

CS 2104
Introduction to Problem Solving

Heuristics for Problem Solving: Externalizing



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Heuristics for Problem Solving (in the small)

- Heuristic: A rule of thumb, a way of doing things that might or might not work
- Goal of problem-solving heuristics: Help us to overcome our own limitations
 - Motivation
 - Working memory
 - Insight
 - Process
 - Emotions

The Mind

Three things that your mind does:

1. Receives/processes external information
2. “Displays” stored information
3. Manipulates information

It tends not to do more than one of these well at a time.

Limited “bandwidth” of attention

Externalizing

- After motivation and mental attitude, the most important limitation on your ability to solve problems is biological:
 - Working memory is 7 ± 2 “pieces of information.”
- You can't change this biological fact. All you can do is take advantage of your environment to get around it.
- That means, you must put things into your environment to manipulate them.
- Externalize: write things down, manipulate aspects of the problem (correct representation).

Example

A rubber ball has the property that, on any bounce, it returns to one-third of the height from which it just fell. Suppose the ball is dropped from 108 ft. How far has the ball traveled the fourth time it hits the ground?

Externalizing

- In this example, drawing the picture left your mind free to concentrate on problem solving.
- Not drawing is probably hopeless, too much to keep track of.
- To be effective, the drawing needs to be set up right – a diagram of some sort makes a big difference.

Example

- Remember these numbers: 483 and 627
- Now, look away and multiply them in your head.

Example

A rectangular board is sawed into two pieces by a straight cut across its width. The larger piece is twice the length of the smaller piece. This smaller piece is cut again into two parts, one three times the length of the other. You now have three pieces of board. The smallest piece is a 7-inch square. What was the original area of the surface of the board?

Straight-line Problems

Problems along one dimension: distance, money, etc.

Organizing the information along a straight line makes the problem easier to solve.

John has a pretty good salary. In fact if the salary of his older brother, Bob, were suddenly doubled, John would make only 100 dollars less than Bob. Bob's current salary is 50 dollars more than that of the youngest brother, Phil. John makes 600 dollars per week. What is Phil's salary?

Draw a line and put the information onto the line.

A Logic Problem

Tom, Dick, Harry, and Al are married to May, Jane, Sue, and Bea, though not necessarily in that order. Jane, who is Dick's sister, has five children. Tom and his wife want to wait a few more years before starting a family. Tom has never introduced his wife to Sue, who is carrying on an extramarital affair with Dick. (May is considering telling Dick's wife about it.) Dick and Harry, by the way, are twin brothers. Who is married to whom?

Matrix Problems

- How can we organize this information?
 - Matrix works well in this case
- Can work on one row/column (e.g., figure out who X is married to.
- Can work one fact at a time.
 - In this case, we will get pretty far. But we'll be left with a 2 by 2 box for Harry/Al and Jane/Sue. How do we break it?
 - We need to relate two facts to infer that Dick, Harry, Jane are all siblings.

Example

- Three boys, Joey, Jimmy, and Pete, have between them nine quarters and a total of \$2.55 in quarters and nickels. Joey has three nickels, and Jimmy has the same number of quarters. Jimmy has one coin more than Joey, who has four coins. How many nickels each do Jimmy and Pete have?

Hand-Shaking Problem

An anthropologist and her husband attended a party with four other married couples. Whenever two people shook hands, the woman recorded that each of the two people shook hands one time. In that way, for all of them (including herself and her husband), she obtained the total number of times that each person shook hands. She noted that one didn't shake hands with one's own spouse. Then she observed: If she didn't count herself, the other nine people all shook hands a different number of times. That is, one person didn't shake any hands, one shook only once, up to one shaking hands of all eight of the others.

Q: How many times did her husband shake hands?

Hand-Shaking Problem

- This one is difficult. Its tough to engage.
- But there are things that can be figured out. You need to play with it awhile.
- Hint: Can the anthropologist's husband be the one who shook hands 8 times?
- Bigger hint: Draw out a table!

Let's arbitrarily let couple #5 be the **anthropologist** and her **husband**.

	C1H1	C1W1	C2H2	C2W2	C3H3	C3W3	C4H4	C4W4	C5H5	C5W5
C1H1	X	X								
C1W1	X	X								
C2H2			X	X						
C2W2			X	X						
C3H3					X	X				
C3W3					X	X				
C4H4							X	X		
C4W4							X	X		
C5H5									X	X
C5W5									X	X

No one shakes hands with his/her spouse or herself/himself., so mark those cells with X's.

Let's arbitrarily let couple #5 be the **anthropologist** and her **husband**.

