

“Meta” Guidelines for Research

Vyas Sekar



Why are we here: "Meta" research

Intangible part of the research and design process:

- Choosing problems to work on
- Problem formulation
- Tackle problems the "right" way
- How can we be more effective in communicating our results

I wish I was more efficient and knew this sooner 😊

Pop Quiz: Do you know these people?



Grace Hopper



Barbara Liskov



**The most dangerous phrase in the language is,
'We've always done it this way.'**

The question of how you know what's worth working on and what's not separates someone who's going to be really good at research and someone's who's not. There's no prescription."

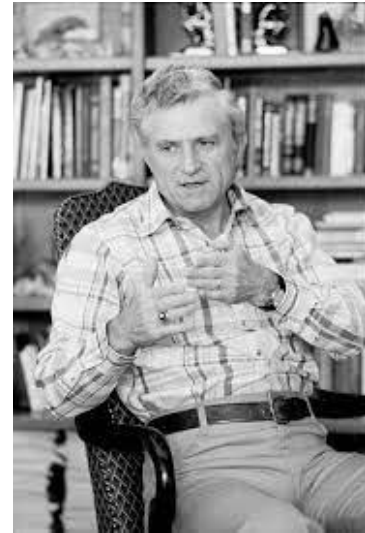
Pop Quiz: Do you know these people?



George Heilmeier



George Polya



Gene Amdahl

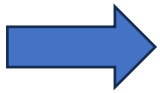


Herbert Simon

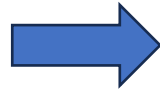
Meta Process for “Research”



Articulate
the
Goals



Identify the
“elephant”
in the room



Formulate,
Solve,
Refine



Articulate
The
Idea!

Heilmeier's Questions

- What are you trying to do? Articulate your objectives using absolutely no jargon.
- How is it done today, and what are the limits of current practice?
- What is new in your approach and why do you think it will be successful?
- Who cares? If you are successful, what difference will it make?
- What are the risks?
- How much will it cost?
- How long will it take?
- What are the mid-term and final “exams” to check for success?

Part 1: Heilmeier Key Takeaways

- Before embarking on a research project ask the Heilmeier questions
- Periodically revisit
- Pivot if evidence suggests otherwise!

Aside: How do you pick problems?

Problem Selection Advice



Embrace the randomness!

Look for pain points and serendipitous opportunities

Collaborate (benefit from awesomeness of other people 😊)

Look at the “world”, Talk to people, Build upon earlier stuff

Process

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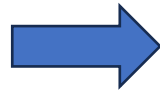
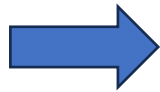


