

CMPT 475: Software Engineering II

Introduction to Research

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References

- Mary Shaw, *Writing Good Software Engineering Research Papers*, Proceedings of the 25th International Conference on Software Engineering, IEEE Computer Society, 2003, pp. 726-736.
- Mihai Pop, How to read a scientific paper.
<http://www.cbcb.umd.edu/confcour/CMSC838K-materials/how-to-read-a-paper.pdf>
- Amanda Stent, How to Read a Computer Science Research Paper, <http://uet.vnu.edu.vn/~chauttm/cs-english/reading-guides/howtoreadacspaper.pdf>

Outline

- Introduction to Research
- Publications / Papers
- Literature Review

Introduction to Research (General)

References

- <http://www.castonline.ilstu.edu/smith/164/Introduction%20to%20Research.ppt>.

Issues...

- Why are we interested in research?
- What is research?
- Key concepts and issues
- Introduction to validity

Why must we understand research?

- help make informed decisions
- need to produce research in career
- evaluating research in the media
- assist in classes

Why is research a valued source of knowledge?

- Common ways of knowing...
 - personal experience/intuition
 - experts/traditions/authority
 - scientific method

What is Science, the Scientific Method, and Research?

- Science...
 - a body of established knowledge
 - the observation, identification, investigation, and theoretical explanation of natural phenomenon

usually the ultimate goal is theory
generation and verification

What is Science, the Scientific Method, and Research?

- Theory...
 - a set of inter-related constructs and propositions that specify relations among variables to explain and predict phenomena
 - should be simple, consistent with observed relationships, tentative and verifiable

What is Science, the Scientific Method, and Research?

- Scientific Method...
 - involves the principles and processes regarded as characteristic of or necessary for scientific investigation
 - process or approach to generating valid and trustworthy knowledge

What is Science, the Scientific Method, and Research?

- Research...
 - the application of the scientific method
 - a systematic process of collecting and logically analyzing information (data)
- Research Methods (Methodology)...
 - the ways one collects and analyzes data
 - methods developed for acquiring trustworthy knowledge via reliable and valid procedures

Characteristics of Research

- objective
- precise
- verifiable
- parsimonious
- empirical
- logical
- probabilistic

Types of Research

- Trochim's Classifications...
 - descriptive
 - e.g., percentage of regular exercisers
 - relational
 - e.g., link between age and exercise
 - causal
 - e.g., effect of behavior change intervention on exercise participation

Types of Research

- Other Common Classifications...
 - basic vs. applied vs. evaluation
 - experimental vs. non-experimental
 - analytical vs. descriptive vs. experimental vs. qualitative

Scientific Method of Problem Solving

- **Step 1:** develop the problem (define and delimit it)
 - identify independent and dependent variables
- **Step 2:** formulate the hypotheses
 - the anticipated outcome
- **Step 3:** gather data
 - maximize internal and external validity
- **Step 4(5):** analyze and interpret results

Variables in Experimental Studies

- **Independent variable**
 - Variable that is manipulated (treatment is administered; has levels)
- **Dependent variable**
 - What you measure. (effect of the independent variable)
- **Simplest** study has one independent variable and one dependent variable

Applied Research

- **Step 1:** develop the problem
 - identify independent and dependent variables
- **Step 2:** formulate the hypotheses
 - the anticipated outcome
- **Step 3:** gather data
 - maximize internal and external validity
- **Step 4(5):** analyze and interpret results

Basic vs. Applied Research

- **Basic research** – type of research that may have limited direct application but in which the researcher has **careful control** of the conditions
- **Applied research** – type of research that has direct value to practitioners but in which the researcher has **limited control** over the research setting

Experimental vs. Non-experimental Research

- **Experimental research**
 - Treatments are given to subjects
 - Cause-and-effect questions
- **Non-experimental research**
 - Treatments are not given to subjects
 - Participants are observed as they naturally exist

Quantitative vs. Qualitative Research

- **Quantitative** – data are gathered such that they can be quantified and subjected to statistical analyses
- **Qualitative** – data are gathered such that they can be analyzed through informed judgment