	C1H1	C1W1	C2H2	C2W2	C3H3	C3W3	C4H4	C4W4	C5H5	C5W5	
C1H1	X	X	v	v	v	v	v	v	v	v	8
C1W1	X	X	●	●	●	●	●	●	●	●	0
C2H2	v	●	X	X							
C2W2	v	●	X	X							
C3H3	v	●			X	X					
C3W3	v	●			X	X					
C4H4	v	●					X	X			
C4W4	v	●					X	X			
C5H5	v	●							X	X	
C5W5	v	●							X	X	

Try making C2H2 be the person who shook hands seven times, and continue on.

Function-Generating Problems

A gambler bets 3 dollars on the first spin of a roulette wheel. Each time he loses he doubles his bet. He has lost n times in a row. How do we express A_{n+1} , the amount of his bet for the next (the $n+1$) spin?

- Perhaps you can do this in your head, but making a table will illustrate the process.

A Table

# of spins	Amount bet, A
1	3
2	$3 * 2 = 6$
3	$3 * 2^2 = 12$
4	$3 * 2^3 = 24$
5	$3 * 2^4 = 48$

Pattern: $A_{n+1} = 3 * 2^n$

Handball Tournament Problem

- The contest follows “knockout” rules: in the first round each contestant will be randomly paired with another; each pair plays one game; the loser is permanently out of the contest. (if an odd number of players entered the contest, then, at first round, one person “draw a bye”, that is, doesn’t play until the second round.) At the second round, the winners, and the person who had drawn a bye, are randomly paired. The process repeats for as many rounds as needed until only one player remains.
- How many games must be played?
- Solve by building up a table of values in the series.

Induction Proofs

- Ideally, table generating can then get enough insight to make a good guess about the conclusion of a series.
- Later you will formalize this by using induction to prove that your guesses are correct.

(Aside: Why should CS students take a math minor? Not because they need the math itself. Rather, because it teaches you to think straight.)

Visualize

Reading Comprehension

- This is critical to our success, both as a student and in later life.
- So it benefits us to do better at it.
- As a reader, visualizing the material is the most powerful way to “see” what is being communicated.

Example

- A seashore is a better place than the street. At first it is better to run than to walk. You may have to try several times. It takes some skill but it's easy to learn. Even young children can have fun.
- Once successful, complications are minimal. Birds seldom get too close. Too many people doing the same thing, however, can cause problems. One needs lots of room. Beware of rain; it ruins everything. If there are no complications, it can be very peaceful. A rock will serve as an anchor. If things break loose from it, however, you will not get a second chance.

Context

- The passage probably doesn't make sense until you know what it is about (flying kites). Then you can visualize it.
- If you were given a test on your comprehension of the passage, the result would depend greatly on whether you knew the context or not.

Visualization and Comprehension

Even when discussing numeric problems, “seeing” the relationship is important.

As Jack walked to town he met three beggars. He gave them each 4 dollars. That left only 2 dollars for himself, but he didn't care. He was happy.

How much money did Jack start with?

Example

- Jack stuffed the 16 dollars into his wallet and decided to go to town to buy a toy. He left his house and walked a half-mile when he met the beggar. The man seemed so poor that Jack gave him half the money in his wallet.
- About every half-mile he was approached by another beggar, each more wretched than the last. He met the third one just at the outskirts of town. Jack gave to each one half the money in his wallet. As he left the third beggar and entered the town he saw that he had only 2 dollars left but he didn't care. He was happy.

Passage Comprehension

- Eighty students served in this experiment on problem solving. Each student received one of four similar problems (referred to as problems A, B, C, and D). Since we were interested in the effects of distraction, half the students worked on their problem with music playing; half worked in silence. The ten students in each condition consisted of one eight-year-old, four ten-year-olds, and five twelve-year-old children.

Questions

1. How many conditions were there? What were they?
2. Why does the author refer to ten students?
3. How many ten-year-olds served in this experiment?

The questions are easy... but you might not have gotten the necessary information out of the passage from unguided reading. It is hard to train yourself to pull out all the information without being primed by a question to answer.

A table of information might help.

Another Passage

- Thirty-six students (eighteen males and eighteen females) served in an experiment on problem solving. Each of these students received three problems, A, B, and C.
- Since each subject was receiving all three problems, the sequence of problem presentation was varied. All possible permutations (BCA, CAB, etc.) were used. Three males and three females were assigned to each of the six different sequences.

Questions

- Why were there six different sequences? Could there have been more than this number? What were these six sequences?
- Did the number of students used, thirty six, strike you as unusual? Why did the experiment use such a number instead of a nice, round number like thirty or forty? What other numbers might the experimenter have used?

Step Back...

Q: What is the most important problem that you have to solve over the next few years?

