will help in eventually achieving the goals. Whether it is the domain model or task model, the construction of the model should be such that it should lead to the goal.

For instance, in making a domain model, it is not just packaging statements about the domain, but it should involve augmenting statements with a series of assumptions about how the information about the systems is connected. In regard to task model, it embodies assumptions about the meaning of goals.

For example, if a diagnostic task is modeled as a process to generate and test over components of a system, then one implicitly assumes that the fault one is looking for can be localised in a component.

Thus, modeling a task corresponding to a goal is to make more precise what one assumes that goal to mean.

The role of the problem solving method is to tie domain and task models together in an argument on what accomplishing the task means in terms of the available models. This is termed as competency theory.

To give an example, a heuristic classification problem solver assumes that the solution to its problem is within the differential and it is what the problem solver believes that it can say about the problem. This actually defines its competence.

In addition the competence theory also talks about what rationality means. A heuristic classification problem solver will use the knowledge and actions pertaining to rationality to reduce the sise of the differential. This is called **specialised**

principle of rationality. It contains the basis for all "why" questions about the system's behaviour.

This model is the case model and it is obtained from the competence theory through actions. Specific control regimes (e.g., data-driven or hypothesis-driven heuristic classification) correspond to different ways of operationalising the specialised principle of rationality. The configuration of models, tasks and methods entails a set of assumptions that together can be interpreted as a model of the problem. The goal of problem solving is to instantiate this model by making it realistic. This can be done by making derivations from

i) the case-specific knowledge obtained by the person's actions and
ii) the assumptions embodied in the domain and task models.

The form of the case model is determined by the selection of problem solving method.
In this view problem solving is no longer an input-output process (as in KADSI). It is also not a means to select actions (as in **Newell's knowledge level theory**). It is also not a model transformation process (as in Components of Expertise). It is in fact a process of organising knowledge by making assumptions (i.e., constructing a model) that allow one to conclude (in effect, only assume) that the task is accomplished.

Successful problem solving is a matter of making the right assumptions and exploring their consequences.PS is thus viewed as the 'creation' of a suitable case model and the interaction with the world is only a resource for this. It is almost a side-effect in the process of maintaining an internal organisation and identity.

Problem Solving Strategies

- Abstraction: solving the problem in a model of the system before applying it to the real system

- Analogy: using a solution that solves an analogous problem

- Brainstorming: (especially among groups of people) suggesting a large number of solutions or ideas and combining and developing them until an optimum solution is found

- Divide and conquer: breaking down a large, complex problem into smaller, solvable problems

- Hypothesis testing: assuming a possible explanation to the problem and trying to prove (or, in some contexts, disprove) the assumption

- Lateral thinking: approaching solutions indirectly and creatively

- Means-ends analysis: choosing an action at each step to move closer to the goal

- Method of focal objects: synthesizing seemingly non-matching characteristics of different objects into something new

- Morphological analysis: assessing the output and interactions of an entire system

- Proof: try to prove that the problem cannot be solved. The point where the proof fails will be the starting point for solving it

- Reduction: transforming the problem into another problem for which solutions exist

- Research: employing existing ideas or adapting existing solutions to similar problems

- Root cause analysis: identifying the cause of a problem

- Trial-and-error: testing possible solutions until the right one is found

Facilitating Factors in Problem Solving

- Existence of requisite knowledge/experience

- Use of appropriate strategies such as analogy , trial and error etc.
- Creative Thinking/Lateral Thinking
- Presence of adequate motivation

Hindering Factors in Problem Solving /Reasoning/Judgment/Creative Thinking

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Heuristics
They are are like general *thumb rules* gathered by experience. All these can hinder decision making, problem solving and judgments :

- Availability heuristic : importance or probability of various events is judged on the basis of how readily they come to mind
- Representativeness heuristic : assuming what is typical is also likely
- Anchoring and adjustment heuristic : taking available info. as reference and then making adjustments to it to reach a decision/judgment. e.g. bargaining after asking price from the seller.

