Conduct Rigorous and Scientific Research

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Outline

- I. Writing and Presentation
- II. Research Formulation
- III. Experimentation

I. Writing and Presentation

1. Typo and grammar mistake
2. Sentence and convention
3. Exercise and discussion

General

- Writing
  - Make your paper error-free (readable)
  - E.g., no typo or grammar mistake
- Presentation
  - Make your paper *logically* written (readers can follow)

- Writing and presentation are different!
  - Writing first (own effort), presentation next (training)

Common Writing Mistakes (1)

- Fragments
  - *If* I had saved some money. I could have bought that new stereo.
  - *Dancing* the night away in my new gown.
  - I wanted a number of items. *Especially* lettuce and mushrooms.
  - I visited the Philadelphia Museum of Art. *And* was most impressed with it.

Common Writing Mistakes (2)

- Run-together and comma-spliced sentences
  - My back hurts it is weak.
  - (Revised) My back hurts *because* it is weak.

  - My back hurts, it is weak.
  - (Revised) My back hurts, *for* it is weak.

Common Writing Mistakes (3)

- Subject and verb agreement
  - *They has worked* all day.
  - (Revised) *They have worked* all day.

  - *Each* of the nurses *are* present.
  - (Revised) *Each* of the nurses *is* present.

  - *Somebody* in the room *have taken* my wallet.
  - (Revised) *Somebody* in this room *has* taken my wallet.

Common Writing Mistakes (4)

- Ambiguous references
  - When *people* discuss their *problems*, *they* should be objective.
  - (Revised) *People* should be objective when *they* discuss their problems.
  - (Revised) The *problems which* people discuss should be objective.

Common Writing Mistakes (5)

- Problems with our "relatives"
  - I lost my *job*, *which* really angered me.
  - (Revised) When I lost my job, I was angry.
  - (Revised) Losing my job made my angry.

  - I had to *leave*, *which* was disturbing.
  - (Revised) Because I had to leave, I was disturbed.
  - (Revised) Having to leave disturbed me.

Common Writing Mistakes (6)

- Dangling modifiers
  - *Walking down the street*, a trash can blocked Joe's path.
  - (Revised) *Walking down the street*, Joe could see a trash can blocking his path.
  - (Revised) *While Joe was walking down the street*, a trash can blocked this path.

Common Writing Mistakes (7)

- Misplaced modifiers
  - Men and women who smoke *often* die of lung cancer.
  - (Revised) Men and women who smoke *excessively often* die of lung cancer.
  - (Revised) Men and women who smoke *will* often *die* of lung cancer.
  - (Revised) *Quite often*, men and women who smoke die of lung cancer.

Common Writing Mistakes (8)

- Faulty parallel structures
  - Joe wanted a *salary* higher than his brother *Bill*.
  - (Revised) Joe wanted a *salary* higher than his brother Bill's *salary*.
  - (Revised) Joe wanted a *salary* higher than *that* of his brother Bill.

More…

- You are supposed to have known all of these!
  - No reason to make such mistakes
- Do not ask me about English grammars
  - Ask yourself
  - Pick up CET-4, CET-6, and TOEFL materials

Sentences

- First
  - Write correct sentences
- For good presentation
  - Use *simple* sentences
  - Abandon *useless* (irrelevant) sentences

Writing Conventions (1)

- Avoid ambiguous words
  - E.g., if => whether
- Avoid offensive words
  - E.g., obviously, very, …
- Do not put “and”, “also”, “but”, or “because” at the beginning of a sentence

Writing Conventions (2)

- User terms/words consistently
  - E.g., We conducted an *experiment* … This *evaluation* …
  - E.g., Section 1 introduces … Section 2 gives … *We explain* … in Section 3

- can not => cannot
- "e.g.," "i.e.," ", respectively"

Writing Conventions (3)

- A, B and C => A, B, and C
  - The group consists of two engineers, Jack and John.
  - The group consists of two engineers, Jack, and John.