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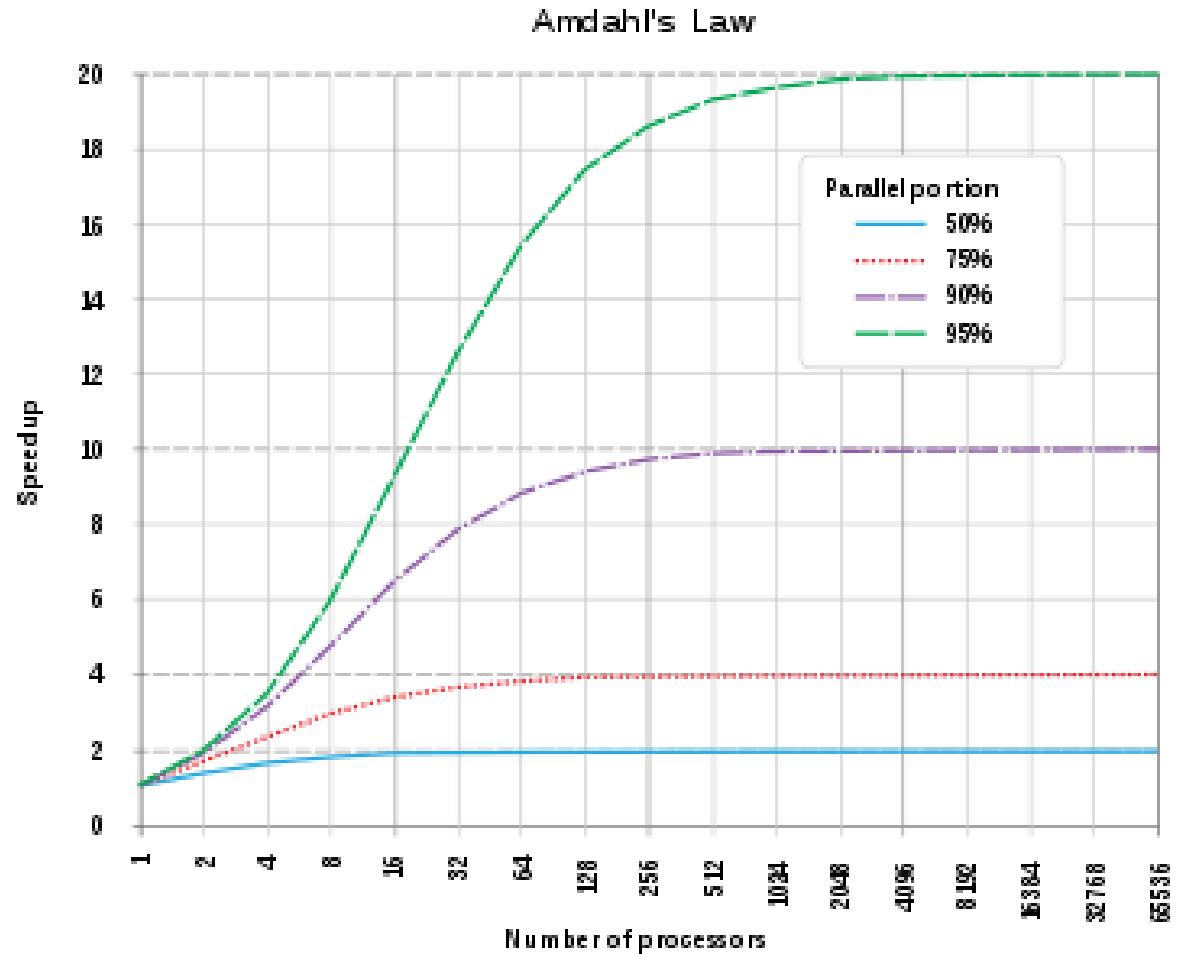


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Amdahl's Law

"the overall performance improvement gained by optimizing a single part of a system is limited by the fraction of time that the improved part is actually used"



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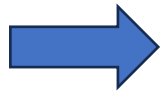


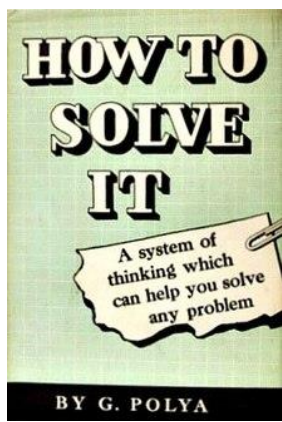
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Understand the problem

- What are you asked to find or show?
- Can you restate the problem in your own words?
- Can you think of a picture or a diagram that might help you understand the problem?
- Is there enough information to enable you to find a solution?
- Do you understand all the words used in stating the problem?
- Do you need to ask a question to get the answer?

Devise a Plan of Attack



Heuristic	Informal Description
Analogy	Can you find a problem analogous to your problem and solve that?
Auxiliary Elements	Can you add some new element to your problem to get closer to a solution?
Generalization	Can you find a problem more general than your problem?
Induction	Can you solve your problem by deriving a generalization from some examples?
Variation of the Problem	Can you vary or change your problem to create a new problem (or set of problems) whose solution(s) will help you solve your original problem?
Auxiliary Problem	Can you find a subproblem or side problem whose solution will help you solve your problem?
Here is a problem related to yours and solved before	Can you find a problem related to yours that has already been solved and use that to solve your problem?
Specialization	Can you find a problem more specialized?
Decomposing and Recombining	Can you decompose the problem and "recombine its elements in some new manner"?
Working backward	Can you start with the goal and work backwards to something you already know?
Draw a Figure	Can you draw a picture of the problem?



