

PROBLEM SOLVING

PROBLEM SOLVING

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PROBLEM SOLVING
OBJECTIVES and PREREQUISITE SKILLS

OBJECTIVES

After module, students should be able to:

1. Describe problem-solving process
2. Solve problems
3. Critique problem-solving process

**PREREQUISITE SKILLS
TEAMING**

PROBLEM SOLVING
PROBLEM SOLVING STRATEGIES
WHY BOTHER?

- solve problems every day
- real problems have many solutions
- goal to pick good solution
- we can sharpen our problem solving skills
- practice problem solving techniques
- problem solving skills critical to career

PROBLEM SOLVING
PROBLEM SOLVING STRATEGIES
WHY BOTHER?

ABET 2000
CRITERION 3

graduates will have an ability to
identify, formulate and solve
engineering problems

PROBLEM SOLVING
DEFINITIONS OF TERMS

"When I use a word, Humpty Dumpty said in a rather scornful tone, it means just what I choose it to mean -- neither more nor less." (Lewis Carroll, 1896)

- **Exercise solving:** know steps
- **Algorithm:** automatic calculation rules (*good for exercise solving*)
- **Problem solving:** what you do, when you don't know what to do
- **Heuristic:** general strategy (*needed for problem solving*)

PROBLEM SOLVING
the engineering tradition

- students shown how to "solve exercises"
- correct answer presented as algorithm "solution"
- "solution" really based on years of experience
- not how problem "solved" first time

PROBLEM SOLVING
the engineering tradition

- students shown following “model”
 - » linear
 - » leads to the correct answer

PROBLEM SOLVING
the engineering tradition

- define the system
- identify appropriate physical laws
- sketch system
 - » EE circuit diagram
 - » mechanics free-body diagram
 - » thermo control volume
- list known and unknowns
- select model
- compute answer
- check units, "reasonableness" of answer, etc.

PROBLEM SOLVING
the engineering tradition

- true problem solving is
 - » messy
 - » not linear
- the following is one example

PROBLEM SOLVING
BODNER'S “ANARCHISTIC”
MODEL OF PROBLEM SOLVING(1/3)

**BODNER'S “ANARCHISTIC”
MODEL OF PROBLEM SOLVING**

**A
MORE REALISTIC
MODEL**

PROBLEM SOLVING
BODNER'S “ANARCHISTIC”
MODEL OF PROBLEM SOLVING(2/3)

1. Read The Problem (RTP).
2. Now, RTP again.
3. Write down what is, hopefully, relevant information.
4. Draw a picture, make a list, write an equation or formula to help you begin to understand the problem.
5. Try something ...this may be solution of subexercises.
6. See where this gets you.
7. Draw another picture/list, or write additional equations.
8. Try something else.
9. See where this gets you.
10. RTP.

PROBLEM SOLVING
BODNER'S “ANARCHISTIC”
MODEL OF PROBLEM SOLVING(3/3)

11. Draw another sketch, etc .
12. Try something else.
14. See where this gets you.
15. Test intermediate results.
16. RTP again.
17. Get frustrated.
18. Write down an answer (any answer).
19. Check the answer.
20. Start over if you have to, celebrate if you don't.

PROBLEM SOLVING
SESSION 1
A/CL/TEAMING EXERCISE

- Select Teams
- half of teams write: CHARACTERISTICS OF EFFECTIVE PROBLEM SOLVER
- half of teams write: CHARACTERISTICS OF INEFFECTIVE PROBLEM SOLVER
- Teams present results

PROBLEM SOLVING
CHARACTERISTICS OF EFFECTIVE
PROBLEM SOLVER

● read the problem(RTP)	● is willing to do multiple step problems
● RTP several times	● does not give up
● Sketches & writes equations, etc. down	● Don' t jump to conclusions
● Redescribe the problem	● Break into subproblems
● Use heuristics	● Start at a point they first understand
● monitors progress	● Use key concepts as building blocks
● Check and recheck.	
● Believe can solve problem	

PROBLEM SOLVING
CHARACTERISTICS OF
INEFFECTIVE PROBLEM SOLVER

● Give up easily	● Don't know where to start
● Lie back and hope for solution	● Fail to identify key concepts
● Unable to redescribe problem	● Guess
● Jump to conclusions	● Quit
● Do not check	● Use no special format
● Don't break the problem apart	

PROBLEM SOLVING
Assignment 1
CALCULATING PERCENTAGES

THE FACTS:

In 1980, the defense budget of a certain country was \$30 million out of a total budget of \$500 million. In 1981, the defense budget of that same country was \$35 million out of a total budget of \$605 million. The country's inflation rate for that one-year period was 10 %.