Writing Conventions (4)

- Avoid passive tone
- Avoid subjective tone
  - E.g., I feel …, I am confident …
- Do not omit "that"
  - E.g., note *that* such a path is always executable

Exercises

- Describe an object in the classroom/meeting room
  - Requirement: error-free and following conventions
  - Word limit: 100

- Describe an activity you attended today/yesterday
  - Requirement: error-free and following conventions
  - Word limit: 100

II. Research Formulation

1. Definition before use
2. Research problem
3. Inadequacy of related work
4. Insight of your proposal
5. Exercise and discussion

General

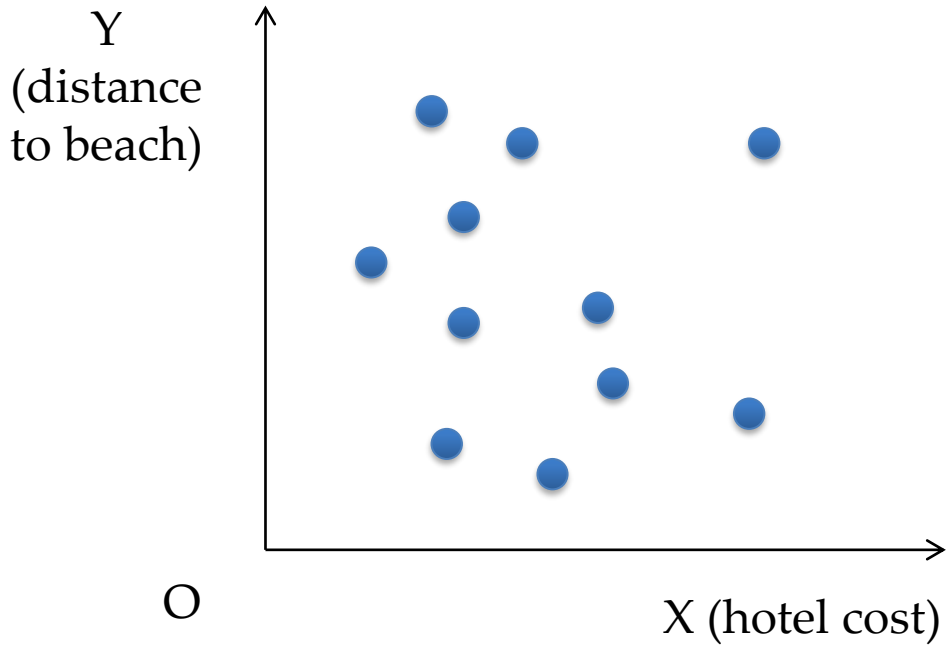
- Conducting research and writing papers are always coupled together
- Implication
  - What you are going to write in papers should have been *already* considered when you conduct research
- Research formulation <= paper presentation

Definition and Use

- Use consistent terms/words
  - E.g., experiment/evaluation, technique/approach, …
- Concepts are defined before use
  - Each key concept must be defined, and non-key concepts should be discarded as many as possible
  - Each concept should carry the *same meaning* throughout the paper (so for variables)
  - Each defined concept should be *mathematically expressible* or *machine computable*

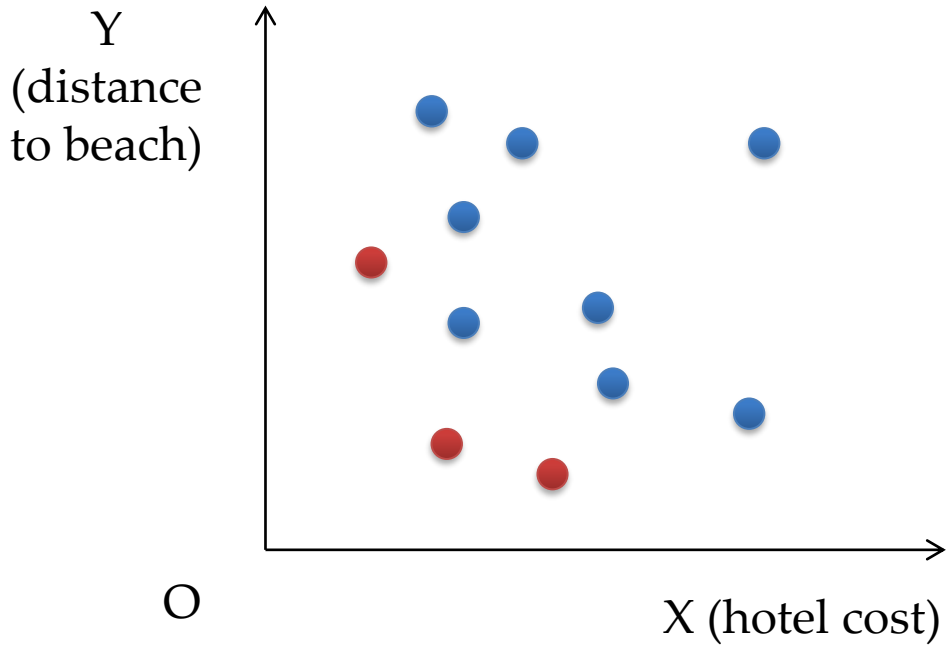
Example (1)