Problem Statement

- Each person will have a slightly different problem statement or emphasis
- The problem is to:
 - Get a degree
 - With the desired GPA
 - With the desired knowledge of the field
 - With the desired knowledge from other fields
 - With desired “other” experiences (academic or otherwise)
 - Without going insane.

How to Succeed as a Student

- Take a “problem solving stance” with this problem of succeeding as a student.
- What are problems that students run into?
- What are strategies for academic success?

Engage the Problem

- Being a student is a job.
 - With all of the professional responsibilities that holding a job implies
 - A full time student has a full time job (typically 40-60 hours/week is expected)
 - To succeed as a student requires applying the same sense of professionalism that you would apply to any other job.

Four Keys to Success

- Learn to network
- Learn to focus
- Learn to present
- Learn to play the game
 - Don't change a winning game, but always change a losing one.

Learn to Network

- The #1 problem for many students is lack of interaction with faculty/staff
 - Not only can they help you academically, they also help you professionally
- #2 problem for many students is lack of interaction with other students in the discipline
 - Build a support environment/community

Learn to Focus: Organization

- Communications/email
- Deadlines in-the-large
 - Degree/semester deadlines
- Deadlines in-the-small
 - Daily/weekly planners
 - To-Do lists
 - Good habits trump good memory

Learn to Focus: Environment

- Doing hard work requires a conducive environment
 - Setting yourself up for success
- Certain types of work don't need full attention
 - Music, etc. might be OK
- Other types of work need complete focus
 - Writing (prose or code), most homework problems, hard debugging.

Persistence vs. Productivity

- Some students just don't work hard enough
- Some students work hard... but don't get good results. Possible causes:
 - Poor networking skills
 - Poor organizational skills
 - Poor working environment

Learn to Present

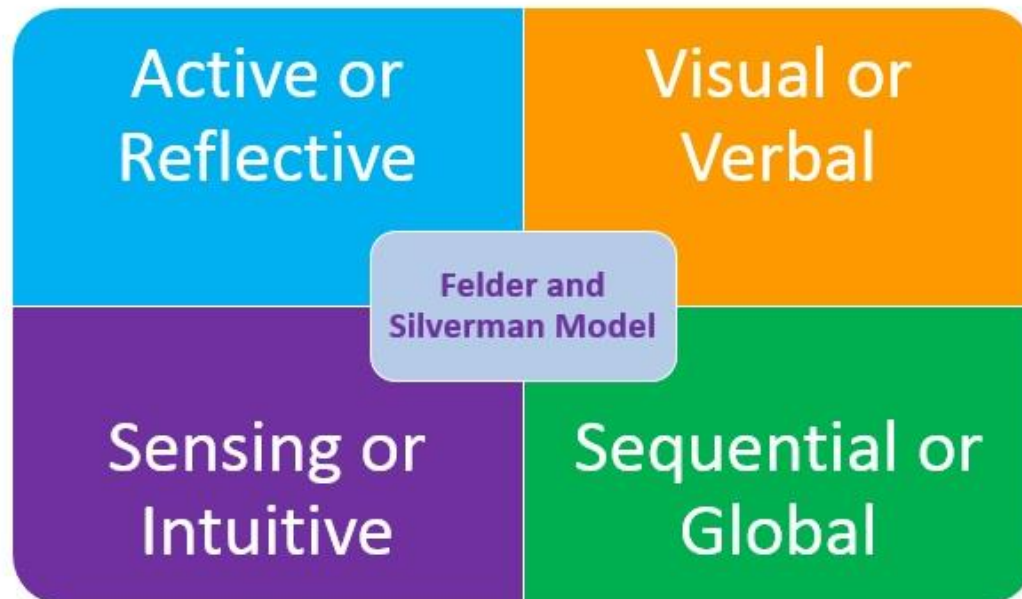
- The primary goal of communication is to invoke the desired response in your audience.
 - Email communications
 - Tests
 - Homework
 - Writing
 - Proof and argument
- We will discuss communication more later in the semester.

Learn to Play the Game

- Being a good student is a (learned) skill, not an (innate) ability
- Get the easy points
 - Never shortchange easy assignments or classes
 - A little investment (or reallocation) of time could raise your overall score
- Learn the testing game
- Learn time management/stress management
- If you need testing time accommodation, don't be shy about getting it.

Change a Losing Game

- Felder & Silverman Learning styles scale
 - What is your preferred approach to learning?
 - Be prepared to adjust to various styles of course
 - Seek adjustment in the course conditions if practical



Resources

- Faculty/staff!!
- Writing Center
- Counseling Center
 - Mental health
 - Eating disorders, substance abuse
 - Stress
 - Career counseling
 - Study skills, etc.

