

# “How to Do Research”

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# Sadly...

- Nobody can tell you how to do research.
- It is difficult enough just to define what research is, or define how to “separate the wheat from the chaff”.
  - “I shall not today attempt further to define the kinds of material I understand to be embraced...but I know it when I see it.” - Justice Potter Stewart
- This leads to a process of trial and error.
- It is hard to know if you are making progress or not.
- Known risks: drift and/or discouragement.

# Think big

- “Believe you can change the world.” (HP)
- Every problem is an opportunity: what are the important problems? Where is the “low hanging fruit”?
- What has changed? What opportunities exist that did not exist before?
  - To answer this you must know the state of the art, the old dead ends, and the recent breakthroughs.
- Know the vision (“grandma pitch”) for every problem you work on.
  - “Concepts of operation” (CONOPS).
  - Own the whole problem.
- Are you a cream skimmer or a bottom feeder?

# Start small

- You have to start somewhere.
  - Avoid “Ambition paralysis”.
- What are the key subproblems? Divide and conquer.
  - Use “wishful thinking” to simplify the larger problem.
  - Identify prerequisites to solving the larger problem.
  - Try “brute force” approaches that are simple but deficient in some way, then refine them.
  - Define interactions/interfaces among subproblems.
- Enumerate the alternatives, then prioritize.
  - Know how each subproblem fits into the larger picture.

# Baby Steps

- “Make a contribution every day.” (HP)
- Set goals: “start with the end in mind.”
- Plan first, then execute.
- But: there is no such thing as a perfect plan.
- So iterate: plan-execute-assess-refine.
- Avoid paralysis: the execution is really the most important part.
  - “Don’t get hung up trying to understand everything at the outset.”
  - “The perfect is the enemy of the good.”
  - If you get stuck, try another approach, goal, or subproblem.
  - “Incremental development and progressive refinement.”

# Defining the Problem

- Define the boundaries of your problem carefully.
  - “Nobody will be impressed if you set the bar too low and jump over it. Nobody will be impressed if you set the bar too high and don’t jump over it.” (Dave Redell)
  - Don’t try to “solve the world” or “boil the ocean”.
- Once you can define the problem, you are well on your way to solving it.
- To solve the problem, you may have to redefine it.

# Defining the Solution

- Make the problem concrete.
  - Start with particulars, then generalize.
- Know what makes the problem hard.
  - “Why couldn’t you just...”
- Identify the standard of success.
  - How will you know when you are done?
  - How to distinguish a good solution from a less-good solution?

# Divide and conquer

- How good a solution do you need for each subproblem? Can you “plug in” a better solution later?
- Strive for the simplest solution to each subproblem, and evaluate the importance of refining it.
  - Avoid the “computer bum” pitfall.
    - Abstraction is a means, not an end.
  - Know what you are doing and why.



# Assemble the tools

- Think about the appropriate methodology.
  - observe, build-and-measure, simulate, model?
- Don't reinvent the wheel: use tools that are lying around.
- What tools have others used on similar problems?

# Communicate

- Generate intermediate outputs.
  - “Stable intermediates” generate “points of accomplishment”: success breeds success.
  - “Writing is nature’s way of showing us how fuzzy our thinking is.”
- Write often to organize your thoughts and “communicate to your future self”.
- Stimulate others to think about your problem.
- Ask for assessment of your outputs!
- Listen: good fortune favors the prepared mind.

# “Stable Intermediates”

- Solved subproblems
- Spin-off problems
- Problem definitions and alternatives
- Taxonomy of previous approaches
- Paths Not Taken
- New Tools and methodologies
- New Metrics
- New data sets

# The Big Picture

- “Strive for independence.”
- You can run but you can’t hide.
- Never get stuck: generate alternatives and pick one.
- Never ask: “What should I do?”
- Balance risk and reward: never give up, but find the most productive path and work on that.
- Know when to declare victory.
- Know when to cut your losses.
- Do what you love; love what you do.