- Skyline points



Example (2)

- Skyline points (cont)



Exercise

- Consider one of your concepts and define it
  - Requirement: mathematically expressible or machine computable

Key Points

- You must have already considered
  - Research problem
  - Inadequacy of related work
  - Insight of your proposal

- Common mistake
  - They are what I have to consider when writing papers

Research Problem

- What I am going to address in this work
- Scope
  - What I can address (applicable scenarios)
  - What I cannot address (limitations)
- Never overclaim or claim imprecisely

Exercise

- Present your research problem

- Answer questions about its scope
  - What I can address
  - What I cannot address

Motivating Example

- Motivating example always with research problem

- Purpose
  - Give *concrete* evidence why we need new efforts
  - Not concrete => nothing (should be discarded)

- Where?
  - Placed in the introduction or a separate section if it is large (when comparing several techniques concretely)

Related Work

- Inadequacy of related work
  - Must be analyzed before proceeding to your proposal
- Requirements
  - The inadequacy should be demonstrated *concretely* using the motivating example or other strong evidence
  - The inadequacy should be discussed *precisely*
- Do not criticize others' work (say difference)

Insight

- Insight of your proposal
  - Key observations or efforts that make your proposal *able to (effectively) address* the research problem, while existing work cannot
  - Link it to a fundamental research problem

- This should not be implementation efforts
  - You are supposed to have made progress in research *methodology*

Common Mistakes

- Pick up a topic that seemingly has not been addressed by existing work
  - Why has it not been addressed before?
- Claim your work without justification
  - You need evidence to back you up
- Mixing framework and implementation
  - Must be *sound* at the framework (theory) level

Now

- You are supposed to
  - Have understood what a good presentation is
  - Work out how to get closer to this goal (long practice)
- Everybody has his (her) own way to go
  - We point out loopholes in your presentation
  - You fix them! And more iterations come…
- Earn experience for yourself

Exercise

- Describe your work
  - Word limit: 150
- Requirement: good presentation
  - Self-explained
  - Research problem + inadequacy of existing work + insight of your proposal + evaluation results or plan

III. Experimentation

1. Questions and subjects
2. Experimental design
3. Threats to validity
4. Exercise and discussion

General

- Experimentation
  - Is not merely a description of the experimental procedure and a list of experimental results
  - Should have a careful *design* (questions and variables) and discuss potential *threats* (construct validity, internal validity, external validity, and conclusion validity)

Experimentation and Case Study

- Experimentation
  - In a lab environment
  - Variables (factors) can be isolated and *controlled*
- Case study
  - Under an industrial (real-world) setting
  - Hard to repeat
- We mostly conduct *controlled experiments*

Key Points (1)

- *Questions* to answer
  - Is Tool A *better* than Tool B?

Why would we expect it to be better?

Why do we need to know?

What will we do with the answer?

Better at doing what?

E.g., Study or physical exercise?

Better in what way?

E.g., Efficiency or durability?

Better in what situations?

E.g., In classroom or dorm?