Quantitative and Qualitative

Quantitative	Qualitative
data – expressed as numbers	data – difficult to measure sensibly as numbers, e.g. count number of words to measure dissatisfaction
Analysis – numerical methods to ascertain size, magnitude, amount	Analysis – expresses the nature of elements and is represented as themes, patterns, stories

Key Concepts and Issues

- time in research
- variables
- types of relationships
- hypotheses
- types of data
- fallacies
- structure of research
- deduction and induction
- ethics
- validity

Time in Research

cross-sectional vs. longitudinal



```
graph TD; A[cross-sectional vs. longitudinal] --> B[repeated measures]; A --> C[time series];
```

repeated measures

time series

Variables

- variable...
 - any observation that can take on different values
- attribute...
 - a specific value on a variable

Examples

Variable

age

Attribute

Examples

Variable

age

Attribute

18, 19, 20, etc...

Examples

Variable

Attribute

Gender or sex

Examples

Variable

Gender or sex

Attribute

Male, female

Examples

Variable

Attribute

satisfaction

Examples

Variable

satisfaction

Attribute

1 = very satisfied

2 = satisfied

3 = somewhat satisfied

4 = not satisfied

5 = not satisfied at all

Types of Variables

- independent variable (IV)...
 - what you (or nature) manipulates in some way
- dependent variable (DV)...
 - what you presume to be influenced by the IV

Hypotheses

- hypothesis...
 - a specific statement of prediction
- types of hypotheses
 - alternative vs. null
 - one-tailed vs. two-tailed

Hypotheses

- alternative hypothesis (H_A)...
 - An effect (that you predict)
- null hypothesis (H_0) ...
 - Null effect

Hypotheses

hypothesis

there is a relationship between age
and exercise participation

H_A

there is a relationship

H_O

there is not a relationship

this is a two-tailed hypothesis as no
direction is predicted

Hypotheses

hypothesis

an incentive program will increase exercise participation

H_A

participation will increase

H_O

participation will not increase or will decrease

this is a one-tailed hypothesis as a specific direction is predicted

Types of Data

- quantitative vs. qualitative

Ethics in Research

- balance between protecting participants vs. quest for knowledge
 - IRB provides one mechanism
 - informed consent/assent
 - confidentiality and anonymity
 - justification of procedures
 - right to services
 - IRB @ SFU
- <http://www.sfu.ca/policies/gazette/research/r20-01.html>

Introduction to Validity

- validity...
 - the best available approximation to the truth of a given proposition, inference, or conclusion

Introduction to Validity

- types of validity...
 - conclusion
 - internal
 - construct
 - external

types of validity are cumulative

Introduction to Validity

- for each type of validity there are typical threats, and ways to reduce them
- this provides our framework for critiquing the overall validity (= worth) of studies

Additional Information

- Describing Refereed Articles
- Sharing Research Findings with Clients

Theory

What you *think*

Cause
Construct

cause-effect construct

Effect
Construct

operationalize

operationalize

Program

program-outcome relationship

Observations

What you *do*

What you *see*

Observation

What you *test*

In *this* study

Outline

- Introduction to Research
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Publications / Papers

Reasons to read a paper

- You were told to
- Describes current research
- Allows you to replicate/extend the results
- Provides you with useful data
- Gives you “pre-digested” thoughts
- To decide whether to publish it
- Teaches you how to write.

Not all papers are equal

- Some you read to fully understand everything – may spend a lot of time reading the paper
- Some you read to get the "gist" – may just read abstract/intro and bounce a bit through results

Reading “mechanics”

- Remove distractions
- Take notes & save notes for future reference
- Jump around through the text, don't just read it like a Harry Potter book

TYPES OF RESEARCH PAPER / ORGANIZATION

Types of papers

- Theoretical
 - prove theorems
 - describe new algorithms
- Implementation
 - describe new software tools
- Experimental
 - describe results of experiments
- Survey/Review
 - review current results in a field of research
- NOTE: not mutually-exclusive, most papers are a mix

Primary vs. secondary sources

- Primary
 - actual description of the work/results reported
- Secondary
 - describe work/results of others
 - e.g. background section in most papers
 - survey papers
 - encyclopedias (e.g. Wikipedia)
- Try to read the primary references (though secondary references are quite useful too)!

