Conducting Research

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Isaac Griffith

CS 4422 and CS 5599
Department of Computer Science
Idaho State University

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Outcomes

At the end of this lecture you should be able to:

- Understand the research process
- Conduct background research
- Develop a research proposal
- Understand the structure of a research proposal paper

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Inspiration

“Research is an organized method of trying to find out what your are going to do after you cannot do what you are doing now” – Charles F. Kettering

Research Process

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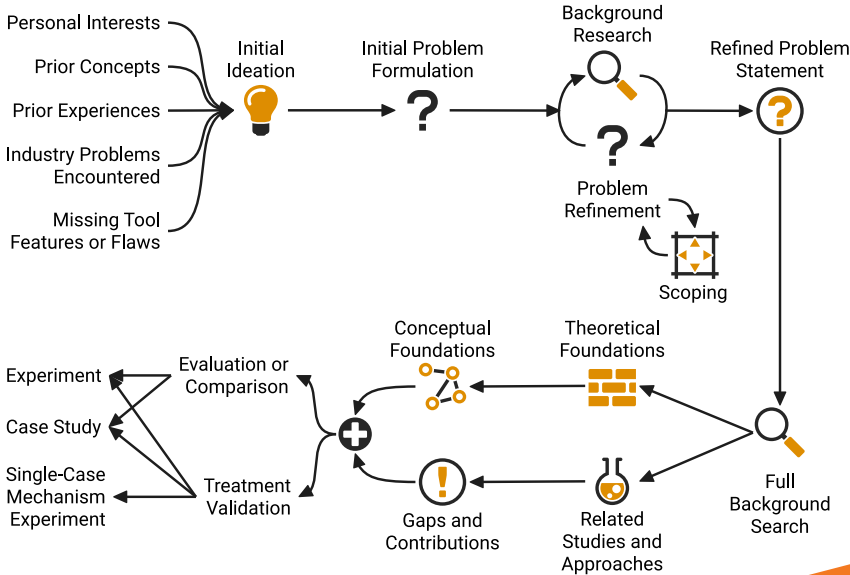
Process



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Ideation

Your goal is to find a problem or knowledge gap that is important to the software engineering industry, software engineering researchers, or even better both.

- We do this typically in the following ways:
  - Reviewing recent research
  - Working with industry
  - Using existing tools
- Identify current problems and why they are important.
  - Industry problems that have academic impact
  - Prior study future work and challenges.
  - Identifying serious flaws or missing features of existing tools
- You want to find something that is interesting to you

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Initial Problem Formation

From your initial ideation begin formulating you problem

- Your initial problem is probably too large
  - Identify sub-problems you can solve now
  - Select the most interesting sub-problem
  - Write a formal problem statement

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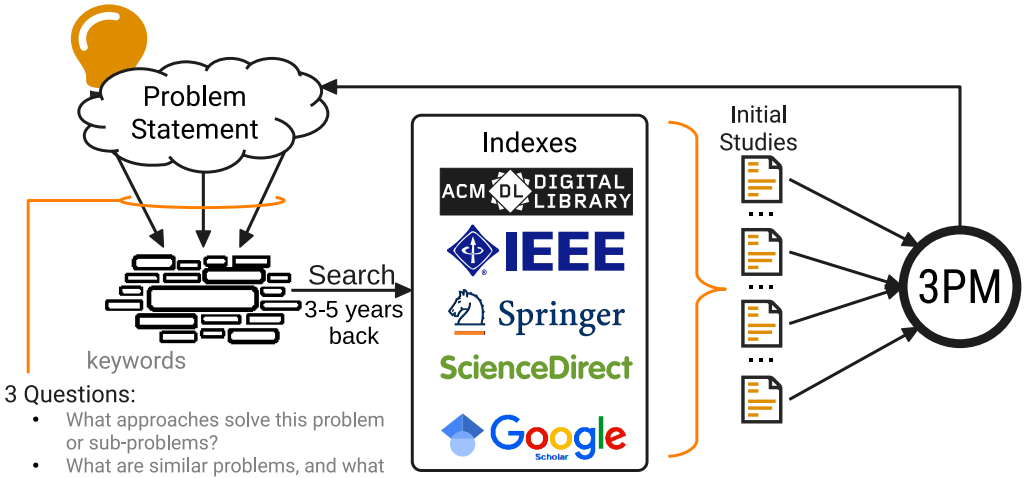
Initial Background Research

Once you have your initial problem defined, it is time to see what has already been done in this area. This is what we call the “background research”.