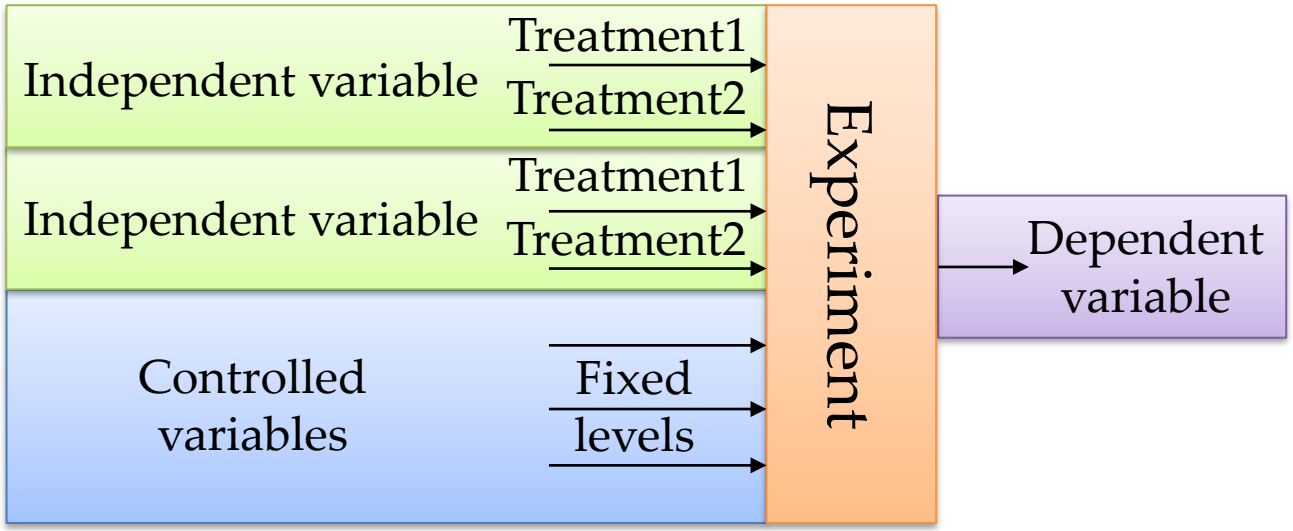
Key Points (2)

- *Subjects* selected
  - Sample of what population?
  - Consider the *representativeness*

- *Variables* and *threats* to validity
  - Variables: See the next page
  - Threats to validity: See an example

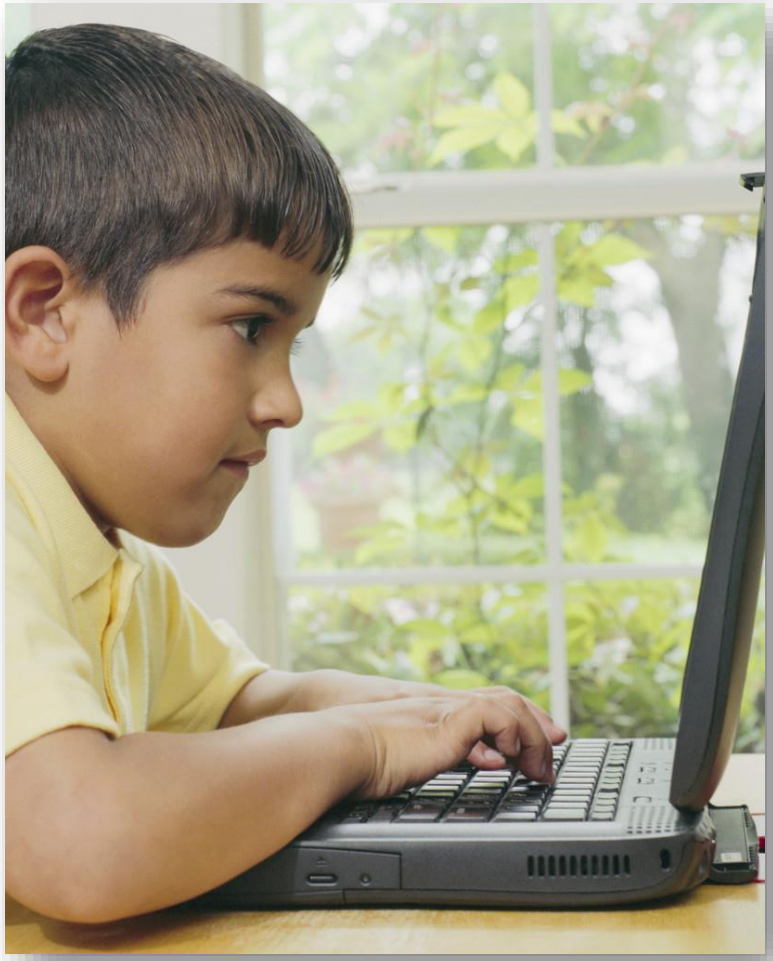
Variables

- Independent variables (factors)
- Dependent variables
- Controlled variables



Example

- Name
  - Stuart Bean ("stu")
- Topic
  - Merging stakeholder views in model-driven development
- Status
  - 2 years into his PhD study
  - Has built a tool
  - Needs evaluation

