Chapter 10: Problem-Solving

Overview

So far in the course, we've learned about how we take in information—how we recognize objects and words, how we acquire and store information, and so on. We haven't addressed very high-level *thinking*. Problem-solving involves going beyond the given information and transforming it to get an answer to a question. Problem-solving relies on many cognitive processes: attention (attending to the aspects of the problem that are most important), memory (bringing to mind strategies and techniques that have worked in the past), and language (understanding and communicating the problem). It certainly relates to decision-making as well, which we'll address in the next chapter.

One way to begin discussing problem-solving is by giving students some examples. Here's an interesting one: A set of encyclopaedia are placed on a bookshelf with the volumes in alphabetical order. There is a bookworm sitting on the front cover of the "A" volume. The bookworm begins chewing his way through the pages, following the shortest possible path toward the back cover of the "Z" volume. Each volume is three inches thick (including pages and covers) so that the entire set of volumes requires 78 inches of bookshelf. The bookworm chews through the pages and covers at a steady rate of three-quarters of an inch per month. How long will it take before the bookworm emerges through the back cover of the "Z" volume?

Most people try to solve this problem algebraically: 78 inches of books at three-quarters of an inch per month leads to the answer 104 months. But encourage students to carefully imagine this situation—the bookworm was starting on the *front cover* of volume A which means it wouldn't have to chew through the pages of volume A (only the front cover). As well, when the bookworm got to volume Z, it wouldn't have to chew through all the pages of that volume (only the back cover). Therefore, the answer is actually less than 104; it's closer to 98 or 99. Problems like this one require visualization.

Numerous websites (one of which is listed below) have interactive versions of the Tower of Hanoi problem. Encourage students to try it and think about their approaches to the problem. As an interesting aside, there is apparently a legend about a Buddhist monastery in Hanoi that has a room with three large posts in it and 64 gold discs. According to an ancient command, the monks there have been moving these disks, following the rules of the puzzle, once every day since the monastery was founded over a thousand years ago. Supposedly when the last move of the puzzle is completed, the world will end in a clap of thunder. Sixty-four disks requires an enormous number of moves so, at one move every day, they are, fortunately, not even close to being done. We should all be ok for a while!

Expertise is discussed in Chapter 12 but it is worth mentioning in the context of the current chapter that there are numerous advantages that experts have over novices in terms of problem-solving. Experts, of course, differ from novices in terms of their knowledge base. A novice will have much more difficulty solving a mathematical problem than an expert mathematician because the novice doesn't have the wealth of knowledge of mathematical procedures. As well, experts find it much easier to remember things that are related to their area of expertise (expert chess players, for example, can easily remember complex arrangements of chess pieces). Experts are better able to recognize commonalities between different problems and are therefore more effective in using solutions that have worked before in fundamentally similar situations.

Experts are also more likely than novices to use the means–end heuristic—that is, they are more likely to split the problem up into sub-problems and work on sub-goals. As well, experts tend to be better at judging a problem's difficulty; they are more likely to know whether they are right and they are better at effectively allocating their time in working through a problem.

Learning Objectives

In this chapter students will:

- Describe the Gestalt approach to insight and problem-solving.
- Consider functional fixedness and how it can hinder problem-solving.
- Examine artificial intelligence approaches to problem-solving and how they resemble the ways humans solve problems.
- Discuss the various approaches to the study of problem-solving in science.

Key Concepts with Illustrative Examples

algorithm (see page 325)

An algorithm is a set of unambiguous procedures that can be used to solve a problem. For example, in deciding a chess move, it is possible to generate and compare each and every possible move. An optimal move may be arrived at in this way but it is likely to be prohibitively time-consuming and inefficient.

constraint relaxation (see page 316)

Constraint relaxation is an aspect of representational change theory in that it suggests that insight can occur after the removal of assumptions that are blocking the problem solution. For example, in the two string problem, the assumption might be that a screwdriver can only be used as a tool rather than a weight. Once that assumption is removed, the problem solver can change their representation of the problem and move toward a solution.

