The Strategies Of Problem Solving

When faced with a problem, humans often use strategies in order to solve them. There are a number of strategies used but for the purpose of this essay, I will focus on the main ones. Each strategy is perfect to use for a specific problem but may not transfer to another in the same way it was used before, whether the strategies can be applied to the problem will depend on the problem structure, whether it is well defined or ill defined and if the solver has enough knowledge of the goal state. Outlined in my essay are algorithms, heuristics and a common technique to facilitate insight.

Algorithms are a popular strategy used when facing well defined problems as they guarantee a successful solution. The specific algorithm I am going to speak about is called a systematic search, the process is identifying all possible solutions and then sequentially testing them systematically. Glassman and Hadad (2013) gave an example of a lock with a combination dial using three numbers, each going up to 40. They posed a problem where the solver does not know the combination and is unable to open the lock. The solver then using the systematic search strategy would try to ascertain all possible combinations and then work through them in sequence until the lock opens. While this strategy guarantees success, it does have its limitations… Systematic search and other algorithms can take a long time depending on the amount of possibilities involved, in the Glassman and Hadad (2013) lock combination problem there were 64,000 possibilities! Had the dial gone up to 60 instead of 40, there would have been 216,000! In the cryptarithmetic problem, where solvers are expected to assign digits to letters in order to calculate a sum studied by Bartlett (1958) there were 362,880 possibilities, a serial processor able to make and test five assignments per minute would take a month to solve the problem; humans tend to do it less than 10 minutes. Problems with a high amount of possibilities makes the process lengthy, tedious and in some cases unmanageable according to Donnarumma, Maisto & Pezzulo (2016) “In problems like the ToH having moderately large state spaces, exploring all the possible paths is very demanding (in some cases, computationally intractable)” . This strategy is fail proof and most efficient when solving well defined problems with few to moderate possible solutions, an example of a better approach to problems with many possibilities is using a mental shortcut called heuristics. In the case of a lock combination or passcode problem, trying significant number combinations such as important dates could get you to the goal state quicker. It is also useful to note that algorithms work based on a sequence that is designed by knowing the problem structure, it is not randomly put in. Without the problem structure, people are unable to use algorithms to solve the problem. A Newell, JC Shaw, HA Simon (1958)

As seen above, heuristics are polar opposites to algorithms, this problem solving strategy focuses on finding an optimal solution in reasonable time as opposed to the correct solution, regardless of time. The means-end analysis method (which is a hybrid of two heuristics, hill climbing and moving backwards) has been heavily researched and discussed since Duncker (1945) and later, Newell and Simon (1972) would say that the most important heuristic method is means-end analysis, the strategy where you calculate the difference between the problem state and the goal state, form sub goals to decrease the difference and then select a mental operator that will maximally reduce the differences. A well-known problem best using means-end analysis is the Tower of Hanoi, after representing the problem, the solver sets sub goals

(Free large disc, free third peg, move large disc to third peg) and completes sub goals, creating new ones if necessary until the problem is solved. In a study by Stock and Cervone (1990) on task persistence, they proved that the people who worked on the “missionaries and cannibals” problem with attainable sub goals in their controlled condition persisted significantly longer than their counterparts with unattainable sub goals or none at all. Another study by Latham and Seijits (1999) resulted in similar findings, participants in the sub goals condition had the highest performance. While means-end analysis is proven to help solve well defined problems quicker and at a higher performance Latham and Seijits (1999), it hinders ill defined ones such as mazes because it lacks information surrounding the goal state. Solvers cannot reduce the difference between the problem state and goal state because the goal state of a maze is unknown. Sweller and Levine (1982). Another limitation of this strategy is that it hinders insight and positive transfer due to the problem solver learning little about the structure of the problem Egan and Greeno (1974) Mawer and Sweller (1982).

Another heuristic that hinders solutions due to the solver lacking information about the problem’s structure is hill climbing, also identified by Newell and Simon (1972) the strategy involves changing the present state in to being closer to the goal state. Eysenk and Keane (2016) argue that the focus on short term goals often does not lead to problem solution and compare it to a climber who tries to climb to the top of the highest peak of a mountain by using “always move upwards” as a strategy, they note that while it might work, it is more likely that the climber will be trapped, surrounded by valleys. Hill climbing, like algorithms moves toward the goal without thought or careful consideration but unlike algorithms do not guarantee a solution and often doesn’t. Hill climbing and successfully reaching the goal requires another heuristic, moving backwards at times in order to get a different perspective of the problem or goal state, a dog trapped behind a fence separating him from a bone is unable to hill climb to the goal, he must step back in order to see the full picture and once he has done this, he will notice an open gate he can access the goal state from. In other scenarios however, both hill climbing and moving backwards can separate you further from the goal and therefore hinder your progress.

Moving backwards is commonly used when a planning problem arises, if someone needs to plan a journey, starting at the goal state and working backwards to plan your moves is sure to give you an easy step by step solution to your problem, this strategy may seem like the goal state knowledge is fully required in order to gain a solution but people often use this technique when they have lost something too. In this scenario, the goal state is unknown as the solver doesn’t know where the goal is but retracing their steps is a fairly methodical approach as even if the exact previous steps cannot be recalled, being in the same place can facilitate insight.

Other strategies used and often given out as advice are trial and error and incubation. Trial and error, similar to algorithms continuously make an effort towards the goal, eliminating unsuccessful solutions as the solver works through them. However, like algorithms, trial and error can be a lengthy and mentally exhausting strategy if using it to solve a complex problem or one with many possibilities. Contradictory to the trial and error strategy is incubation which works by taking time to step away from solving the problem, Wallas (1926) found it can facilitate insight. People often advise others to “sleep on it” this is helpful because as Wallas suggested, once putting the problem aside the subconscious is able to work on solving the problem in the background. Wagner et al. (2004) tested this theory with participants solving mathematical problems, some participants were able to sleep for a while and then they were all tested several hours later, of those who slept 59% were able to find the hidden shortcut but only 25% in the

non sleeping condition managed to. However, unlike the other strategies outlined above, incubation was found to enhance solving in creative problems with more possibilities than simpler ones with less Sio et al. (2013)

In conclusion, each strategy used alone has limitations due to the structure knowledge of the problem, time constraints and mental effort. Problem solvers are better equipped at finding successful solutions when combining strategies such as the means-end analysis, using a combination of strategies prevents mental set – the tendency of solvers to repeat previous successful problem solving strategies even when inappropriate Luchins (1942)