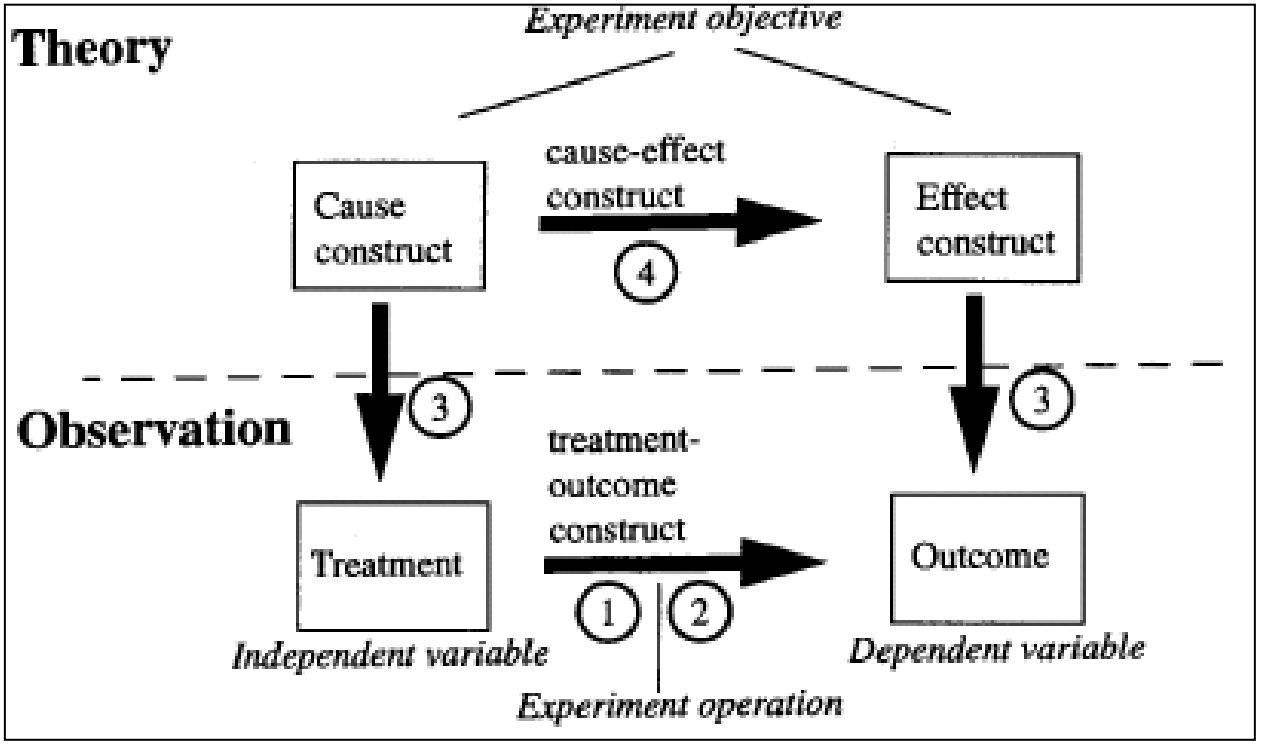


Stu's Evaluation Plan

- Experiments
  - Independent variable: Stu-merge vs. Rational Architect (RA)
  - Dependent variables: correctness, speed, assessment
  - Controlled variables: task (merging class diagrams from two different stakeholders' models), subjects (graduate students in software engineering)
- Hypotheses
  - H1: Stu-merge produces *correct* merges *more often* than RA
  - H2: Subjects produce merges *faster* with Stu-merge than RA
  - H3: Subjects *prefer* using Stu-merge to RA
- H1 accepted (strong evidence), H2 & H3 rejected