Paper organization

- Title & author list
 - Abstract
 - Introduction
 - Materials and Methods
 - Results
 - Discussion/Conclusion
 - Open problems
-
- Depending on the journal/conference/type of work these can vary in content/order

Theory paper

- Introduction
- Preliminaries
- Specific topic 1
- Specific topic 2, ...
- Future work
- Conclusions

HOW SHOULD I READ A RESEARCH PAPER?

Venue

- First things first: Where was the paper published?
- If the work is similar to what you do, this should give you ideas about which journals/conferences you should target with your own work
- Over time, you'll learn to evaluate journal/conference quality based on the quality of papers you read.

Title and author list

- Title
 - what is this paper about?
- Author list
 - who did the work? where are they from?
 - try to remember the names: these people may become collaborators, colleagues, or bosses sometime in the future.
 - also useful when planning a postdoc or future job
- Author list conventions
 - alphabetical (traditional CS)
 - ranked: first author did most work, last author (senior author) led the study (usually the PI)

Abstract

- Brief outline of the results presented in the paper
- Read it carefully
 - Can you understand what the paper is about?
 - Do the conclusions make sense?
 - Can you come up with a solution to the problem addressed by the paper?
 - How comfortable will you be reading this paper?
- Note: from any paper you should at least read the title, author list, and abstract

Introduction

- Introduces the problem(s) addressed in the paper and prior art
- Questions to ask:
 - now that the problem is stated in more detail than in the abstract, can you think of a solution (or conclusion)?
 - is enough/any prior art listed? If not, why? Is the author hiding anything?
 - can you see why this paper is an advance over what was done in the past?
- Introduction will also give you pointers to other papers you might want to read

Materials and Methods

- The “meat” of the paper - how the work was performed.
- Play the guessing game: for every problem or theorem stated, try to think of a solution before reading any further.
- Is sufficient information provided for you to understand how the paper “works”? What's missing? Is the paper correct?
- Note: in conferences papers are often “extended abstracts” - many details are missing. Try to fill them in.

Results

- Verbose conclusions of the paper
- Often this section also contains “materials and methods”-type content
- Questions to ask:
 - what conclusions can you draw from the data presented? (ask before the paper “brainwashes” you)
 - does the experiment/data support the conclusions described in the paper?
 - are there alternative conclusions that the authors did not consider?
 - how would you set up the experiment?
- Make sure figures do not lie

Conclusions

- The authors' summary of the contributions provided by the paper.
- Often, also philosophical discussions on the problem, or field of research
- Questions to ask:
 - do you agree with the authors' conclusions?
 - what are your own conclusions?
 - do the authors' conclusions derive logically from the material presented in the paper?

Open problems

- Many “traditional” CS papers end in an open problems section - questions the authors have asked themselves but cannot easily answer.
- This section is very important
 - provides you with problems you might want to work on
 - tests your understanding of the paper - many open problems are questions you should have asked yourself while reading the paper.

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Literature Review

What is Literature Review?

- A literature review is an account of what has been published on a topic by accredited scholars and researchers.

<http://www.writing.utoronto.ca/advice/specific-types-of-writing/literature-review>

Why do we need literature review?

- Besides enlarging your knowledge about the topic, writing a literature review lets you gain and demonstrate skills in two areas
 - **information seeking**: the ability to scan the literature efficiently, using manual or computerized methods, to identify a set of useful articles and books
 - **critical appraisal**: the ability to apply principles of analysis to identify unbiased and valid studies.

<http://www.writing.utoronto.ca/advice/specific-types-of-writing/literature-review>