- Research Indexes aggregating CS and SE conference and journal proceedings:
  - IEEExplore
  - ACM Digital Library
  - SpringerLink
  - ScienceDirect
- You can access them via the library

Initial Background Research



3 Questions:

- What approaches solve this problem or sub-problems?
- What are similar problems, and what approaches solve them?
- What theoretical concepts and frameworks and prior approaches form the basis of your approach?

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Scoping

The goal of sketching out your research approach is to determine if you can complete the research project in the time allotted to you.

- You need to determine the following:
  - the scope of the problem you have defined
  - your ability to implement by the deadline, the following:
    - your research approach
    - data collection
    - results analysis
    - reporting and presentation

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The Full Background Search

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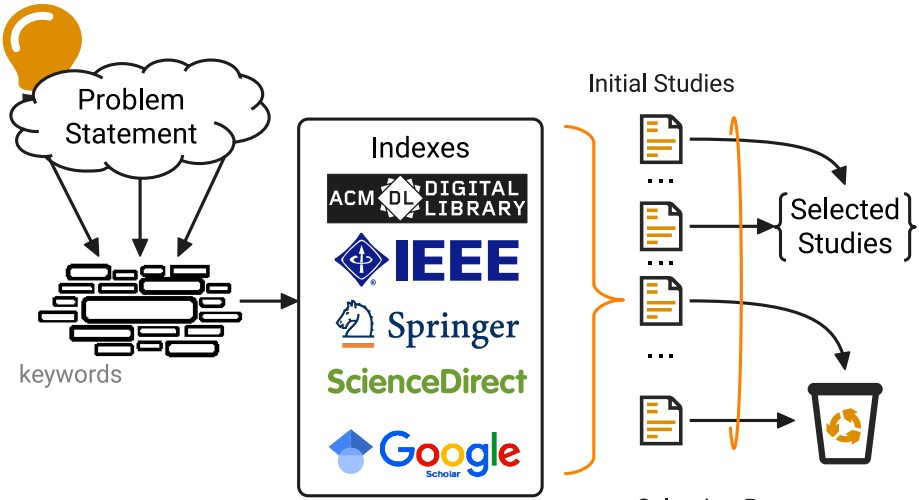
Finding Studies



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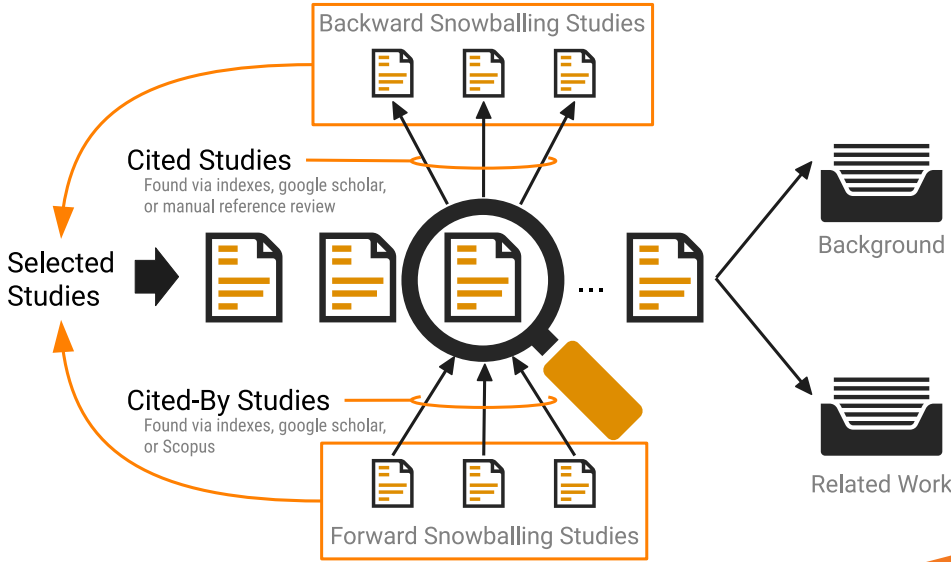
Snowballing



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Two Piles

Once you have completed your paper reviews and identified those pertinent to your project, you should break them down into the following two piles.

Pile 1: Foundational Work

- Describe tools you are reviewing
- Describe the techniques you use
- Provide theoretical foundations

Pile 2: Related Work

- Provide alternative approaches to the same problem.
- Provide alternative solutions to the similar problems.
- Or, they solve related but different problems.

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Reading Papers - 3PM

The Three Pass Method

First Pass

1. Read the title
2. Read the abstract

Second Pass

1. Read the title
2. Read the abstract
3. Read the introductory section
4. Read the conclusions

Final Pass

1. Review your previous notes
2. Start from the title and read the entire paper
   - Focus on methods, results, and discussion

All Passes

- Take notes along the way
- At any time during your reading that you realize this paper is not pertinent, discard it.