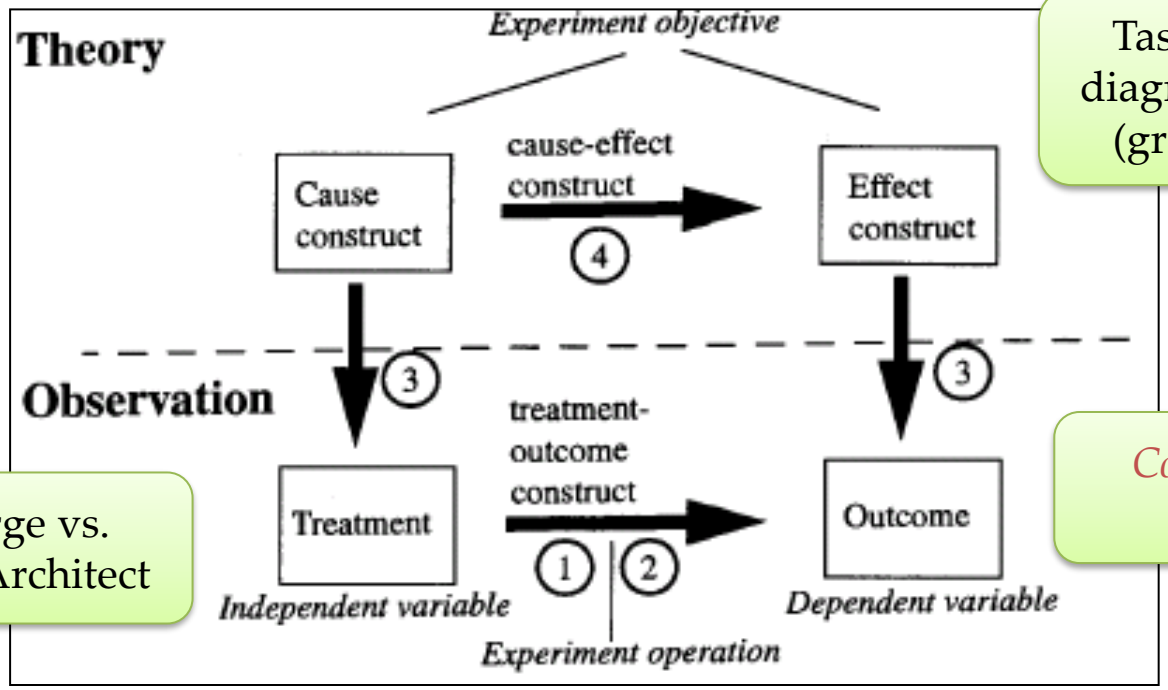
Threats to Validity Analysis

- ③ construct validity ② internal validity
- ④ external validity ① conclusion validity



Threats to Validity (1)

- ③ construct validity
  - What do we mean by a merge? What is correctness?
  - 0-5 point scale for subjective assessment - insufficient discriminatory power (both tools scored very low)



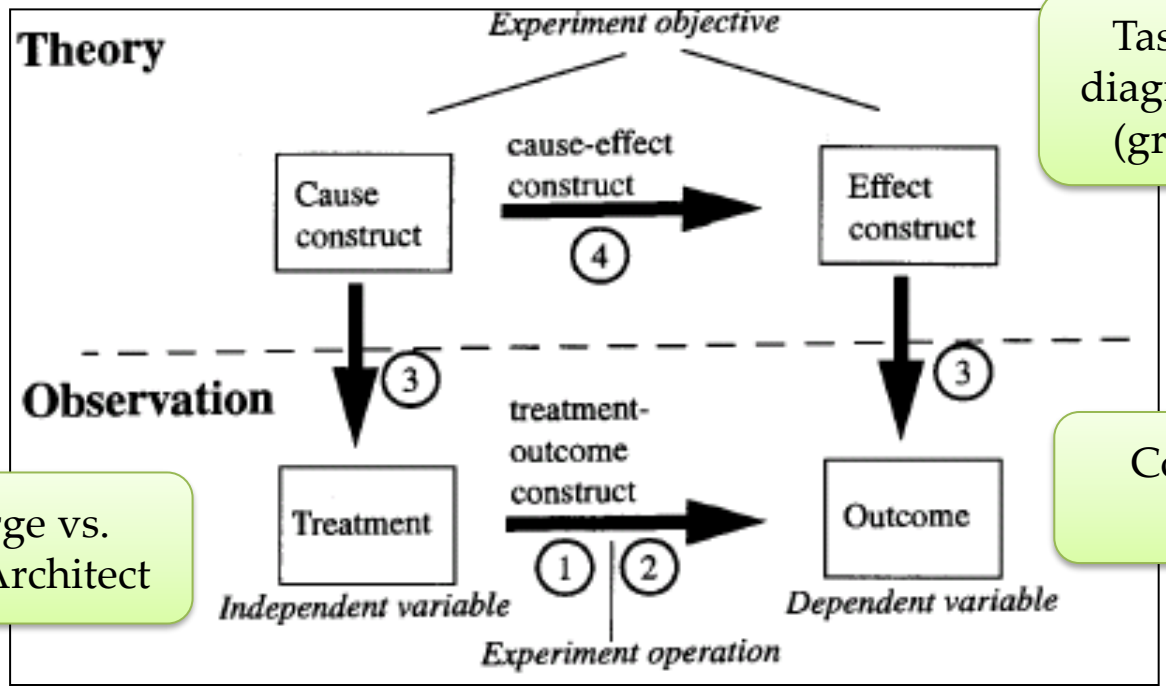
Task (merging class diagrams) and subjects (graduate students)