THE TASKS:

Use the facts to argue that the defense budget

1. increased from 1980 to 1981.
2. declined from 1980 to 1981.

PROBLEM SOLVING
SESSION 1
Assignment 1

- half teams solve:
 1. increased from 1980 to 1981
- half teams solve:
 2. declined from 1980 to 1981
- IN SESSION 2: present solution 1 and 2

PROBLEM SOLVING
Creative problem solving(1/4)

creative problem solving adds two components

1. generating creative ideas
2. improving ideas into better solutions

PROBLEM SOLVING

Creative problem solving(2/4)

divergent thinking
 search and stretch our thinking
 consider many possibilities and directions

convergent thinking
 screen and select
 choose most promising possibilities

PROBLEM SOLVING

Creative problem solving(3/4)

- collect, analyze and condense data
 - » convergent thinking to set positive goal
- brainstorm
 - » divergent thinking to get "wild and crazy" ideas
- decision making
 - » divergent thinking to make constructive improvements
 - » convergent thinking to get practical solutions
 - » selection of the best idea for implementation
- Implementation
 - » also requires creative problem solving
 - » involves divergent and convergent thinking

PROBLEM SOLVING

Creative problem solving(4/4)

- Creative problem solving is thorough and takes time
- The quality of ideas improves if the mind is given enough time to incubate and think through the problem
- Each step of the creative problem-solving process can be likened to a tool box--many different techniques are available during each phase to enhance the process and achieve an optimum result

PROBLEM SOLVING

END
 OF
 SESSION 1

PROBLEM SOLVING

START
 OF
 SESSION 2

PROBLEM SOLVING

SESSION 2

Assignment 1
 present solution 1 and 2

PROBLEM SOLVING
SESSION 2
QUIZ 1

WRITE:

3 CHARACTERISTICS
OF
EFFECTIVE PROBLEM SOLVER

PROBLEM SOLVING
CREATIVE PROBLEM SOLVING
HEURISTIC

I can

- Define the Problem
- Generate Solutions
- Decide the Course of Action
- Implement the Solution
- Evaluate the Solution

PROBLEM SOLVING

1. Define: Define the Problem

- a. Identify unknown or stated objective
- b. Isolate system, identify knowns and unknowns
inputs, laws, assumptions, criteria, and constraints
- c. List inferred constraints and criteria
- d. Identify stated criteria

PROBLEM SOLVING
1. Define: Define the Problem
WHAT'S THE REAL PROBLEM?(1/2)

THE CASE OF THE HUNGRY GRIZZLY BEAR
OR
AN EXERCISE IN DEFINING THE "REAL PROBLEM"

A student and his professor are backpacking in Alaska when, from a distance, a grizzly bear starts to chase them. They both start running, but it's clear that eventually the Bear will catch up with them. The student takes off his backpack, gets his running shoes out and starts putting them on. His professor says, "You can't outrun the bear, even in running shoes!"

PROBLEM SOLVING
1. Define: Define the Problem
WHAT'S THE REAL PROBLEM?(2/2)

The student replies, "I don't need to outrun the bear; I only need to outrun you!" The student realized that the bear would be satisfied when he caught one person; consequently the student defined the real problem as outrunning the professor rather than the bear. This example illustrates a very important point: problem definition. Problem definition is a common but difficult task because true problems are often disguised in a variety of ways.

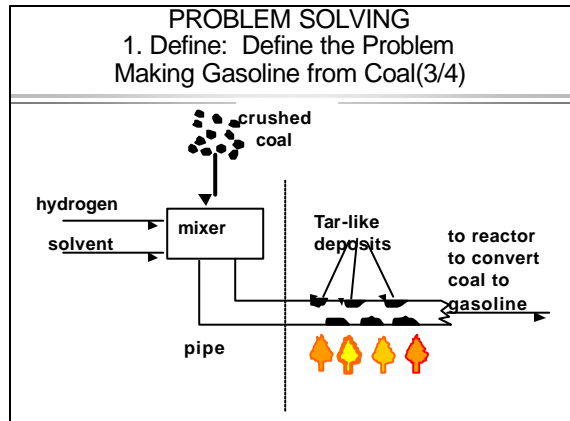
PROBLEM SOLVING
1. Define: Define the Problem
Making Gasoline from Coal(1/4)

- industrial problem incorrectly defined
- problem thought to be correctly defined
- easy to fall into trap of solving wrong problem
- millions of dollars wasted
- problem-solving heuristic finds true problem