Mental set
Mental set was first articulated by **Abraham Luchins** in the 1940s and demonstrated in his well-known water jug experiments. Mental set is a tendency of a person to solve problems by following already tried mental operations or steps. particular strategy would sometimes help in solving a new problem. However, this tendency also creates a mental rigidity that obstructs the problem solver to think of any new rules or strategies. Thus, while in some situations mental set can enhance the quality and speed of problem solving, in other situations it hinders problem solving.

It is of common experience while solving mathematical problems. After completing a couple of questions, we form an idea of the steps that are required to solve these questions and subsequently we go on following the same steps, until a point where you fail. At this point we may experience difficulty in avoiding the already used steps. Those steps would interfere in our thought for new strategies.

Functional Fixedness
Functional fixedness is a specific form of mental set and fixation. FF is when subjects are hindered in reaching the solution to a problem by their knowledge of an object's conventional function. It occurs in problem solving when people fail to solve a problem because they are fixed on a thing's usual function. The act of using a hardbound book to hammer a nail demonstrates overcoming functional fixedness. Functional fixedness limits the ability for people to solve problems accurately by causing one to have a very narrow way of thinking.

Motivational and emotional blocks
Lack of motivation, fear of failure, fear of being different, fear of ridicule or rejection, poor self-concept, negativism, etc. e.g. A person may find that s/he can not do it further, may leave the problem in between or may accept the intermediate idea as the final idea. Further, some people, for example, have negative assumptions about themselves. They feel that they are not capable of doing some tasks.

Cultural barriers
are related to excessive adherence to traditions, expectations, conformity pressures, and stereotypes. Conformity to some extent is essential for social existence but excessive conformity to traditions, rituals, and procedures are likely to block creative thinking/problem solving. Cultural blocks arise due to the fear of being different, the tendency to maintain status quo, willingness to accept mediocrity, preservation of personal security, social pressure, over dependence on others, etc.

Unnecessary constraints
This particular phenomenon occurs when the subject, trying to solve the problem subconsciously, places boundaries on the task at hand, which in turn forces him or her to strain to be more innovative in their thinking. The solver hits a barrier when they become fixated on only one way to solve their problem, and it becomes increasingly difficult to see anything but the method they have chosen. Typically, the solver experiences this when attempting to use a method they have already experienced success from, and they can not help but try to make it work in the present circumstances as well, even if they see that it is counterproductive. e.g. **nine dot problem.**

Irrelevant information

Irrelevant information is information presented within a problem that is unrelated or unimportant to the specific problem. Irrelevant information would serve no purpose in helping solve that particular problem. It is a common barrier that many people have trouble getting through, especially if they are not aware of it. Irrelevant information makes solving otherwise relatively simple problems much harder.

For example: "Fifteen percent of the people in a city have unlisted telephone numbers. You select 200 names at random from the city telephone directory. How many of these people have unlisted phone numbers?"

Presentation of problem
The way information is represented can make a vast difference in how difficult the problem is to be overcome. Whether a problem is represented visually, verbally, spatially, or mathematically, can have a profound effect on how long a problem takes to be solved.

Confirmation bias
Confirmation bias can be described as one's unconscious or unintentional corruption of the scientific method. Thus when one demonstrates confirmation bias, one is formally or informally collecting data and then subsequently observing and experimenting with that data in such a way that favors their preconceived notion. Research has found that professionals within scientific fields of study also experience confirmation bias. **Hergovich's** et al. experiment conducted online, for instance, suggested that professionals within the field of psychological research are likely to view scientific studies that are congruent with their preconceived understandings more favorably than studies that are incongruent with their established beliefs.

Is Problem Solving Related to Intellectual Ability?