A literature review must do these things

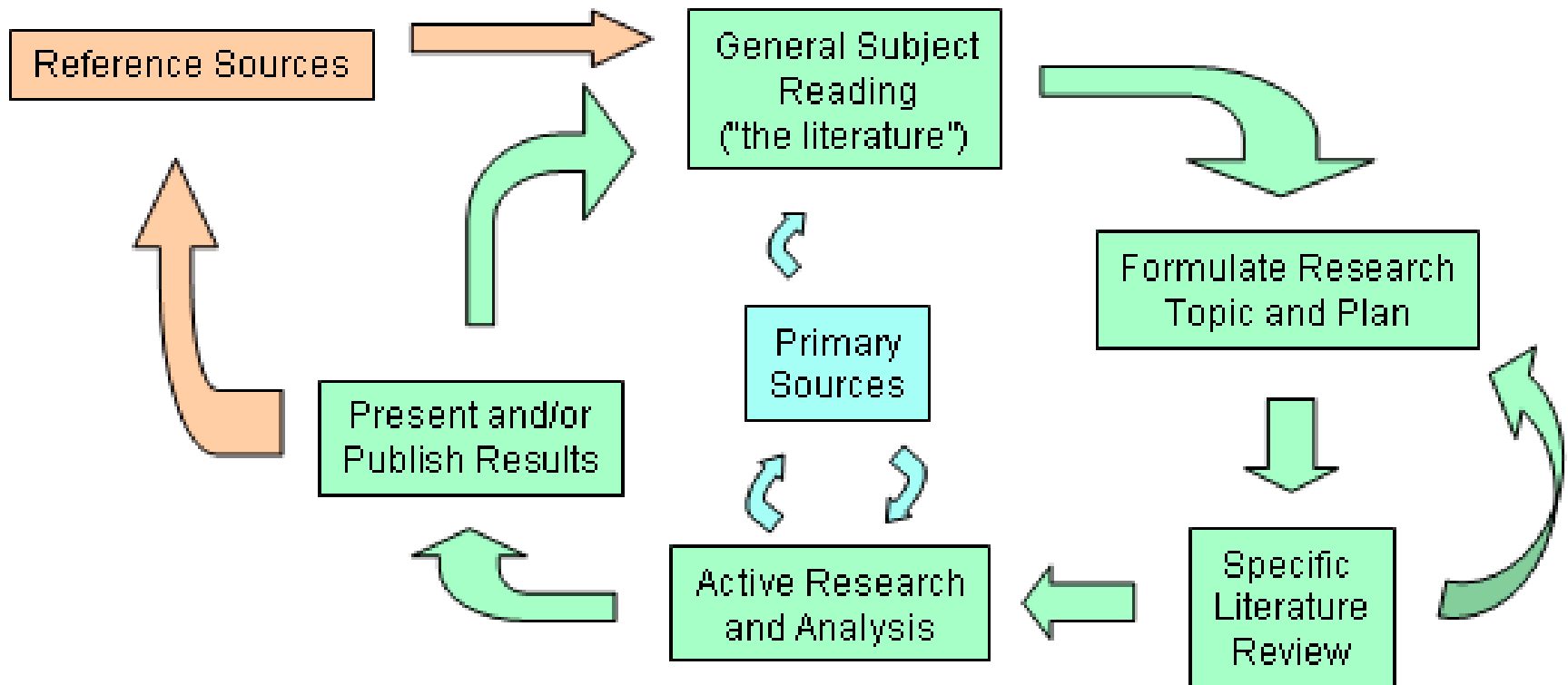
- be **organized** around and related directly to the thesis or research question you are developing
- **synthesize** results into a summary of what is and is not known
- **identify** areas of controversy in the literature
- **formulate** questions that need further research

<http://www.writing.utoronto.ca/advice/specific-types-of-writing/literature-review>

Types of Literature Reviews

- Stand-Alone Literature Review Articles
- Research Proposal
- Research Report in the Workplace

The "Information Cycle"



Read

- I.H. McLean, \Literature Review Matrix,“
<http://psychologyinc.blogspot.com/>
- S. Peyton Jones, \Research Skills,“ <http://research.microsoft.com/en-us/um/people/simonpj/papers/giving-a-talk/giving-a-talk.htm>.
- T. Roscoe, \Writing Reviews for Systems Conferences,“
<http://people.inf.ethz.ch/troscoe/pubs/review-writing.pdf>.
- H. Schulzrinne, \Writing Technical Articles,“
<http://www.cs.columbia.edu/hgs/etc/writing-style.html>.
- G.M. Whitesides, \Whitesides' Group: Writing a Paper,“
<http://www.che.iitm.ac.in/misc/dd/writepaper.pdf>.

Summary

- Introduction to Research
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QUESTIONS?