PROBLEM SOLVING
1. Define: Define the Problem
Making Gasoline from Coal(2/4)

major oil company process

- grind coal
- mix with solvent and hydrogen
- heat in furnace
- furnace plugs with tar-like material



PROBLEM SOLVING
1. Define: Define the Problem
Making Gasoline from Coal(4/4)

- research group instructions
 - » "Improve solvent to prevent deposits"
- major research program initiated
 - » 1.5 years later ... improved solvent not found
- real problem
 - » coal and solvent react to form tar
- simple solution
 - » small furnace pipe ... gives high velocity
 - little reaction time
 - particles scour pipe wall clean

PROBLEM SOLVING

2. Explore: Generate Solutions

- a. identify tentative relationships
- b. recall past related problems
- c. hypothesize, visualize, idealize
- d. discover real problem and constraints
- e. consider short-time, long-time implications
- f. identify meaningful criteria
- g. choose basis
- h. collect missing resources
- i. guess answer
- j. simplify & get answer
- k. solve part of problem

PROBLEM SOLVING
2. Explore: Generate Solutions
The Case of the Putrid Pond(1/3)

- large waste treatment sludge pond
 - » (500,000 square feet ~10 football fields)
- liquid in pond is viscous and sticky
- unwanted floating objects appear on pond
 - » (dead animals, branches, etc.)
- can not cover pond
- devise ways to solve problem

PROBLEM SOLVING
2. Explore: Generate Solutions
The Case of the Putrid Pond(2/3)

Brainstorming

- Generate as many solutions as possible--quantity counts.
- Wild ideas encouraged
- No criticism allowed--judgement deferred

PROBLEM SOLVING

END
OF
SESSION 2

PROBLEM SOLVING

START
OF
SESSION 3

PROBLEM SOLVING
SESSION 3
Assignment 2

present
rubric for evaluating
problem-solving process

PROBLEM SOLVING

1. Rubric for evaluating problem-solving process

Each yes is worth 15 points. As the team solved the problem did they:

	YES	NO	SCORE	POINTS
RTP more than once?	—	—	EXCELLENT	75 or better
Draw sketches(s)?	—	—	GOOD	60
Write things down?	—	—	ADEQUATE	45
Restate the problem?	—	—	NEED IMPROVEMENT	30
Stay on the topic?	—	—		
Monitor progress?	—	—		
Evaluate trial solutions?	—	—		
SUM	—	—		

NOTES

1. What one thing could the team do better to improve their problem solving skills?
2. What one thing, that the team did, was most positive?

PROBLEM SOLVING
SESSION 3
QUIZ 2

WRITE:
3 CHARACTERISTICS
OF
EFFECTIVE BRAINSTORMING

PROBLEM SOLVING

3. Plan: Decide the Course of Action

- a. Identify problem type, select among heuristics
- b. Generate alternative ways to achieve objective
- c. Map out the solution procedure to be used
- d. Assemble resources needed

PROBLEM SOLVING
3. Plan: Decide the Course of Action
NUMBERS(4/8)

Idea evaluation:

- no challenge(or fun) to 4, 5 or 6
- 2 or 3 fun ... not practical
- leaves 1 and 7

Idea judgment:

- option 1
 - » gives correct solution
 - » involves unnecessary work
- option 7
 - » gives correct solution
 - » easiest

PROBLEM SOLVING
4. Act: Implement the Solution

a. Follow procedure; use resources

b. Evaluate and compare alternatives

c. Eliminate unsuitable alternatives

d. Select best alternative

PROBLEM SOLVING
4. Act: Implement the Solution
NUMBERS(5/8)

●3-column table of integers for x , $3x$, $x+3x$, where $x=1, 2, 3 \dots$

●When third column is 24 ... the answer

x	$3x$	$x + 3x$
0	0	0
1	3	4
2	6	8
3	9	12
4	12	16
5	15	20
6	18	24
7	21	28
8	24	32

Implementation of Idea 1

●by inspection ... numbers are 6 and 18

●needed guess for x

●more complicated problem ... bad guess wastes time and effort

PROBLEM SOLVING
4. Act: Implement the Solution
NUMBERS(6/8)

●solve equations

- $x + y = 24$
- $y = 3x$

Implementation of Idea 7

in two ways:

(a) plotting

(b) direct substitution

PROBLEM SOLVING
4. Act: Implement the Solution
NUMBERS(7/8)