Carry out the Plan

- Persist with the plan that you have chosen.
- If it continues not to work, discard it and choose another.
 - Fail Early 😊

Review/Extend

- Reflect
- Post Mortem
- Find opportunities to improve

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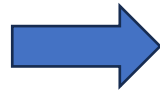
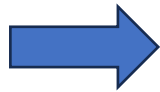


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In the words of Simon

In an information-rich world, the wealth of information means a dearth of something else: a scarcity of whatever it is that information consumes.

What information consumes is rather obvious: it consumes the attention of its recipients.

Hence a wealth of information creates a poverty of attention and a need to allocate that attention efficiently among the overabundance of information sources that might consume it

Putting it together: Process

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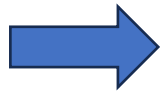


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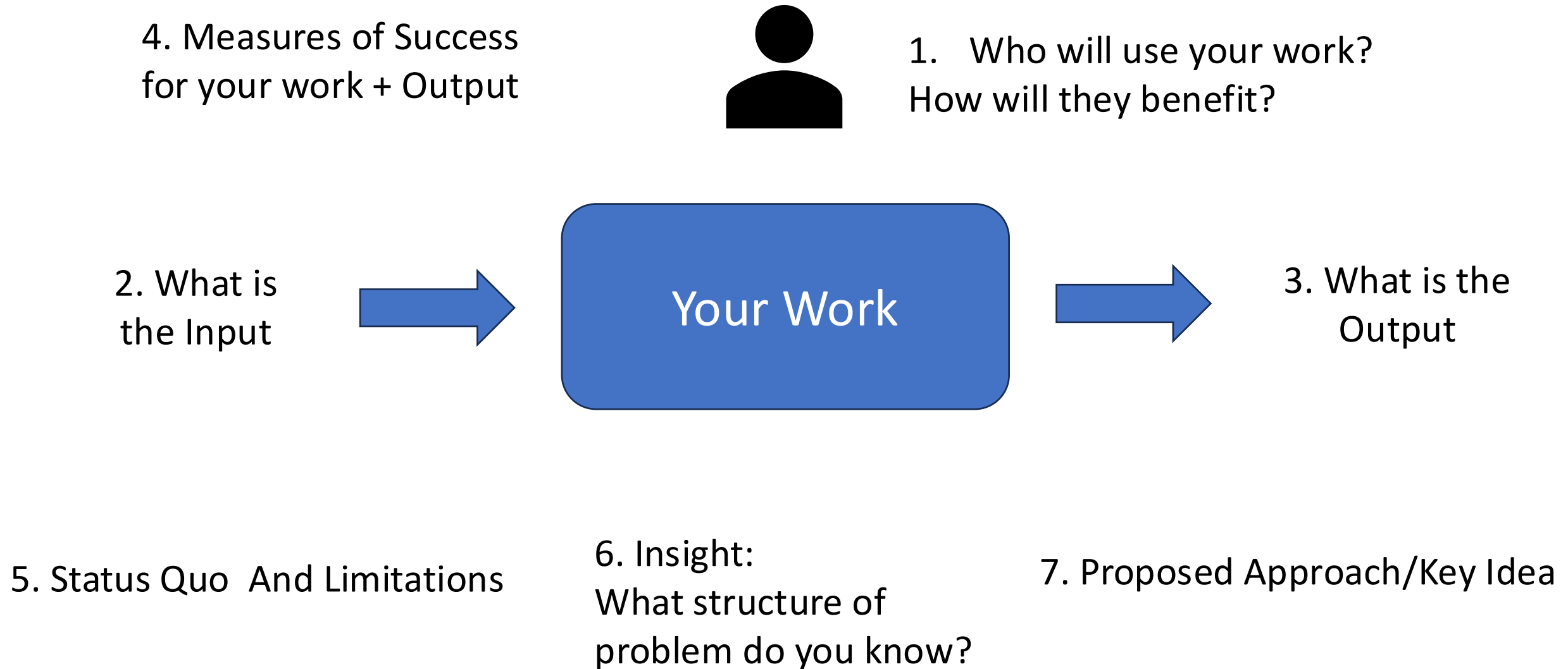
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Takeaways/ Recommendations

