

Tips for Developing Everyday Research Skills

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What was my research path?

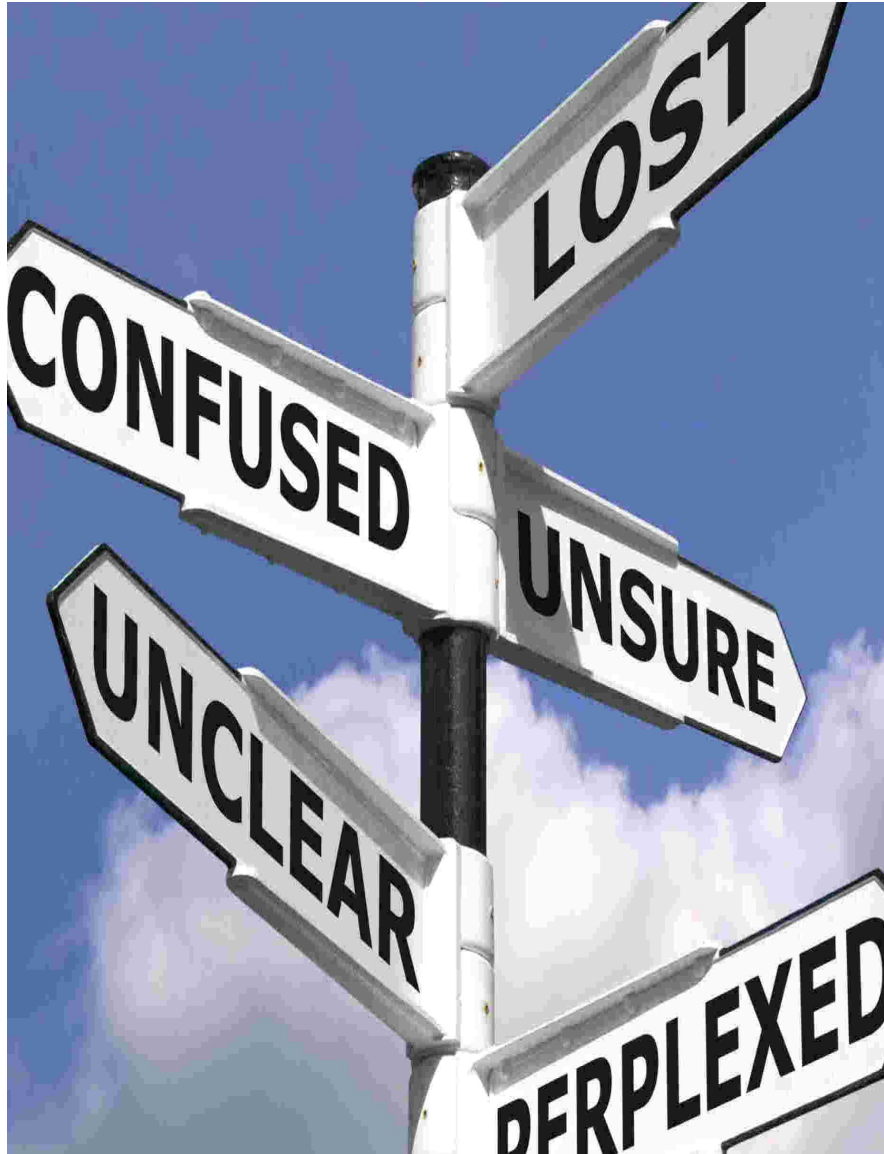
CRA-W Distributed Mentor Project

- After junior year, accepted to 10 week **paid** research internship
- Matched with Prof. Margaret Martonosi at Princeton University
- Cache simulation project which we published as a workshop paper

Graduate school at Stanford University

- Worked with Prof. Bill Dally
- Balancing compute and communication needs on chip multiprocessors

