Chapter 14
Problem Solving

Problem solving is a purposeful, goal-directed action. It is a process that involves finding, analyzing, and solving those problems. Problem solving has the ultimate goal of overcoming any obstacles, and finding out a solution to the problem that resolves the issue in the best possible way. A problem can be anything, right from trying to remember the name of your favorite restaurant, to a difficult numerical problem. How a problem is solved, however, depends on the unique situation it exists in. In some cases, one might take the help of carefully learnt factual information to solve a problem, while in some other situation, creative solutions might be the best way to go.

In order to solve a problem correctly, it is important to follow a few steps, which have also been referred to as the ‘Problem-Solving Cycle’. This cycle includes some basic steps that can be followed in order to solve a problem. But this is only in the ideal situation scenario; in reality, many times people often skip some steps, or even go back to earlier steps a number of times until the desired goal is reached.

The Problem-Solving Cycle includes the following steps –

- Problem Identification
- Problem Definition and Representation
- Strategy Formulation
- Organization of Information
- Resource Allocation
- Monitoring
- Evaluation

Steps in the Problem Solving cycle –

- **Problem Identification** – Problem identification is the first step in problem solving, and requires the identification of the problem. It may sound as a simple task, but is not always so. One may identify the wrong problem to begin with, which then may make all further attempts in problem solving as futile and useless.

- **Problem Definition and Representation** – After the problem has been identified, the next step is to appropriately and fully define the problem so that it can be solved.

- **Strategy Formulation** – The next step in the problem solving cycle is to develop a strategy in order to solve the problem. The approach used here may vary according to the situation and also according to the person’s preferences.

- **Organization of Information** – The information that is available needs to be organized, before one can come up with a solution to a problem. The more the information that is available, the better prepared a person is to come up with an accurate solution.

- **Resource Allocation** – Before problem solving begins, it is important to decide how high in the priority list the problem is, so that appropriate amount of resources can be allocated to it. If the problem is judged to be very important, then more resources can be allocated to finding its solution.

- **Monitoring** – Monitoring is also an important process in solving a problem. Monitoring the progress while working towards a solution is important, as the strategies and approaches employed presently can be reevaluated if a good progress is not being made in the problem solving process.

- **Evaluation** – The last step in problem solving is evaluation. After the solution of the problem has been found, it is important to evaluate the results in order to find whether or not the best possible solution to the problem has been reached. This evaluation might be immediate, such as checking the results of a math problem to ensure the answer is correct, or it can be delayed, such as evaluating the success of a therapy program after several months of treatment.
Problem solving is basically a process that involves a state of desire for reaching a goal from a condition that is far from it. Generally, problems can be classified into two types; one that are well defined, and one that are not.

- **Ill-Defined problems** –
  Ill- defined problems, as the name suggests, are those problems which are not defined properly. These are the problems that do not have any clear goals, or information, or solution paths, or any clear expected solutions. In ill-defined problems, it is not clear what information one should start from. It is also not clear when the solution has been reached, or what rules apply in finding out that solution.

- **Well-Defined problems** –
  Well- defined problems, in contrast, are those in which all the aspects of the problem are clearly laid out. These problems have specific goals, clearly defined solution paths, and clear expected solutions. Well defined problems generally present with a small set of information from where one can start, and often come with a set of rules or guidelines to abide by while working towards a goal.

**Gestalt Approach to Problem Solving**
A school of thought emerged from Germany in the early 20th century, known as the Gestalt psychology, and was concerned with entities/experience as a whole rather than consisting of parts.
The gestalt approach of problem solving was proposed by a number of German psychologists in 1920's and 30's. They criticized previous experiments involving arbitrary rules for problem solving (E.g. Thorndike’s hungry cats). They drew a distinction between reproductive thinking, involving re-use of previous experience; and productive thinking involving a novel restructuring of the problem. The Gestalt psychologists argued that problem solving was a productive process. In particular, in the process of thinking about a problem individuals sometimes restructured their representation of the problem, leading to a flash of ‘insight’ that enabled them to reach a solution.

Insight was first observed by Wolfgang Köhler while conducting studies on apes, and he found the animals to demonstrate insight in problem solving situations. Insight occurs during productive thinking when the problem is suddenly restructured and the solution becomes clear. Gestalt psychologists claimed that insight involves unique processes. Matcalfe and Weibe (1987) recorded that the participants feeling of ‘warmth’ as they tried to solve a problem. The non-insight problems had steadily increasing feelings of warmth, whereas, the insight problems were characterized by a sudden burst of warmth upon solution.

