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RESEARCH METHODS IN SE

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Software Engineering (SE)

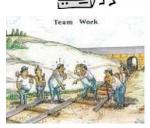
- □ A multi-disciplinary field
- We need to investigate
 - Which tools, techniques, and processes they use?,
 - What social and cognitive processes surrounding them?
 - How individual software engineer develop software?
 - How teams and organizations coordinate their efforts?











Research Methods

- Controlled Experiments (including Quasi-Experiments)
- □ Case Studies (both exploratory and confirmatory)
- □ Survey Research
- Ethnographies
- Action Research

Empirical Investigations

- Common tasks
 - Identify goals, questions and measures (metrics)
 - Choosing research method(s)
 - □ Planning, designing, and carry out investigations
 - Data collection,
 - Data Analysis
 - Results
 - Validity considerations
 - Conclusions

Two Motivating Examples

- To assess the effectiveness of a novel fisheye-view file navigator
- To assess how developers in industry use (or not)
 UML diagrams during software design

Research Questions

Kind of research questions

- RQ. "Is a fisheye-view file navigator more efficient than the traditional view for file navigation?"
- □ Ambiguous!
 - □ Who?
 - File navigation?
 - □ Circumstances?
 - □ Efficiency?

- RQ. "how widely are UML diagrams used as collaborative shared artefacts during design?"
- □ Ambiguous!

Defining the precise meaning of terms is Crucial!

Formulating exploratory Questions

- □ Existence Questions
 - Ex: "Does X exists?"
- Classification Questions
 - Ex: "What is X like?"
- Descriptive-Comparative Questions
 - Ex: "How does X differ from Y?"

Formulating Base-rate Questions

- Frequency and distribution questions
 - Ex: "How often does X occur?", "What is an average amount of X?"
- Descriptive-Process questions
 - Ex: "How does X normally work?"
- Relationship questions
 - Ex: "Are X and Y related?"
 - Correlation and Causality

Formulating Base-rate Questions

- Causality Relationship questions
 - □ Causality questions -"Does X cause Y?"
 - Causality-Comparative questions "Does X cause more Y than does Z?"
 - Causality-Comparative Interaction "Does X or Z cause more Y under one condition but not others?"

Choosing a Research Method

- Depends
 - available resources,
 - access to subjects,
 - opportunity to control
 - the variables of interest,
 - the skills of the researcher
 - how closely the method aligns with the question(s) that have been posed

Controlled Experiments

- Investigation of a testable hypothesis suggesting causal relationships
- Identification of study variables and instruments
 - Independent, dependent, block variables
 - Subjects, objects
- Design of experiments
- More of a quantitative than qualitative method
- □ Theory driven
- Validity consideration

Controlled Experiment

- Strengths
 - Theory driven
 - Exercise maximum degree of control over study variables
 - Repeatable
 - Better generalization is possible
 - A tool for SE education

Controlled Experiments

- Weaknesses or Limitations
 - Small Scope
 - Underlying assumptions may be wrong
 - □ Tends to be artificial

Case Studies

- "An empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident." [Yin 2002]
- □ Exploratory vs. confirmatory
- □ Selection of a case is a crucial step
 - Purposive sampling vs. random sampling
- Quantitative as well as qualitative

Case Studies

Strengths

- Offer in-depth understanding of a phenomenon in real situations
- Situations where effects are expected to be wide ranging, or take a long time (e.g. weeks, months, years) to appear
- situations where the context is expected to play a role in the phenomena

Case Studies

Weaknesses

- the data collection and analysis is more open to interpretation and researcher bias
- Limited generalization

Surveys

- Characteristics of a broad population of individuals
- □ Use of interviews/questionnaires for data collection
- Selection of a representative sample from a welldefined population
 - More of a qualitative than quantitative

Surveys

- Strengths
 - Small to large scope
 - Generalizable

Surveys

- Weaknesses
 - control for sampling bias
 - Low response rate can be problematic
 - Inappropriate survey questions
 - □ Difficult to interpret or less insightful

Ethenographics

- □ Field studies
- □ Study a community of people
- focus on a broad technical community (e.g. Java programmers in general), or a small, closely knit community (e.g. a single development team)
- Researcher as an observer or a participant observer
- The biggest challenge is to perform detailed observation, data collection, and analysis

Action Research

- Solving a real-world problem while simultaneously studying it
- A long drawn method
- An iterative approach to problem solving
- Immaturity as an empirical method (tends to be ad hoc)
- An appealing framework for mixing research with professional activities

Mixed-Mode Approaches

- All methods have limitations
- Weaknesses of one method can be compensated for by the strengths of other methods
- □ Key decisions involve
 - the strategy for data collection
 - the sequence in which different methods are employed
 - quantitative and qualitative data
- □ Three general approaches
 - Sequential explanatory strategy
 - Sequential exploratory strategy
 - Concurrent triangulation strategy

Data Collection Techniques

Separate lecture

Empirical Validity

- □ Construct validity:
 - the "right" (relevant and minimal) metrics, design
 - "Are we actually measuring what we intend to measure?"
- □ Internal validity:
 - the "right" data values.
 - "Does the data really follows from the experimental concepts?"
- □ Conclusion validity:
 - the right (appropriate) data analysis?
- □ External validity:
 - the "right" (representative) context
 - "Can the results of the experiment be generalized?"

Threats to validity

Examples:

- Violated assumptions of statistical tests
- Researchers may influence the results by looking for a specific outcome.
- □ If the group is very heterogeneous there is a risk that the variation due to individual differences is larger than due to the treatment.
- Incorrectly designed Experiment
- Effect of confounding factors
- Research bias
- □ ...

Other Dangers

- Manipulating several explanatory variables simultaneously so the effect on the response variable cannot be interpreted
- Over-complex design
- □ Carryover effects or learning
- Insufficient subjects (lack of power)
- Unrealistic task/environment
- Unrepresentative subjects usually students

Confounding Effects in SE Experiment

- □ Technique Learning Effect
- □ Object Learning Effect
- □ Boredom Effect
- Enthusiasm Effect
- □ Experience Effect
- □ Procedure Effect

Practical Considerations

- Relate to time, budget and personnel resources, and access to data
- Methods that are primarily qualitative
 - Designing good research question
 - Researching skills Observation, recording social behavior, patience,
- □ Methods that are primarily quantitative
 - Require more significant time in the planning
 - □ Pilot studies
 - Researching Skills critique, management, innovation

Conclusions

- □ An overview of research methods
- □ Each has its own strengths and weakness
- □ Use of mixing-methods
- Validity considerations

References

Guide to Advanced Empirical Software Engineering,
 Forest Shull, Janice Singer, and Dag I.K. Sjøberg,
 Springer 2008