Research Methodologies

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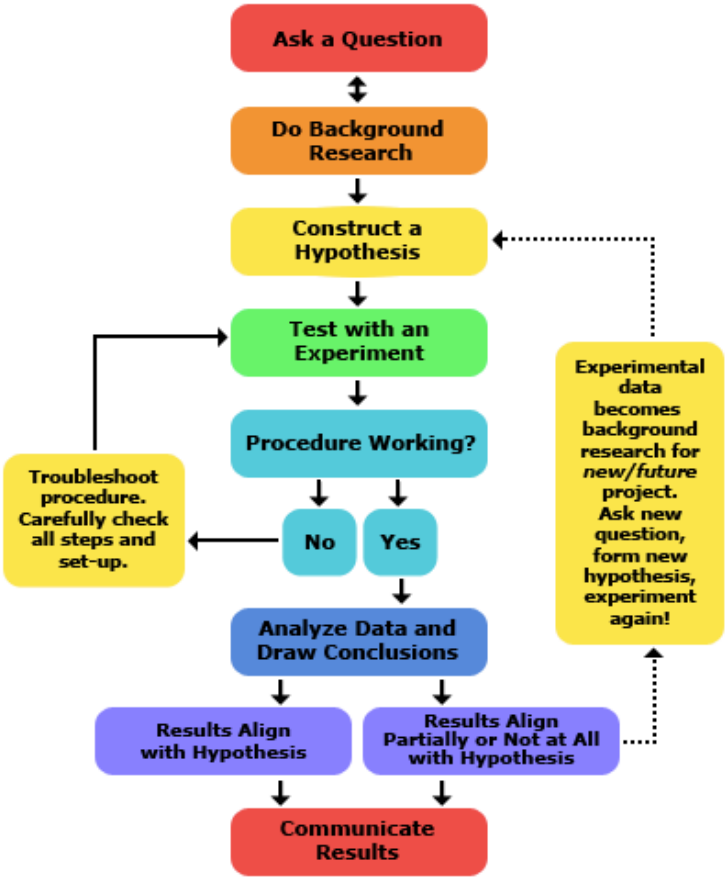
Overview of Research Methodologies

- Qualitative Research
  - Ethnography, Case Study, Grounded Theory, Autobiography, Participatory Action Research, Phenomenology (each grounded in a specific discipline and philosophical assumptions)
- Quantitative Research
  - Case studies, survey methods, experiments
- Mixed Methods
  - Draw from qualitative and quantitative methods

Quantitative

- A quantitative approach is one in which the investigator primarily uses post-positivist claims for developing knowledge (i.e. cause and effect thinking, reduction to specific variables and hypotheses and questions, use of measurement and observation, and the test of theories). (Creswell, 2003, p.19)

Scientific Method



http://www.sciencebuddies.org/science-fair-projects/project_scientific_method.shtml#overviewofthescientificmethod

Falsifiability

- Hypothesis can be disproven
  - Can conceive of an observation that would disprove the hypothesis
- Example
  - All swans are white

Sheep in Scotland

- A mathematician, a physicist, and an engineer are riding a train through Scotland.

- The **engineer** looks out the window, sees a black sheep, and exclaims, "Hey! They've got black sheep in Scotland!"

- The **physicist** looks out the window and corrects the engineer, "Strictly speaking, all we know is that there's at least one black sheep in Scotland."

- The **mathematician** looks out the window and corrects the physicist, " Strictly speaking, all we know is that is that at least one side of one sheep is black in Scotland."

Good Hypotheses

- It is theoretically **grounded**: it is based upon literature relevant to the topic.
- It specifies the **relationship** between the values of two or more variables.
  - Direction (or **tendency**) of the relationship
- It makes a **testable** comparison using empirical data.

http://writing2.richmond.edu/writing/wweb/polisci/hypothesis.html

Bad Hypotheses

- Not falsifiable
  - Buggy files are related to changes 
- Too vague
  - Some projects will have more bugs than others
- Not measurable
  - Bad developers introduce more bugs

Fixing the Hypotheses

- Not falsifiable
  - Buggy files are related to changes
  - Files that change frequently are positively correlated with files that contain more bugs.
- Too vague
  - Some projects will have more bugs than others
  - Infrastructure projects have a fewer bugs per LOC than end user software
- Not measurable

  - Bad developers introduce more bugs
  - Developer evaluations are negatively related to the number of bugs they introduce to files.

Activity: Translate your research question into a hypothesis

- It is theoretically grounded: it is based upon literature relevant to the topic.
- It specifies the relationship between the values of two or more variables.
  - Direction (or tendency) of the relationship
- It makes a testable comparison using empirical data.

Confounds

- The number of changes to a file is positively related to the number of bugs
- Confounds
  - Expertise of developers working on the file
  - Complexity of the file
  - etc

Experiment

- Controlled environment
  - All developers have similar training
  - All work on the same files
- Vary only
  - The number of changes developers make to the files
  - How many bugs are introduced

Limitations of Experiments

- Reductionist
  - Assume it is possible to eliminate all confounds
  - Assume that variable under study is interesting to real situations
  - More controls, more conditions
- Interactions
  - Setting is often important
  - How do the different variable interact with each other
- Very time consuming to construct

Case Study

- “Phenomenon and context are not readily separable”, Yin
- The interactions are the most important part
- Setting is important
- Extract measures and model from real data

Data and Methodology

- Case study
  - Which software projects did you choose and why
  - Large size, successful, tie to your question
- Data
  - Where did it come from
    - Version history, bug repository, etc
  - How did you mine and link it?
  - Any anomalies or things you had to clean?
  - Other limitations of the data

Methodology Measures

- For your paper:
  - We have specific measures for each of our research questions
  - Each measure will be operationalized in the section in which it is used.
  - The validity and limitation of each measure is also discussed in the section in which it is used.