These findings that the insight problems were characterized by a sudden burst of warmth upon solution raised a few questions regarding the nature of this phenomenon. Questions regarding its meaning, about whether it follows an ‘all-or-nothing principle’ started being raised. It was also argued whether it was possible to work towards insight. In a study conducted by Novick and Sherman in 2003, the difference between subjective experience and the underlying process was studied and highlighted. In a series of experiments, expert and non-expert anagram solvers were presented with a series of anagrams. In the results that were obtained, the researchers observed that when rating the experience of solving anagrams both groups often reported ‘pop out’ solutions; the solution came suddenly, seemingly out of nowhere. However, in another experiment the participants were asked to indicate if the word was an anagram or not, after a brief exposure to that word. The results obtained here showed that the performance of both the groups was better than chance. Jung-Beeman et al (2004) in an fMRI study, found evidence of different brain activation for problem solving that involved insight. The anterior superior temporal gyrus was associated with self reported insight.

Furthermore, the Gestalt psychologists described and explained several aspects of thought that acted as barriers to successful problem solving. One of these was commonly referred to as mental set. This occurs when a problem solver becomes fixated on applying a strategy that has previously worked, but is less helpful for the current problem.
Another barrier to problem solving is **functional fixedness**, whereby individuals fail to recognize that objects can be used for a purpose other than that they were designed for. In other words, it is a Gestalt term referring to when learning or past experience impedes problem solving.

In a classic experiment demonstrating functional fixedness, Duncker (1945) gave participants a candle, a box of thumbtacks, and a book of matches, and asked them to attach the candle to the wall so that it did not drip onto the table below. Duncker found that participants tried to attach the candle directly to the wall with the thumbtacks, or to glue it to the wall by melting it. Very few of them thought of using the inside of the box as a candle-holder and tacking this to the wall. In Duncker’s terms the participants were “fixated” on the box’s normal function of holding thumbtacks and could not re-conceptualize it in a manner that allowed them to solve the problem. He further suggested that the participants were more likely to solve the problem if the box was emptied before it was presented.

However, even though functional fixedness is considered as a barrier to solving problems, it is not always a bad thing. In many cases, it can act as a mental shortcut allowing us to quickly and efficiently determine a practical use for an object.

**Representational Change Theory** –

Representational change theory is an attempt to incorporate some Gestalt ideas into a working theory (Ohlsson, 1992). This theory suggests that because a problem solver has all the required knowledge at hand, their failure to find a solution is due to the way they are mentally representing the problem. If the problem is not represented in such a way as to accommodate retrieval of the necessary knowledge, the solver will reach a block or impasse that will prevent further progress. It further suggests that insight occurs when the solver’s mental representation changes to allow retrieval of the required knowledge. It is based on the following assumptions:

- A problem is represented in a certain way in the person’s mind and this serves as a probe for information from long-term memory.
- The retrieval process spreads activation over ‘relevant’ long term memory items.
- A block occurs if the way a problem is represented does not lead to a helpful memory search.
- The way the problem is represented changes and the memory search is extended, making new information available.
- Representational change can occur due to ‘elaboration’ (addition of new information) ‘constraint relaxation’ (rules are reinterpreted) or ‘re-encoding’ (functional fixedness is removed).
- Insight occurs when a block is broken and retrieved knowledge results in solution.

**Progress Monitoring Theory** –

The Progress monitoring Theory was put forth by MacGregor et al (2001). There are two main features:

- **Maximization heuristic:** Here, each move or decision is an attempt to make as much headway as possible towards the goal. This means that the solver will attempt to move themselves as closely as possible to the goal (or current sub-goal) on each move.
- **Progress monitoring:** The rate of progress is assessed constantly, and if it is deemed to be slow and inefficient *criterion failure* occurs. An alternative strategy is then sought. This means
that the solver will make a note of their progress, and criterion failure occurs if it is found to be unsatisfactory in any way.

MacGregor et al., in their version of the nine dot problem, stated that problem solvers will seek to maximize the number of dots they cross out with each successive line that they draw. The minimum amount of dots that must be crossed out is just over two on average (nine dots to cross out using four lines). As it is quite easy to cross out three dots with the first line, and two with the next two lines, then for the first three moves, there is never a large difference between the current state of the problem (in terms of how many uncrossed dots exist) and the number of moves remaining (in terms of how many lines have yet to be drawn). Criterion failure is only encountered on the fourth and final move. The poor performance on the nine dot problem is therefore explained by criterion failure being reached too late, rather than because the problem solver imposes an unnecessary constraint of keeping lines within the bounds of the square. Only when problem solvers have the capacity to look several moves ahead of themselves will they reach criterion failure sooner, at which point they may realize alternative solutions where some of the lines end outside of the nine-dot square.

**Transfer of Training –**

Transfer of training basically refers to how our experience of past problems influences our ability to solve new ones. Essentially, there are three types of transfer of training:

- **Positive Transfer**
  This is when prior learning or training facilitates acquiring a new skill or reaching the solution to a new problem. In this situation the individual performs better than he would have without the prior training.