Einstellung effect (see page 322)

In general, a good strategy in problem-solving is to recognize the commonalities between different problems and use the solution to one problem to help solve another similar one. However, this approach can become counter-productive when the person falls into the rut of over-using a solution for problems that are not fundamentally similar. This rigidity in problem-solving is called the Einstellung effect. If resetting the modem has worked in the past to fix the Internet, then that may be your first tactic. If the satellite is down, though, then nothing you do with your modem is going to work.

functional fixedness (see page 311)

People have a tendency to see an object as useful only for its usual purpose. An example of functional fixedness comes from Duncker's classic 1945 experiment. Given a box of tacks, a candle, and a book of matches, the task is to find a way to mount the candle to the wall. Most people didn't think to use the box as a candle holder. A box is thought of as something that items are put things into, not as something that serves as a platform.

Gestalt switch (see page 307)

The Gestalt switch refers to a sudden change in the way information is organized. Although common examples are the old/young woman or the duck/rabbit images, another example is the spinning woman. When you first look at the image, it appears she is spinning clockwise, however, if you watch her shadow, after a moment she begins to spin in the opposite direction.

heuristic (see page 325)

A heuristic is a general rule that is usually useful. A good rule of thumb in playing chess, for example, is not to use the queen too early in the game. Once in a while, though, using the queen early on can be part of a clever way to win the game.

insight problem (see page 308)

Insight problems cannot be solved using a defined set of procedures. It must be examined from a different angle. An insight problem may initially seem impossible but, all of a sudden, the solution comes to mind.
Consider this example: A stranger approached a museum curator and offered him an ancient bronze coin. The coin had an authentic appearance and was marked with the date 544 BC. The curator had happily made acquisitions from suspicious sources before, but this time he promptly called the police and had the stranger arrested.
Why?
Once you gain the appropriate insight, there is an "a-ha" reaction because you have overcome something that was blocking your attempt to find the solution: BC stands for "before Christ" and couldn't possibly be stamped on a coin at that time.

problem space (see page 326)

Problem space refers to how a problem is represented, including the goal to be reached and the various ways of transforming the given situation into the solution. Although the text book uses examples of carefully formulated problems there are many everyday examples as well. If you were invited to a party and you realize you do not have anything appropriate to wear (problem), you need to identify what you need, where to go to buy it, actually making the purchase, and bringing it home. All of these are included in the problem space.

structurally blind/reproductive thinking (see page 310)

Structurally blind/ reproductive thinking refers to the tendency to use familiar or routine procedures, reproducing thinking that was appropriate for other situations, but is not appropriate for the current situation. We do many things everyday using reproductive thinking because it requires less thought. For example, whenever you go to brush your teeth you probably use the same procedure every time. You may find, however, that although this method works with a manual toothbrush, it would probably not be as effective if you switched to an electric toothbrush.

Zeigarnik effect (see page 332)

You may have noticed that many television shows end their season with a "cliffhanger"—an ending that leaves you wanting to know what happens next. This need that you have to find out how the story ends is an example of the Zeigarnik effect, which is the "quasi-need" to finish incomplete tasks.

Discussion and Debate Ideas

1. Have the class discuss Alexander Pope's observation that "a little learning is a dangerous thing." The text refers to this quotation in the context of structurally blind thinking. It is also relevant to issues of feeling of knowing—a little learning can increase feeling of knowing beyond what is warranted. Have the class consider this example: Imagine you are taking a trip to a distant city and, when there, you are going to have to find your hotel, figure out places to go, and so on. Let's say that you have never been to this city before. Your feeling of knowing for solving the problem of getting around would be very low. What are you going to do? You are probably going to get detailed directions to the places you want to go and you're likely to look up whatever information you can beforehand. Let's say, instead, that you know the city very well (maybe you used to live there). Your feeling of knowing would be very high and your knowledge level would be very high; you don't need to look up directions because you aren't going to need them. Now think about the situation when you have a little knowledge. If you've been to this city once or twice before, you may have some vivid memories of what you did there and you probably have some sort of basic idea of how the city is laid out. You are unlikely to worry too much about directions because your feeling of knowing is quite high. If you have spent only a short amount of time there, though, you probably don't *really* know where you're going. A little knowledge can substantially increase your feeling of knowing (your confidence) even if your knowledge level is quite low. Discuss other ways that metacognition can affect which strategies are used in tackling a problem.