(a) plotting

- Intersection is solution
- due to inaccuracy
 - » may read $x \approx 6.1$
 - » may read $y \approx 17.9$
- must be integers
- choose whole numbers
 - » 6
 - » 18

PROBLEM SOLVING
4. Act: Implement the Solution
NUMBERS(8/8)

(b) direct substitution

- substitute $y = 3x$ into $x + y = 24$
- get $x + 3x = 24$
 - » or $4x = 24$
 - » or $x = 6$
- easy by hand
- answer tells us
 - »first integer is 6
 - »second integer is 18
- cats idea is visualization of this

PROBLEM SOLVING
5. Reflect: Evaluate the Solution

a. Check that the solution is blunder-free.

b. Check reasonableness of results.

c. Check procedure and logic of your arguments.

d. Communicate results.

PROBLEM SOLVING
5. Reflect: Evaluate the Solution
THE TRUCK PROBLEM(1/3)

- You own delivery company
- fixed costs of operating truck(cost=C)
 - » gasoline, taxes, insurance (on the rig, the driver, and the cargo), maintenance, union dues (which you are paying for the drivers), road tolls
 - » fixed costs average 50 cents/mile independent of speed
- wear and tear at higher speeds
 - » cost equal to speed times 1/8 cents a mile (per mph)
 - » example, 60-mile trip, average speed of 48 mph, C=\$3.60
- labor cost inversely related to the speed, drivers paid \$10/hour
- find most economical speed(S) in mph to operate truck

PROBLEM SOLVING
SESSION 3
A/CL/TEAMING EXERCISE

1/2 teams solve:
THE TRUCK PROBLEM

1/2 teams critique solvers with:
Rubric for evaluating problem-solving process

PROBLEM SOLVING
5. Reflect: Evaluate the Solution
THE TRUCK PROBLEM(2/3)

- solve the problem in mathematical terms
- minimize C (cost) with respect to S (speed)
- differentiate C with respect to S
- solve for S when derivative = 0
- $dC/dS = 0$
- costs = $50 + S/8 + 1000/S$ in cents/mile
- $dC/dS = 1/8 - 1000/S^2 = 0$
- S = 90 MPH

PROBLEM SOLVING
5. Reflect: Evaluate the Solution
THE TRUCK PROBLEM(1/3)

- numerical solution is 90 mph!
- is this a reasonable answer?
- are there factors not in model?
 - » speeding tickets above speed limit
 - » chance of accidents at higher speed
- mathematically correct answer makes no sense
- how much "saved" going from 65 to 90 mph?
 - » Costs(65) = 73.3
 - » Costs(90) = 72.4
- 1 cent ... insignificant against increased risks

PROBLEM SOLVING

END
OF
SESSION 3

**PROBLEM SOLVING
INSTRUCTION OUTLINE
SESSION 1**

1. Introduction (10 minutes – 8 slides)
2. TEAM EXERCISE (15 minutes – 1 slide)
3. REVIEW TEAM EXERCISE (10 minutes – 2 slides)
4. ENGINEERING PROBLEM SOLVING (10 minutes – 3 slides)
5. Assignment 1 (5 minutes – 2 slides)

**PROBLEM SOLVING
INSTRUCTION OUTLINE
SESSION 2**

1. assignment 1 solution (5 minutes – 1 slide)
2. Quiz 1 (5 minutes – 1 slide)
3. CREATIVE PROBLEM SOLVING (1 minute – 1 slide)
 - A. 1. Define (1 minute – 1 slide)
 - B. HUNGRY BEAR (3 minutes– 2 slides)
 - C. gas from coal (5 minutes– 4 slides)
2. Explore (5 minutes – 2 slides)
- E. Putrid Pond (5 minutes – 3 slides)
- F. A/CL/TEAMING EXERCISE (5 minutes – 1 slide)
- G. NUMBERS (10 minutes – 3 slides)
4. Assignment 2 (1 minute – 1 slide)
 - A. 1. Rubric for problem-solving (2 minutes – 1 slide)

**PROBLEM SOLVING
INSTRUCTION OUTLINE
SESSION 3**

1. Quiz 2 (5 minutes – 1 slide)
2. Plan: Decide the Course of Action (2 minutes – 1 slide)
3. NUMBERS (3 minutes – 1 slide)
4. 4. Act: Implement the Solution (5 minutes – 1 slide)
5. NUMBERS (10 minutes – 4 slides)
6. Reflect: Evaluate the Solution (5 minutes – 1 slide)
7. THE TRUCK PROBLEM (5 minutes – 3 slides)
8. A/CL/TEAMING EXERCISE (15 minutes – 1 slide)