A/c to **Wenke and Frensch (2003)**, there exists no convincing empirical evidence that would support a causal relation between any intellectual ability, on the one hand, and complex explicit or implicit problem-solving competence, on the other hand. This conclusion was based on a lack of evidence, not necessarily a lack of theoretical relation. Hence, the possibility of a causal relation between intellectual ability and complex problem-solving competence might exist but it is argued that there exists no convincing empirical evidence as yet that would support such a relation.

The conclusion has two important consequences:

1. From the empirical evidence that is currently available it appears that the relation between intellectual ability and complex problem solving performance might be moderated by a complex interaction among subjects, tasks, and situations.With restricted range in subjects, unreliable measurement and certain kinds of problem-solving task, the empirically obtained correlations attenuate. Thus, the future task may be to find not whether there is a correlation, but when.

2. There exist good evidence that differences in complex problem-solving competence, both explicit and implicit, are tied to differences in task knowledge and strategy. Whether or not differences in strategy and in the structure and acquisition of task knowledge may, in turn, be due to differences in specific intellectual abilities is, as yet, an open empirical question.

Reasoning

Reasoning is the process of gathering and analysing information to arrive at conclusions. In this sense, reasoning is also a form of problem solving. The goal is to determine what conclusion can be drawn from certain given information.

We see a person desperately running on the railway platform, we could infer a number of things such as: he is running to catch the train which is about to leave, he wants to see off his friend sitting in the train which is about to leave, he has left his bag in the train and wants to get in before the train leaves the station. To figure out why this person is running, we could use different kinds of reasoning, deductive or inductive.

Deductive Reasoning : Reasoning that begins with an assumption. e.g. based on our prior experience, we might assume that people run on the platform to catch a train, we would then conclude that this person is getting late and is running to catch the train. Thus deductive reasoning begins with making a general assumption that we know or believe to be true and then drawing specific conclusion based on this assumption. In other words, it is reasoning from general to particular. One mistake that is made in deductive reasoning is that it is not known whether the assumption is true. If the base information is not true, i.e. then our conclusion would be invalid or wrong. e.g. a mouse reasoning in this manner -" All cats have four legs, I have four legs, therefore I am a cat"

Inductive Reasoning : Inductive reasoning is drawing a general conclusion based on particular observation. It is form of reasoning is based on specific facts and observation. e.g. another way to figure out why the man is running on the platform would be to analyse other possible reasons and observe what the man is actually doing and then draw a conclusion about his behaviour. e.g. one might observe the other person's subsequent action or actions such as: entering into the train compartment and returning with a bag. Based on observation one would conclude that the person had left his bag in the train. One mistake one would probably make here is jumping to a conclusion without knowing all possible facts.

Most cases of scientific reasoning are inductive in nature. Scientists and even lay persons consider a number of instances and try to determine what general rule covers them all.

Analogy

Analogy is another form of reasoning which involves four parts, A is to B as C is to D with the relation between the first two parts being the same as the relation between the last two. For example, water is to fish as air is to human; white is to snow as black is to coal.

Analogies can be helpful in PS. They help us in identifying and visualising the salient attributes of an object or event, which would otherwise go unnoticed.

Creative Thinking

Nature of Creative Thinking

Q. How is creative thinking different from other forms of thinking. Discuss.

Creative thinking is distinguished from other types of thinking by the fact that it involves the production of novel and original ideas or solutions to problems. Besides novelty (*jugaad)*, originality is also an important characteristic of creative thinking. Every year new models of household appliances, tape-recorders, cars, scooters, and television sets produced may not be original unless unique features are added to these products. Creative thinking thus refers to originality and uniqueness of ideas or solutions that did not previously exist.

Creative thinking is also generally characterised by what **Bruner** calls **"effective surprise"**. If the product or idea is unusual, the response of most who experience it is one of instant surprise or of being startled. Another important criterion that characterises creative thinking is its **appropriateness** in a particular context. Simply thinking of being different without any purpose, doing things in one's own ways, being non-conformist, indulging in fantasy without any purpose or coming out with a bizarre idea, is at times mistaken for creative thinking.