2. Have the class practise functional "un-fixedness." What *else* could you use a garlic press for? What about a snow shovel? A roll of toilet paper? Point out that thinking of alternate uses requires a fresh mindset with regard to the object. Note the relation to the construct of creativity (which will be covered in Chapter 12). Also relevant is Gibson's concept of affordances (from Chapter 1). That some affordances of an object seem more obvious than others demonstrates our history with that object.

3. What separates humans from other animals? At one time, it was thought that what set humans apart was our ability to use tools. It has become clear, though, that other animals can use objects as tools and, in some cases, can even invent tools for various purposes. If a chimpanzee needs to collect termites from underground, he may fashion a scooping agent from a tree branch. It does seem a reasonable argument that other animals can't compete with us when it comes to complicated, abstract problem-solving (thanks largely to our sophisticated language skills). Then again, careful observation of what animals (especially the "smart" animals like chimpanzees) are capable of is surprising.
   Have the students watch this film clip: http://www.youtube.com/watch?v=ySMh1mBi3cI. Now, have them consider their supposed superiority. Would *they* have thought of that?

4. Simon (1995) argued that a computer can be programmed to demonstrate a form of insight in solving the mutilated checkerboard problem. Have the class debate whether or not this is truly "insight." Is it different in a meaningful way from human insight? Consider the case of Watson (referenced in Chapter 10). Is it fair to apply the term "insight" to Watson's Jeopardy responses?

5. The text discusses how sometimes children are able to solve problems that an adult cannot because they are not constrained by any one way of thinking. Discuss how this principle might also affect an expert's vs. a novice's approach to solving a problem.

6. Insight often follows a break away from the problem. Have students share their experiences of insight. Are there any patterns in the types of situations in which they have experienced insight?

7. Discuss the possible differences between solving problems in a laboratory and solving them in everyday life. Which would be easier? Why?

8. Master chess players often plan their moves well in advance. Part of this is the ability to anticipate the moves of the opponent. Discuss the problem-solving skills that a master chess player may have that would allow this ability. Draw on other cognitive factors that you have covered in previous chapters (e.g., working memory, visual imagery, spatial ability, etc.).

9. Find an object that students are unlikely to recognize. Have them generate ideas as to what the object might be used for. Then repeat this with an object with which they would be very familiar. They should find they exhibit functional fixedness for the familiar object.

Further Reading, Media Suggestions, and Teaching Aids

1. **Remote Associates Test: http://socrates.berkeley.edu/~kihlstrm/RATest.htm**

   This site provides a listing of items (along with solutions and difficulty level) from the Remote Associates Test, a classic example of implicit problem-solving.

2. **Tower of Hanoi: http://www.mazeworks.com/hanoi/index.htm**

This website contains an interactive version of the Tower of Hanoi problem. The number of discs can be adjusted and performance can be timed.

3. **Koblich, G., Ohlsson, S., Haider, & H., Rhenius, D. 1999. Constraint relaxation and chunk decomposition in insight problem solving. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 25, 1534–1555**.

   The authors introduce the research supporting representational change theory. Four experiments were conducted using match stick mathematics problems. Findings suggest that constraint relaxation and chunk decompensation are more effective explanations of insight than alternative theories.

4. **The Candle Problem:**
   https://www.youtube.com/watch?v=PUKe55aZaYQ&feature=youtu.be

   This video covers the candle problem as well as a number of others.

5. **Are Crows the Ultimate Problem Solvers? Inside the Animal Mind (BBC):**
   https://www.youtube.com/watch?v=cbSu2PXOTOc

   This video presents a crow with a complex puzzle that needs to be solved in order to retrieve a reward.

Homework or Study Questions

1. **How are feeling of warmth and feeling of knowing different with regard to non-insight and insight problems?**

   A greater feeling of warmth is elicited as the individual gets closer to a solution to a non-insight problem. There is unlikely to be a feeling of warmth for insight problems as they do not involve a step by step progression. Feeling of knowing is a self-indication of how likely the individual is to be able to solve a problem before actually attempting to solve it. For non-insight problems, people are typically quite accurate in their feeling of knowing predictions. Although feelings of knowing exist for insight problems, people tend to be inaccurate in their predictions. Unlike non-insight problems, insight problems require the use of knowledge that the individual may not be aware they possess.

