Chapter 8

Problem Solving

Problem Solving

- Engineers solve problems and make things.
- Problem solving requires many tools, techniques, and skills.
- Keep adding to your toolbox as you progress through your career.

Analytic Problem Solving

- Analysis refers to the set of tools an engineer employs. Analysis supports design. It is not an end unto itself.
- Different flavors of engineers (mechanical, electrical, etc) have different analytical tools.
- Analysis tools are very important to answer key questions in a design (e.g., will this bolt fail under this expected load?).
- Most engineering courses teach analysis.

Toolbox of Solved Problems

- Many analyses are formalized into specifications and standards.
- A mechanical engineer rarely performs stress analysis on a bolt. S/he picks the standard bolt based on the expected load.
- Once you have worked out an integral, do you work the next integral of the same kind or do you tabulate your answer and reuse your prior work?

Reverse Engineering

- Mechanisms are examples of “solved problems.”
- Reverse engineering refers to taking apart a mechanism and figuring out how it works.
- The more solved problems an engineer understands, the more versatile s/he is.

5 steps to problem solving

- Define the problem
- Gather the facts (state your knowns and unknowns)
- Develop a hypothesis
- Test the hypothesis
- Evaluate the results

Estimate and Verify Accuracy

- In real life, there are no answers in the back of the book.
- After exhaustive effort, you have developed an answer to a problem.
- How accurate is this answer?
- It is usually possible to bound the answer.

Bounding Answers

- Run a simplified analysis with best case and worst case loading conditions.
- Build a simple prototype.
- Solve a simpler problem. For instance, if you want to determine the moment of inertia of a wheel, try a cylinder to get an upper bound.
- Order of magnitude of the solution is very important. (OoM = ballpark)
- At every step of the process, keep asking, is this answer reasonable?

How to determine what to analyze?

- Most engineering curricula teach analysis.
- Historically, engineering firms used to hire rooms of young engineers to perform the same paper analysis.
- Assemble all these solutions and look for the same answers.
- Computer has done away with this approach.
- Engineering curricula are moving towards developing creative engineers.
- The Titanic was fast and agile compared to academia.

Creative Problem Solving

- How to determine what problems to analyze?
- There are infinities of solutions – analysis cannot pick from among them.
- Synthesis allows a creative person to select a promising candidate to pursue.
- Engineering design has more akin with art than with analysis.

Convergence and Divergence

- Divergence – increase the number of candidate solutions
  - Brain-storming
  - Idea-generation (ideation)
- Convergence – remove non-viable solution candidates.
  - Analyze candidate solutions
  - Define quantitative metrics and compare candidate solutions against those metrics

Basadur's Simplex Creative Problem Solving Profile

- Four Quadrants
  - Generating (problem/fact finding)
  - Conceptualizing (abstract thinking)
  - Optimizing (convert ideas to plans)
  - Implementing (make it so)
- Comes with a neat graphic description
- Organizations need to balance

Brain-storming

- Switching on Evaluation tends to switch off Ideation.
- Goal is to search your brain (and others' brains in a group setting) for every possible idea related to a subject
- Use a formal, documented process
- Need a facilitator

Step 2: Activity topic

- The facilitator should describe the topic and context of the brain-storming activity.
- Prior to the session, it is helpful to research the topic. Come prepared.
- The topic should be clearly stated in a concise statement (a thesis).

Step 2. Idea Purge Phase

- In a pre-determined timed period (five minutes should suffice), each person independently writes down every idea related to the topic that s/he can think of.
- Keep it short and sweet. No long descriptions/explanations.
- Auditory thinkers might want to speak into a voice-memo device.
- Write down *everything*

Step 3. Relaxation

- Take a short time to relax (1 minute).
- Talk about anything but the topic under discussion.
- The facilitator may want to engage the group in an unrelated (short) discussion.

Step 4. Idea Purge Part 2

- For a short time (1 minute), write down any new ideas that might occur.
- Tension (Step 2) followed by relaxation (Step 3) followed by tension (Step 4) can shake loose unexpected ideas.

Step 5. Idea Trigger Phase

- The facilitator should go around the room, person by person, and ask them to speak their best idea.
- Anyone else who has that idea should cross it off her/his list.
- Any new ideas that occur during this phase should be written on the list.
- If you don’t have anything new on your list, pass.
- Facilitator will write the ideas (and organize them) until everyone passes.
- This step takes as long as it takes.

Step 6. Compilation Phase

- Compile ideas through group discussion
- Eliminate duplicates
- Eliminate crazy ideas
- Put ideas into categories
- Combine similar ideas into a more refined idea

Why does brain-storming work?

- Tension and relaxation helps the brain be creative.
- Competitiveness in a group setting will get people to put forth their best effort.
- Other people's ideas serve as external stimulus to make new connections.
- Enhancing/polishing someone else's idea generates cooperativeness and facilitates buy-in.