Researchers tend to agree that thinking is said to be creative when it is reality-oriented, appropriate, constructive, and socially desirable.

Convergent and Divergent Thinking

J.P. Guilford, a pioneer in creativity research, proposed two types of thinking: convergent and divergent.

Convergent thinking refers to thinking that is required to solve problems which have only one correct answer. The mind converges to the correct solution. To illustrate, look at the question given below. It is based on a number series, where you have to find the next number. Only one right answer is expected. Q. 3,6,9….. what will come next? Ans. 12.

Divergent Thinking: employed in open ended questions like : What are the various uses of cloth?, What improvements will you suggest in a chair so that it becomes more comfortable and aesthetically pleasing? Answers to the above questions require divergent thinking which is an open-ended thinking where the individual can think of different answers to the questions or problems in terms of her/his experiences. Such kind of thinking helps in producing novel and original ideas.

Characteristics of Divergent Thinking

Fluency : the ability to produce many ideas for a given task or a problem. The more ideas a person produces, the higher his fluency ability.e.g. more the number of uses of a paper cup, more would be the fluency.

Flexibility : indicates variety in thinking. It may be thinking of different uses of an object, or different interpretation of a picture, story or different ways of solving a problem. In case of uses of a paper cup, e.g. one may give an idea to use it as a container or to draw a circle, etc.

Originality : the ability to produce ideas that are rare or unusual by seeing new relationships, combining old ideas with new ones, looking at things from different perspectives etc. Research has shown that fluency and flexibility are the necessary conditions for originality. The more and varied ideas one produces, the greater the likelihood of original ideas.

Elaboration : the ability that enables a person to go into details and workout implications of new ideas.

Divergent thinking abilities facilitate generation of a variety of ideas which may not seem to be related. For example, what are the common ideas for enhancing food production? The likely answers would be related to quality of seeds, fertilizers, irrigation, and so on. If someone thinks of cultivation in a desert for extracting protein from weeds, it would be a remote idea.

Both convergent and divergent thinking are important for creative thinking. Divergent thinking is essential in generating a wide range of ideas. Convergent thinking is important to identify the most useful or appropriate idea.

Lateral Thinking (Edward De Bono) aka Divergent Thinking (Guilford)

Edward de Bono has used the term **'lateral thinking'** to what Guilford termed as **divergent thinking.** He makes a distinction between vertical thinking and lateral thinking. **Vertical thinking** involves mental operations that move in a straight line back and forth between lower and higher level concepts whereas lateral thinking involves looking for alternative ways of defining and interpreting problems. He states "vertical (logical) thinking digs the same hole deeper, i.e. thinking deeper in the same direction; lateral thinking is concerned with digging a hole in another place".

De Bono suggests that lateral thinking can help make mental leaps and is likely to create a number of ways of thinking. De Bono developed the **'Six thinking hats'** technique to stimulate different modes of thinking. One can put on or take off these hats according to the type of thinking required to be used.

White hat means gathering information, facts, figures, and filling gaps in information.

Red hat covers expression of feelings, and emotions on the subject.

Black hat represents judgment, caution and logic.

Yellow hat covers thinking on what will work and why it will be beneficial.

Green hat is for creativity, alternatives and changes.

Blue hat represents thinking about the process and not the ideas as such.

The 'six thinking hats' reflect different perspectives from which an issue or problem is viewed. The technique can be used individually as well as in groups.

Stages of Creative Thinking

Recent research has shown that thinking of new and unusual ideas involve more than a flash of insight. There are stages before and after the new ideas come. These are :

1. The need to think : The starting point in creative process is the need to think or bring out something new which initiates the effort. Not everyone experiences this need, as one can be happy and contented, in carrying out routine work.