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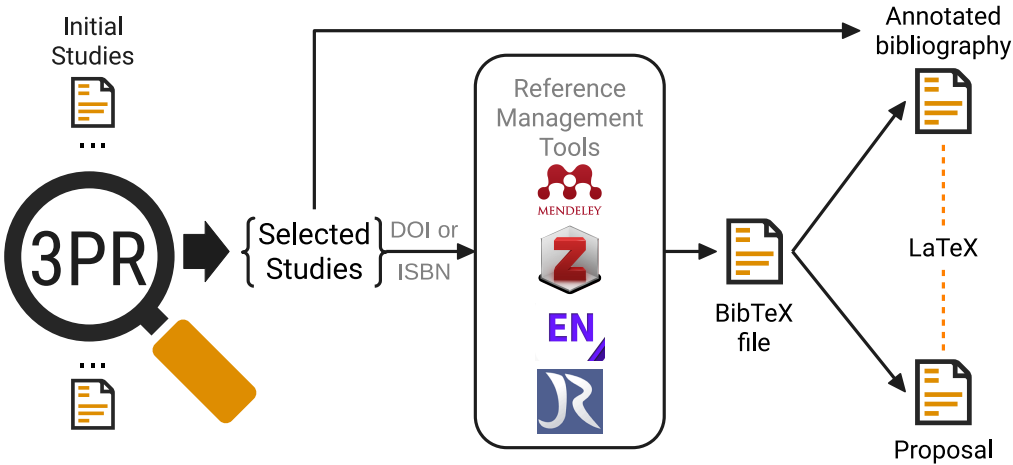
Too Many Papers?



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Writing the Proposal

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Structuring Your Proposal

Title, Authors, Abstract

1. Introduction Section
   - Motivation
   - Problem Statement
   - Research Questions
   - Paper Organization
2. Background and Related Work Section
   - Foundational Knowledge
   - Related Works
   - Contributions
3. Methods (not methodology) Section
   - Approach
   - Experimental/Case Study Design
   - Metrics and Measures
   - Analysis Procedures
   - Data Sources
4. Conclusions
   - Summary of your approach
   - Limitations of your approach
   - Timeline and Project Scope

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Abstract

- A summary regarding the content of the paper
- Before the introduction
- After the title and authors of the paper
- Similar to an “executive summary”

For this course, we will use a form called a **Structured Abstract**

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Section 1: Introduction

This section sets the scope and defines the objective of the research.

- The motivation of the work to capture the readers' interest.
- Describe the need for the research
- Present the context within which the research is conducted
- Research objectives and Problem statement

The Funnel

- Start with the large and important problem that needs to be addressed
- Then address a sub-problem which is the focus of the research

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Research Objectives

- Use the Goal-Question-Metric (GQM) approach.
- The GQM goal template looks something like this:

```
Analyze <Object(s) of study>
for the purpose of <Purpose>
with respect to their <Quality focus>
from the point of view of the <Perspective>
in the context of <Context>
```

- This scopes and describes the objective in a single statement

Review Table 7.3 on page 87 of “Experimentation in Software Engineering” for examples of each of the items in angle brackets.

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Questions and Metrics

- Refine your research goal into a set of questions.
- These questions help define your empirical approach.
  - Your approach serves to answer these questions
- You then define a set of metrics
  - When measured (data collection) provide the results for analysis
  - Examples: Lines of Code, Code Coverage, Number of Methods, Days Worked, etc.

Paper Organization

Alerts the reader to the structure of the paper.

- Something like: “The remainder of this paper is organized as follows. Sec. 2 … Sec. 3 … Sec 4. … … Finally, Sec. 7. summarizes the findings and describes the avenues for future work.”
- Integrate at end of the introduction section
- Needed to address the break in flow from the background section

Section 2: Related Work

- A synthesis of your background research:
- It typically has two main subsections
  - **Theoretical Foundations** – A synthesis of the most important concepts and findings from the “Foundational Work” pile.
  - **Related Work** – A synthesis of the most important concepts and findings from the “Related Work” pile
    - with special emphasis on the gaps that your work is going to fill.

Section 3: Research Methods

- This is the subject of the last section of this talk

Section 4: Conclusion

- **Conclusion** - This presents a summary of the paper specifically including:
  - Key findings and their relation to other works
  - How the key findings related to the larger problem from the introduction
  - Limitations of your work.
  - The next steps and future work.
- For a proposal, since you have no results yet:
  - summarize of your proposed approach
  - discuss expected findings
  - provide a scoping and timeline of the project

Are there any questions?