2. **Describe two approaches to the study of insight problems: the progress monitoring theory and the representational change theory.**

   According to the progress monitoring theory, people favour the most straightforward route to a solution. An insight problem, though, cannot be solved by the most straightforward route. When this approach fails, people consider alternate possibilities and are amenable to the insight required to reach a solution.

   The representational change theory proposes that a change in the representation of the problem is necessary for insight. To achieve a representational change, it may be necessary to eliminate a solution-blocking assumption (constraint relaxation) or to separate the problem into independently-considered chunks (chunk decomposition).

3. **How is the Luchins' "water jar problem" a demonstration of an Einstellung effect?**

   In the water jar problem, there are three jars (A, B, and C), each with a different capacity. The goal is to use the jars to obtain a target amount by adding and subtracting. For the first set of problems, the target could be achieved using the equation, B – A – 2C. For a subsequent problem, this equation can be used but it is an unnecessarily complicated solution. Participants, having developed an Einstellung, tended to use it anyway.

4. **How does the General Problem Solver (GPS) use means–end analysis to solve the Tower of Hanoi problem?**

   Means–end analysis is a problem-solving heuristic that involves systematically reducing differences between current and goal states. GPS creates a goal stack to analyze the problem, with the final goal placed at the bottom of the stack. Subgoals are piled on top of the final goal and are reached one by one. Production rules, consisting of a condition and an action, are used to reach subgoals until the problem is solved.

5. **The nine-dot problem has been described as one of the most difficult insight problems. What is it about this problem that makes it difficult to solve?**

   People have difficulty solving this problem because they make the assumption that all their lines must be drawn within the square. They become fixated by this assumption and therefore, cannot see the solution.

6. **Summarize the involvement of the dorsolateral prefrontal cortex in solving the water jar problem.**

   Intact left dorsolateral prefrontal cortex function is crucial for performance on the water jar problem as it allows the person to inhibit obvious moves in order to make counterintuitive ones.

7. **Describe the different components of the problem space.**

   The problem space includes all the steps involved in solving a problem, including the goal to be reached and the various ways of transforming the given situation into the solution. This could also include subgoals.

8. **Review the effect of practice on problem-solving.**

   Practice in problem-solving can lead to a number of errors such as negative transfer where the person tends to respond with a previously learned rule sequence, even if it is not appropriate. Additionally, an overlearned response sequence can lead to a strong but wrong routine.

9. **Describe the effect of sleep on insight problem-solving.**

Wagner et al found that 59% of participants who slept were able to produce insightful solutions to problems when tested. This was compared to 22% of participants who had not slept.

Suggestions for Research Paper Topics

1. Einstellung is a German word meaning "attitude." Is there any evidence for cultural differences in flexibility/rigidity when it comes to problem-solving?

2. It has been suggested that young children tend to be less functionally fixed than older children. What other evidence can you find for group differences in functional fixedness? For example, are experts more or less functionally fixed than novices?

3. Where *is* insight in the brain? Can it really be said that insight resides anywhere? Review the literature regarding the involvement of the anterior cingulate cortex and the hippocampus. Can you find any case studies of patients with damage to those areas and a resulting deficit in problem-solving?

4. Conduct a literature search on the Zeigarnik effect. Is it correlated with particular personality factors? Is it correlated with career success?

5. Examine the evidence supporting or contradicting Kohler's observation of insight in primates.

6. Some species of primates exhibit excellent skill for developing and using tools. Do these primates show functional fixedness?

7. One of the criticisms of laboratory experiments is that the findings do not always generalize to real-world situations. One area of problem-solving that supports this criticism is with analogical problems. Review the literature on the analogical paradox. What factors influence this paradox?

8. Explore cultural differences that might exist in solving specific types of problems. Why might these differences exist?

9. Based on the topics covered in the chapter, what advice would you give to a student preparing to write an exam that would require solving complex problems?