2. Preparation stage : Requires one to understand the task or problem in hand, analyse the problem, and become aware of the background facts and related information. The process evokes curiosity and excitement to think more and more in different directions. The person tries to look at the task or problem from different angles and viewpoints. Here, divergent thinking abilities discussed earlier play their role to help one extend in new directions.

3. Incubation Stage :When the person is trying to generate alternative ideas and trying to view the problem or task from an unusual perspective, there may be a feeling of getting stuck. One may even get disgusted with failure and may leave the problem or the task for sometime. This is the stage of incubation. Research shows that creative ideas may not occur immediately during incubation when the individual is not consciously thinking about the problem but seeking relaxation from conscious effort. They may occur or strike when a person is doing something else, for example, going to sleep, waking up, taking a bath or just walking along. e.g. Archemdies and bath tub Eureka Eureka !

4. Illumination Stage :The 'Aha'! or 'I have found it' experience, the moment we normally associate with emergence of creative ideas. There usually is, a feeling of excitement, even satisfaction, of having found a creative idea.

5. Verification Stage : When the worth or appropriateness of ideas or solutions are tested and judged. Here, convergent thinking plays its role in selecting the appropriate idea or solution that works.

Fostering Creativity /Creative Thinking

- Herditary Factors/Intellectual abilities

- Environmental Factors : surroundings should be made stimulating which fosters imaginations and is vibrant.

- Styles of Thinking : encouraging thinking from flexibly, imaginatively various perspectives ,promoting thinking holistically as well as analytically.

- Personality Attributes : promoting traits like willingness to go beyond conventions , intrinsic motivation, task-focused motivation etc.

- Knowledge in the respective field should be encouraged. e.g. students interested in science should be encouraged to study more about recent researches.

- Practice and training : research has also shown that all of us can make better use of our abilities for creative thinking through practice and training.

Forming subgoals heuristics - - Intermediate steps toward a solution.

Trial and error heuristics - - Involves trying possible solutions sequentially and discarding those that are in error until one works.

Hill climbing heuristics - - which entails selecting the alternative at each choice point that appears to lead most directly to one's goal. (Choosing the steepest upward pathway).

Searching for analogies heuristics - - using the solution to a previous problem to solve a current one. Similarities between problems.

Changing the representation of problem heuristic - - Whether you solve a problem often hinges on how you envision it. Problems can be represented in a variety of ways: mathmatically,spatially, or verbally.

Cultural Problem solving - - Easterners see whole,(big picture), where as westerners see parts.

Decision making - - involves evaluating alternatives and making choices among them.

Simon's theory of bounded rationality - - Asserts that people tend to use simple stratagies in decision making that focus on only a few facets of available options and often result in irrational decisions that are less than optimal.

The effect of an abundance of choices on decisions - - Although enormous freedom sounds attractive, it does have unexpected costs, such as: Routinely making errors, postdecision regrets. That contibutes to depression.

Additive strategy - - Lists and rate the desired attributes that influence your decision. Pick the one choice with the largest total.

Elimination by aspects - - People also make choices by gradually eliminating less attractive alternatives.

Risky decision making - - Involves making choices under conditions of uncertainty.

- **Availability Heuristics** - - Involves basing the estimated probability of an event on the ease with relevant instances come to mind. Example(estimating divorce rates,by friends and family).

- **Representitive Heuristics** - - Involves basing the estimated probasbility of an event on how similar it is to the typical prototype of that event. (Example,coin toss)

- **Conjunction fallacy** - - Occurs when people estimate that the odds of two uncertain events happening together are greater than the odds of either event happening alone. Example, (College professors becoming polititions)

- **Ignoring base rate** - - Estimating probabilities, people tend to ignore information on base rates. (Example, Sales people to Librarians are 75 to 1)

- **Overestimate the improbable** - - people tend to overestimate the over dramatic, vivid but infrequent events, that recieve media coverage. (Example, tornadoes, murders, and floods)

- **Recognition heuristic** - - If one of two alternatives is recognized, but the other is not. The recognized alternative has higher value.