Measures

- Tied to each research question
  - Give the motivation and background
- Often a proxy of what we want to measure
  - Describe what we want to measure and how we are limited by the data we have
- Describe how it is measured or calculated

Developer Expertise

- Motivation: Expertise has been described as an important predictor of developer success
- How: We measure expertise as the number of changes a developer makes to the system
- Assumption/limitation: developer may make trivial changes or commit other developers changes
- Alternatives: Weighted, by area

Activity

- Describe a measure to test your hypothesis

Statistical Model

- The number of bugs is predicted by …
  - Bugs ~ churn + expertise + location + org_size + … + your_new_factor
- Dependent variable or response variable
  - Outcome you are trying to predict (eg Bugs)
- Control variables
  - The variables that others have measured that might affect your prediction (churn, expertise)
- Independent variables
  - The measures that are in your research questions or hypothesizes (your_new_factor)

Bugs predicted by

Class	Predictor	Est.	StdErr	p-val	Devnc
File	log(LOC)	0.43	0.03	0.00	2450
Chng	log(Logical)	0.25	0.02	0.00	978
	log(Releases)	2.67	0.07	0.00	2331
	log(Diffusion)	0.08	0.03	0.00	321
Socl	log(Workflow)	0.43	0.05	0.00	255
	log(Experience)	0.28	0.04	0.00	13
Geo	Distributed	0.14	0.07	0.04	41.94
	Mentor	0.53	0.12	0.00	27.97
Org	log(OrgSize)	0.48	0.06	0.00	160
	log(From)	−0.40	0.07	0.00	51
	log(Until)	−0.06	0.03	0.09	6
	log(Left + 1)	0.33	0.04	0.00	74
	log(New + 1)	−0.01	0.04	0.70	0

Activity

- Name the response or dependent variable
- Name the factor or measure you are introducing
- Discuss confounding factors.
- Write your model

Validity

- Construct Validity
  - Are our measurements meaningful
  - Are we measuring the right thing?
- Internal Validity
  - Other plausible rival hypotheses to explain findings
- External Validity
  - Do the findings generalize to other settings?
- Reliability
  - Would other researchers get the same results?

Validity

- Construct Validity
  - Based on previous studies, others have used similar measures
- Internal Validity
  - How good are our predictions?
  - Explain most of variance, good internal validity
- External Validity
  - Did you choose a representative sample of projects?
- Reliability
  - Data quality and data publically available
  - Historical data that is publically available

Selecting Cases and Replication

- Problem: findings from a single case study only applies to that case study
  - Limited generalizability
- Replicate on other projects
  - Which to select?

Selecting Cases and Replication

- Dimensions or framework of features that are interesting
    - Size in terms of files, complexity, number of devs, domain, etc
- Literal replication
  - First test of findings
  - Do they hold in similar case studies
- Contrasting replications
  - Choose the cases that that will test the findings that are the weakest

Empirical Software Engineering Method

- Questions and Hypotheses
- Method, Data, and Study Design
- Measures (descriptive statistics)
- Statistical Model
- Results
- Discussion
- Theory answers questions
- Modify hypotheses

Qualitative Research

Qualitative - Definition

- A qualitative approach is one in which the inquirer often makes knowledge claims based primarily on **constructivist** perspectives (i.e. the multiple meanings of individual experiences, meanings socially and historically constructed, with an intent of developing a theory or pattern) or advocacy/ participatory perspectives (i.e. political, issue-oriented, collaborative or change oriented) or both. (Creswell, 2003, p.18)

Research Questions

- Qualitative
  - In qualitative study inquirers state research questions, **not objectives** (i.e. specific goals for the research) or hypotheses (i.e. predictions that involve variables and statistical tests). (C., 2003, p.105)

Characteristics of Qualitative Research

- Takes place in the **natural** setting
- Uses multiple methods that are **interpretive**
- Is **emergent** rather than tightly prefigured
- Fundamentally interpretive (role of researcher as **interpreter**)
- Researcher views social phenomena **holistically**
- Researcher systematically reflects on their own **bias** and perspectives
- Researcher uses **complex reasoning** that is multifaceted, iterative, and simultaneous
- Researcher adopts and uses one or more strategies of inquiry

Research Methods

- Interviews
- Focusgroups
- Participant observation (field notes)
- Video
- Text and Image analysis (documents, media data)

Data Analysis (C., p.191)

- Organize and prepare the data for analysis
- **Read all data**, get a sense of the whole
- Begin detailed analysis with **coding** process
- Generate a description of the setting/people as well as categories or **themes** for analysis
- Represent themes (writing, visual, etc.)
- **Interpret** and make meaning out of data
- *iterative, non-linear process

Credibility

- Use of Triangulation
- Use of Member Checking
- Clarification of Bias
- Use of Negative or discrepant information
- Prolonged field time
- Peer Debriefing
- (C., 2003, p.196)

Useful Methods

- Participant observation
- Interviews/Focusgroups with stakeholders
- Survey
- User testing
- Ethnography

Choice of Methodology & Methods

- Depends on
  - Research Questions
  - Research Goals
  - Researcher Beliefs and Values
  - Researcher Skills
  - Time and Funds

References

- Creswell, J.W. (2003). *Research design. Qualitative, quantitative and mixed methods approaches*
- R.K. Yin *Case Study Research: Design and Methods*
- Required reading:
  - Easterbrook et al *Selecting Empirical Methods for Software Engineering Research*
    - http://www.cs.toronto.edu/~sme/papers/2007/SelectingEmpiricalMethods.pdf