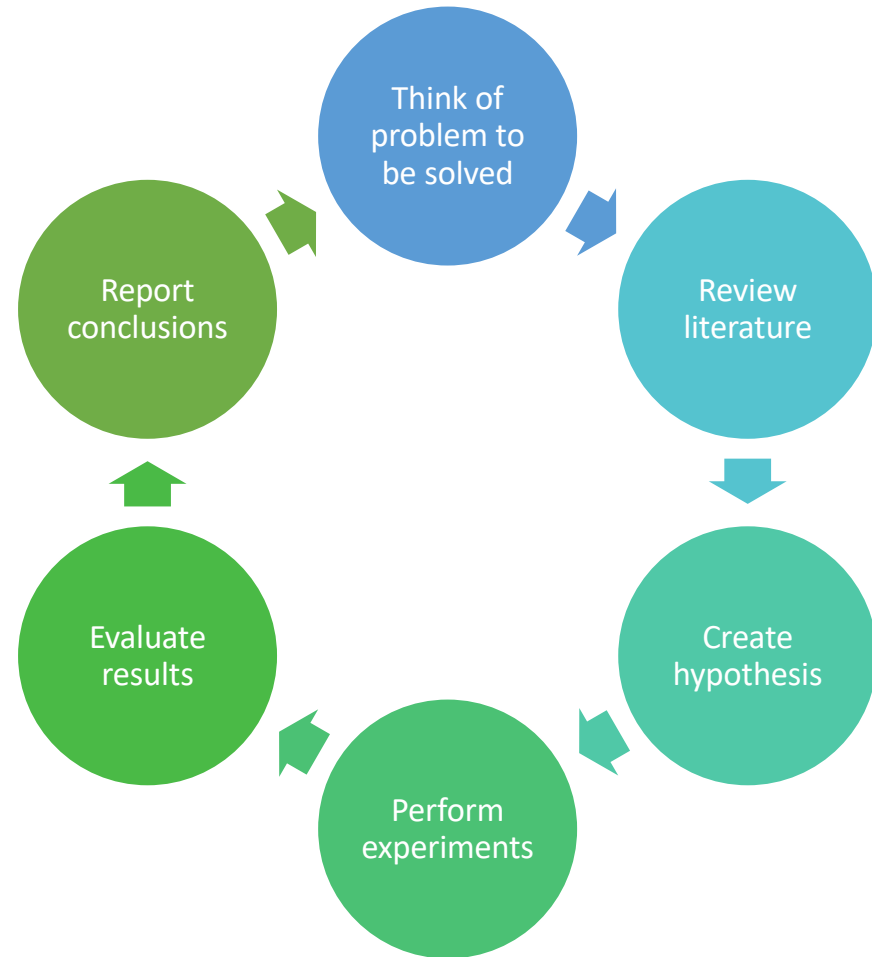
Faculty member at liberal arts college



I Had No Idea What To Do

- For the internship, I did what my mentor suggested
- In graduate school, my PhD advisor was very hands off
 - Learned through trial and error
 - Learned from my fellow graduate students
 - Learned from observing talks including Q&A
- As a faculty member, I've learned more
 - By advising research students
 - By observing my colleagues advise students
 - By attending conferences and watching people ask questions

What is the research process?



Tips for Everyday Research

How do you learn about existing research?

- How do you read a paper?
- How do you find other papers to read?

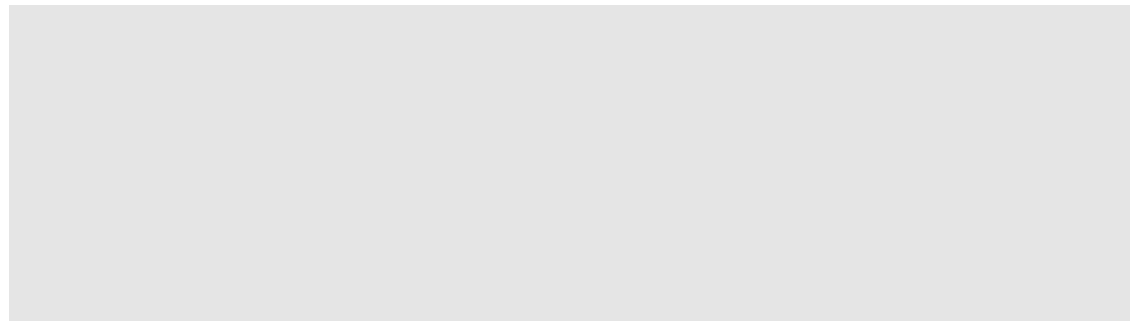
How do you create the framework needed for your research?

- How do you learn what tools or techniques should be used?
- How do you learn to use those tools or techniques?

How do you learn what questions to ask?

- How do you learn what questions to ask about your work?
- How do you learn what questions to ask about other people's work?
- How do you learn to come up with next research steps?

How do you learn about
existing research?





Textbooks are Great Resources!

- Typically cover concepts in a general way
 - Don't go into the details of many different approaches
- Provide information about terminology
 - Incredibly useful as a reference (as is the Internet)
- Include paper citations to related work used to write the text
 - Starting point for a literature search!

How do you find a good textbook?