Stu-merge vs. Rational Architect

Correctness, speed, *assessment*

Threats to Validity (2)

- ② internal validity
  - *Confounding* variable: time taken to learn the tool (subjects were all familiar with RA, not with Stu-merge)



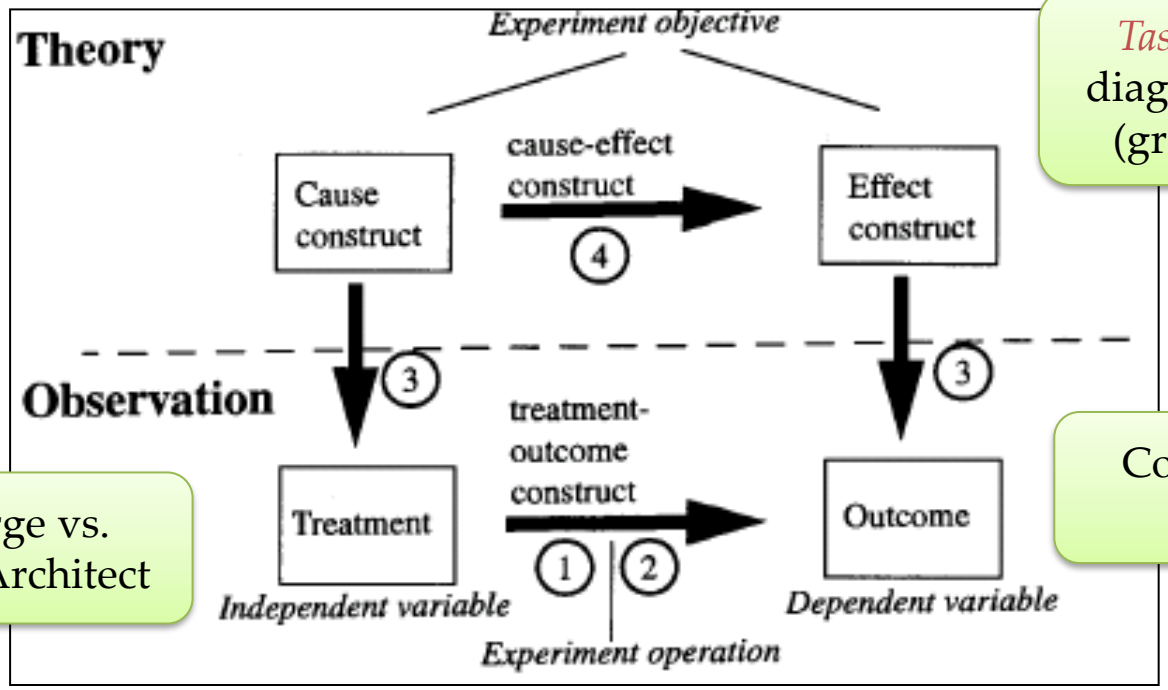
Task (merging class diagrams) and subjects (graduate students)

Stu-merge vs. Rational Architect

Correctness, *speed*, assessment

Threats to Validity (3)

- ④ external validity (representativeness)
  - Task: class diagram models were of a toy problem
  - Subject: graduate students as sample of what population?