- **Negative Transfer**
  This is when prior learning or training hinders acquiring a new skill or reaching the solution to a new problem. In this situation the individual performs worse than that he would have, if he had not been exposed to the prior training.

- **Zero Transfer**
  In this situation, past experience or training neither enhances nor hinders acquiring a new skill or reaching the solution of a new problem.

**Far and Near Transfer –**

'Far’ transfer is much more challenging in that it requires the learner to abstract the new situation and engage in reflection and meta-cognition to help construct a way to solve the problem. Far transfer refers to transfer to a dissimilar context. For example, learning about experimental method in science class (control groups, confounding variables etc.) and using the same principles in real world settings (deciding how to make the nicest biscuits)

Near transfer refers to transfer to a similar context. Lab studies often limited to near transfer. 'Near’ transfer occurs when the scenario in which original learning had occurred is similar to the new problem scenario so that the learner can successfully apply preconceived problem-solving processes.

**Expertise –**

In general terms, expertise refers to the mechanisms underlying the superior achievement of an expert, i.e. one who has acquired special skill in or knowledge of a particular subject through professional training and practical experience. People can acquire knowledge about a specific topic over several years.

These people approach solving a problem by using -
Superior knowledge/experience
- Quicker decisions
- Automaticity
- More confidence

This factor which helps some people approach, and solves problems in a different and efficient way is known as 'Expertise'. This is a knowledge-rich type of problem solving which is less researched, but possibly more relevant. One commonly studied group of experts are chess players. They are found to have very detailed information about pieces stored in long term memory. They are much better than novices at 'chunking'. It has been observed that Chess masters are significantly better than novices at remembering the location of pieces from a game. However, in a study by Chase and Simon (1973), it was seen that this effect disappears when the pieces are placed randomly on the board.

![Real game position vs Random arrangement](image)

However, it is wrong to assume that superior memory is the only characteristic of the people with expertise. Holding & Reynolds (1982) argue that experts also possess superior strategic processing skills to novices. A number of theories have been put forth in the context of Expertise in problem solving.

### Template theory

Template theory suggests that the experts organize chunks into meaningful complex structures known as templates. The chess players might remember the chess pieces as being in a strong, weak or neutral position as a whole. Templates can hold larger amounts of information than simple chunks, and can be direct thinking strategically.

Most of the research surrounding this theory has taken place in the domain of chess. According to template theory, chunks of chess pieces are contained in LTM, and the role of STM is to contain pointers to this information. When a chess expert sees an array of pieces and positions, the activity in his memory systems will depend on the novelty of the arrangement. As a player gains more experience with specific moves or arrangements, these chunks become templates. Templates contain not only chunks but also slots to accommodate variable features. A template is a useful and practical way to represent expertise in the domain of chess, as the slots of a node allow for access to and from several different paths. This theory assumes a much more dynamic role for the short-term store, incorporating new information into the template.

In a study conducted by Charnes et al. (2001), chess boards were presented to experts and novices, and their eye movements were recorded for the first second after presentation. Even in this short time experts were more likely than novices to fixate on tactically relevant pieces (80% v 64%). Global structures of game patterns seem to be stored by experts. Another experiment which was conducted by McGregor & Holmes (2002) involved showing chess boards to experts and novices. The participants had to indicate if they had seen a particular board before or not. The results showed that the experts were better at realizing that they had not seen a particular board if one important piece was shifted than if the whole board was translated one space over.

However, the template theory has its limitations. It is not clear from template theory what the precise information is that is being stored. Attack/defense relations are more memorable than piece location, but this does not help in deciphering what the contents of memory are.

### Anderson's ACT Theory –

Adaptive Control of Thought theory or the ACT theory proposes three connected systems at work in experts -

- Declarative memory (semantic network)
- Procedural memory (simplifying decision making)
- Working memory
According to this theory, as the novice becomes an expert, there is **knowledge compilation**, resulting in a shift from declarative to procedural memory. **Proceduralisation** is where production rules are drawn up to make decisions and take action more quickly. The is the **Composition** which improves performance by reducing a repeated sequence of actions to a single action.

Zbrodoff, in 1995, conducted a study in which the participants had to answer questions about the alphabet. For example, they were asked to solve the following; \( S + 4 = ? \) The Answer to this problem was ‘W’. It was observed that initially, the participants were quicker to answer \( S + 2 \) than \( S + 4 \). This is because initially participants were running through the alphabet in their head. However, after practice, the times became equal as participants began to rely automatically on past experience.

Studies have shown that there is good evidence of a shift from declarative to procedural memory as people become well practiced at a particular task. However, though this model deals well with **unvarying** procedures (touch typing), it does not say much about creative/adaptive expertise (like that seen in scientific theory).