- Search online for college/university courses on the topic
 - See what textbooks they are using in their classes
- Look in the contents and index for terms related to your topic
 - May be able to read one chapter in one textbook
 - Might need to cobble together multiple textbook's small subsections on topic
- Bonus: find lecture slides, related readings, example problems

Papers are where the details are found



- In computer science, most research is published at conferences
 - ACM
 - IEEE
- Some work is published in journals
 - Often longer, more thorough presentation of conference work
 - Summary of work from several papers for bigger perspective

How do you read a paper?



- It depends.
- What are your goals?
 - First pass:
 - High level understanding of problem, proposed solution, results, and limitations
 - Second+ pass:
 - Detailed understanding of approach taken and tools and techniques used with goal of guiding your experiments or approach
 - Understanding of specific situations where approach is limited with goal of proposing future work



But really,
how do you
read a paper?

Skim abstract, introduction, and conclusion

- Mark words you don't know and look them up
- Decide if this paper is of enough interest to keep reading

Read paper for comprehension

- Mark key ideas in margins
- Write down questions in margins
- Don't get bogged down in understanding details completely

Write a brief summary*

- Include key thoughts about the paper
- Include a citation (e.g., BibTex)

Decide whether to reread for details

Write a summary

- What problem is being solved?
- Who cares about the solution and why? How important is the problem?
- What is the insight motivating the proposed solution?
- What is the proposed solution?
- How effective is the solution and what are its limitations?
- What insights/observations can be made with respect to the solution's limitations? What future work does this suggest?

How do you find other papers to read?

Look at papers in recent years of top related conferences/journals

- Start with where papers you have read were published and where the papers they cited were published

Backward search

- Look at papers cited by the papers you already have

Forward search

- Look at papers that cited the papers you already have

Researcher search

- Look at other work by authors of papers you've read

Use Paper Repositories and Search Engines



Paper repositories

ACM Digital Library

IEEE Xplore



Paper Search Engines

Google Scholar

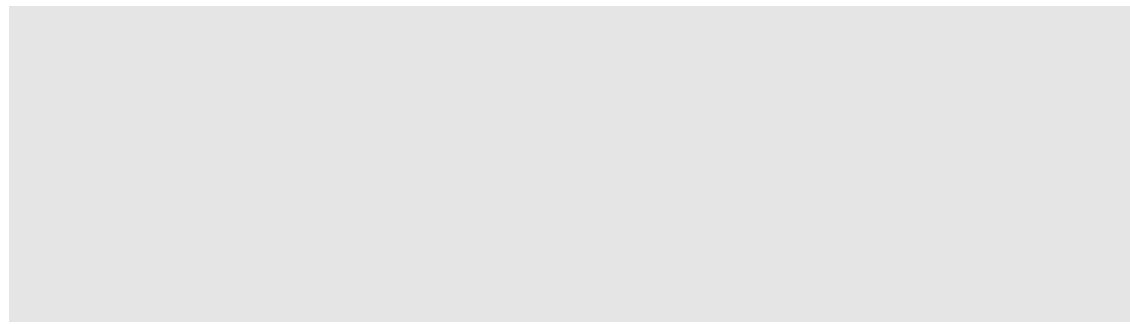
CiteSeerX

If you can't find a copy online or via your mentor, send the authors an email requesting a copy.

Helpful Advice On Finding and Reading Papers

- “How to Read an Engineering Paper” by William G. Griswold
 - <http://cseweb.ucsd.edu/~wgg/CSE210/howtoread.html>
- CRA-W’s “Critically reading a research paper” Exercise
 - <https://cra.org/cra-wp/wp-content/uploads/sites/5/2015/07/Reading-A-Research-Paper.pdf>
- CRA-W’s “Identifying related literature” Exercise
 - <https://cra.org/cra-wp/wp-content/uploads/sites/5/2015/07/Identifying-Related-Literature.pdf>

How do you create the
framework needed for your
research?



Which tools and techniques should you use?

- Research advisor may provide recommendations
- Go back to related work and see what other people use
 - Do several papers use the same tool to collect data?
 - Do several papers use the same approach to generate input data?
 - Do several papers use similar types of mathematical approaches to prove ideas?
 - Do several papers use similar approaches to enlist and evaluate human subjects?
 - Do several papers use the same statistical approaches to analyze data?

How do you
learn to use
those tools
or
techniques?