- Heilmeier/Liskov: For any new/current project write a Heilmeier doc
- Amdahl/Liskov: For any process/performance/bottleneck, apply profiling, focus on high order bits and big wins
- Polya/Hopper: Formulate, Refactor, Visualize problems in Input/Output
- Simon/Hopper: Empathy for your audience's attention

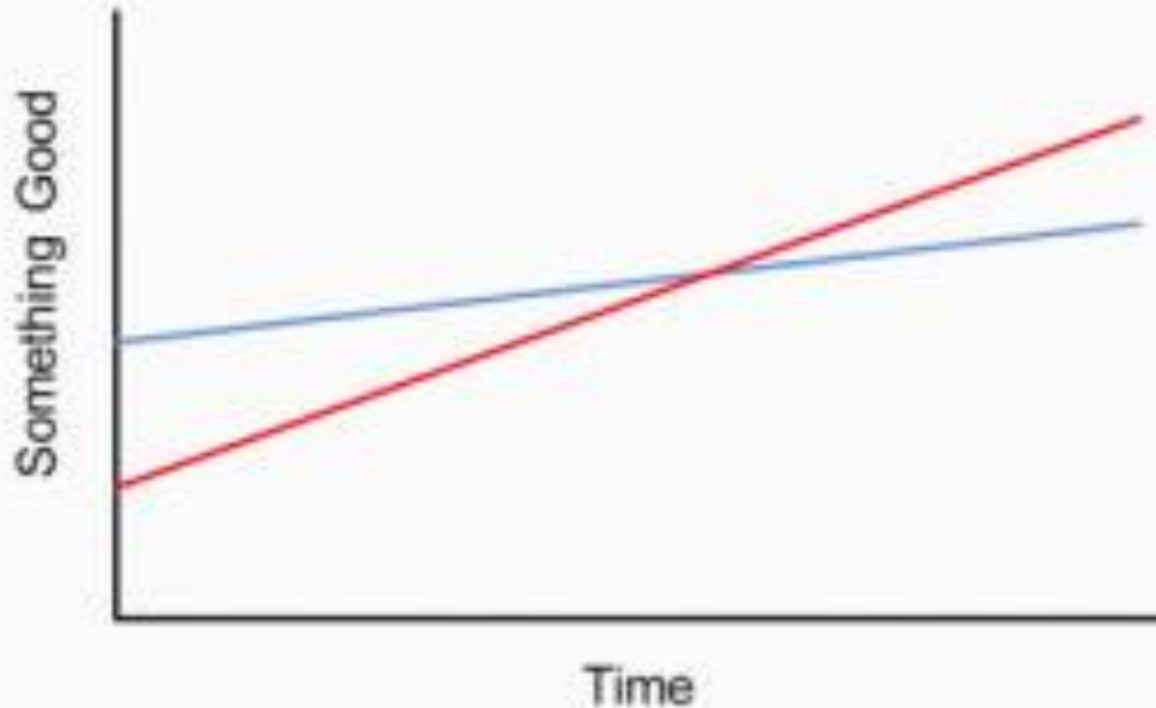
Vyas Cheat Sheet for Project Formulation



Bonus: Ousterhout's Law

“how fast you learn is a lot more important than how much you know to begin with”

**A Little Bit of Slope
Makes Up for a Lot of Y-Intercept**



Source: <https://briankeng.com/2015/07/a-little-bit-of-slope/>

Useful references

Greatresearch.org

Smart Brevity

<https://austinkleon.com/steal/>, <https://austinkleon.com/show-your-work/>

Randy Pausch Last Lecture: https://www.youtube.com/watch?v=ji5_MqicxSo

<https://www.microsoft.com/en-us/research/video/how-i-became-a-storyteller-and-how-you-can-too/>

Grace Hopper on Future Possibilities: <https://www.youtube.com/watch?v=si9iqF5uTFk>