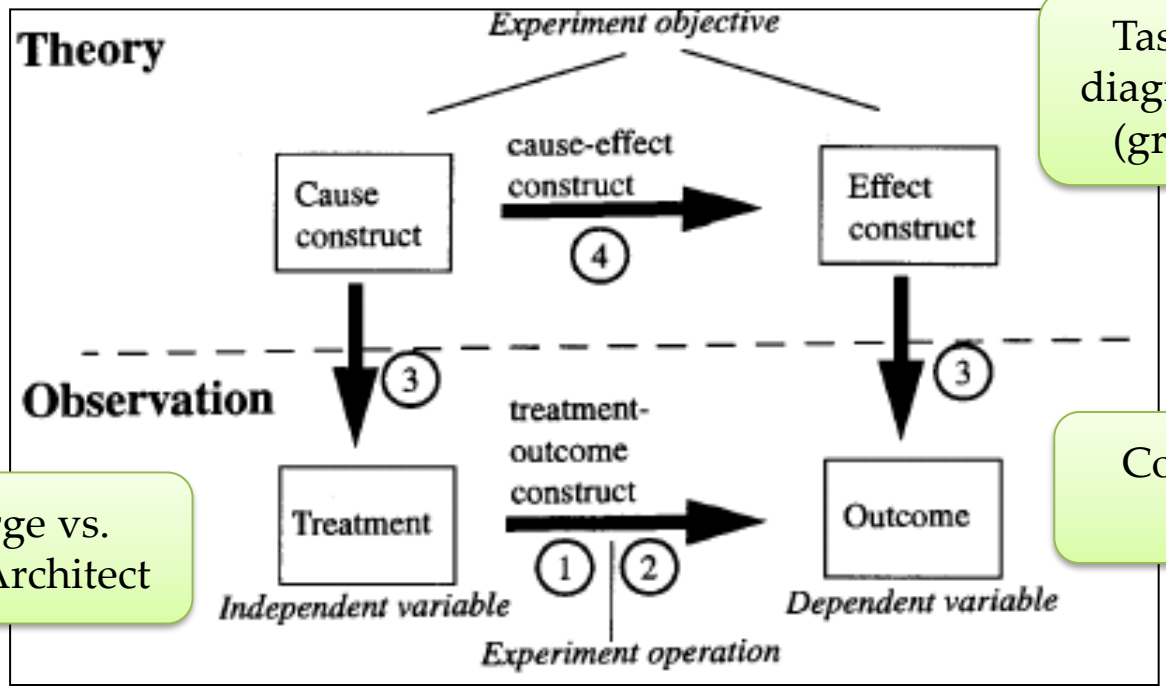
Task (merging class diagrams) and *subjects* (graduate students)

Stu-merge vs. Rational Architect

Correctness, speed, assessment

Threats to Validity (4)

- ① conclusion validity (theoretical reliability)
  - Bias: subjects knew Stu-merge was Stu's own tool



Task (merging class diagrams) and subjects (graduate students)

Stu-merge vs. Rational Architect

Correctness, speed, assessment

Exercise

- Describe your experimental design
  - *Questions* to answer
  - *Subjects* to select
  - *Independent* variables, *dependent* variables, and *controlled* variables (no *confounding* variable)

- Answer questions about
  - *Threats* to construct validity, internal validity, external validity, and conclusion validity
  - Why do they *not affect* your conclusion?

Referred Materials

- S.C. Cheung, “Empirical Experimentation”, COMP610F course slides, 2010.
- Steve Easterbrook, “Case Studies for Software Engineers”, FSE-DS keynote speech, 2006.
- Frances Kurilich and Helen Whitaker, “Re: Writing Strategies for Student Writers”, Harcourt College Pub, 1988.
- Xinming Wang, “Empirical Studies in Software Engineering”, group meeting talk, 2007.
- Tao Xie, “Common Technical Writing Issues” and “How to Write Research Papers”, HKUST-visit talk, 2007.