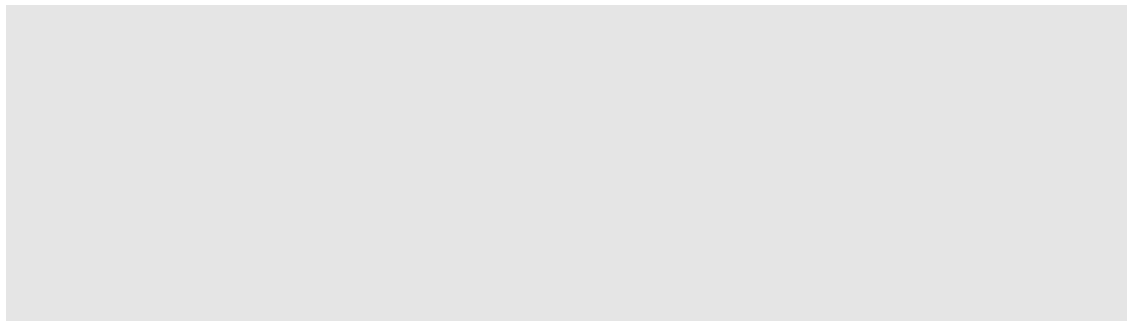
- Mathematical and statistical concepts
 - Textbooks and online class resources are great for this!
 - Sometimes you have to resort to early papers introducing the technique
- Tools
 - Commonly used tools likely documented online
 - Look for recordings of tutorials from conferences about tool
 - Many tools will have an online user community

Spend Small Amounts of Time Learning Tools to Improve Productivity

- Version control system
 - git
- Editor
 - emacs, vim, VSCode
- Debugger
 - gdb
- Scripting language
 - bash scripts, python, perl
- File parsing languages
 - python, perl
- Data analysis tools
 - python, R, matlab
- Data visualization tools
 - matplotlib
- Document preparation tools*
 - TeX, LaTeX, BibTeX

*I recommend using Overleaf

How do you learn what
questions to ask?



How do you learn what questions to ask?



- How do you learn what questions to ask about your work?
- How do you learn to come up with next research steps based on your results?
- How do you learn what questions to ask about other people's work?
- How do you learn to come up with entire new research projects?

Don't Panic!

Research is an
apprenticeship
where you learn
experientially

Only through
experience will you
learn what types of
questions to ask

How do you get this experience?

Your research mentor will ask you questions to guide you

- Teach about the process while helping with specific project

When you talk about your research to others*, they will ask questions

- Some questions may be insightful, some may be uninformed, all are worth considering
- Discuss those questions with mentor and fellow researchers so they can help you categorize

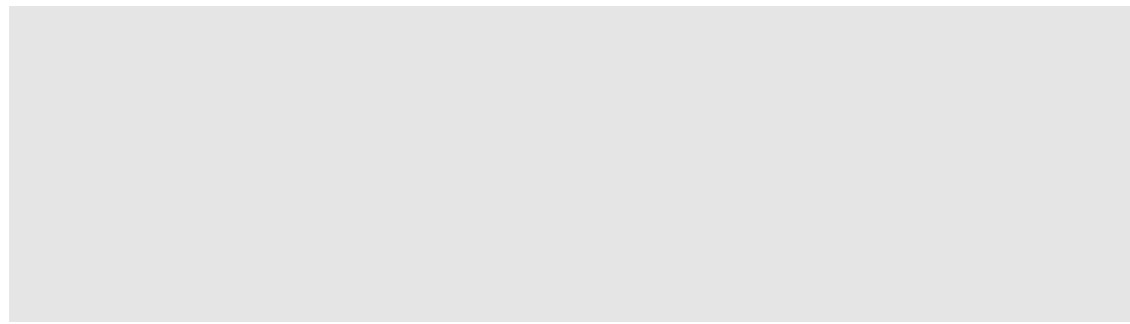
Observe what types of questions other folks ask

- In department talks, in small group meetings, at poster presentations
- Talk to others about the questions afterwards to understand which were insightful and why the questions were relevant

Okay, but how do you even start thinking about questions?

- Question the importance of the problem being solved
- Question whether the approach being taken is the most appropriate for the type of problem
- Question whether the experimental environment or mathematical techniques being used are appropriate and sufficient
- Question whether the data being collected is the most appropriate data to support or refute the hypothesis
- Question why outliers from general trends in the data exist
- Question the applicability of the approach in broader or other contexts

One more research tip...





Let your mind wander and
rest

- When we're tired, it's hard for our brain to work on problems constructively
- When we've been staring at a problem for hours, we can't see new ways of approaching it
- Walk away from your research and rest and do something that brings you joy
 - Your brain will recharge and may work on the problem behind the scenes
- If you're still struggling, chat with other people about your ideas

Have fun, and
rejoice in failing
and learning from
those failures!

