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Case Studies

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What "Case Study" means?

- The term case study frequently appears in title and abstracts of papers
  - Its meaning varies a lot
- A case study is defined as an empirical method aimed at investigating a object (or phenomena) in its context
  - It relies on multiple sources of evidence

Case Study in SE

- Software engineering is a multi disciplinary discipline and involves
  - Psychology, sociology, business, etc.
  - Case studies are common in these disciplines
- Case studies are suitable for many kinds of Software Engineering research

Key Characteristics

- It is flexible to cope with complex or dynamic phenomena of the real world
- Its conclusions are based on multiple sources of evidence
- It adds to existing knowledge about the phenomena under study

Flexibility of Case Studies

- A case study does not need strict boundaries between the studied object and its environment
  - Planning a case study is still necessary
- It provides deeper understanding of the phenomena under study in their real context

Sources of Evidence

- Different kinds of evidence, figures, statements, and documents are linked together to support the conclusions
  - Results are hard to generalize
- Case studies do not aim to provide conclusions with statistical significance

Advantages and Drawbacks

- Advantages
  - Case studies are easier to plan
  - Results are more realistic
- Drawbacks
  - Data are hard to interpret
  - Results are difficult to generalize

The Case Study Process

- A case study involves five activities
  1. Planning (define its goal and protocol)
  2. Preparation for data collection
  3. Data collection
  4. Data Analysis
  5. Reporting

Planning a Case Study

Planning a Case Study

- The following elements should be taken into consideration in the planning phase
  - Goal: what to achieve?
  - Research questions: what to know?
  - The case: what is studied?
  - Theory: what is the frame of reference?
  - Methods: How to collect data?
  - Selection strategy: where to seek for data?

Goal and Research Questions

- The case study goal is more general and less precise than in fixed research experiments
- Research questions state what is needed to achieve the goal
  - The goal is refined in research questions
- Both goal and research questions evolve during the case study

The Case (Object)

- The case of study can be
  - A software project
  - A individual or group of people
  - A process, policy, or pattern
  - A technique or a tool, etc
- “Toy programs” or “toy projects” cannot be considered as case studies due to their lack of real-life context

Theory and Methods

- A theory is usually defined to make the context of the case study clear
  - It defines the frame of reference
  - The context can also be expressed in terms of viewpoints
- Methods to collect data are defined as
  - Direct (e.g., interviews)
  - Indirect (e.g., tool instrumentation)
  - Independent (e.g., analysis of documents)

Selection Strategy

- In case studies, the object of study is explicitly selected
  - In surveys and experiments, subjects are often randomly sampled
- Some criteria used in the selection
  - Typical or representative, critical, or unique in some extent
- Many case studies are selected based mainly on the availability

Data Collection

Types of Data Collection

- Data collection is divided into three levels
  - 1st Level (direct): the researcher is in direct contact with the subjects
  - 2nd Level (indirect): the researcher collects raw data without interacting with the subjects
  - 3rd Level (independent): analysis is based on artifacts already available

Costs and Control

	Costs	**Control**
1st Level	High	High
2nd Level	Medium	Medium
3rd Level	Low	Low

Data Sources

- Several sources of information should be used to reduce wrong conclusions
  - The conclusion is stronger if it is based on different data sources
- Some data sources are
  - Interview
  - Observations
  - Archival Data
  - Metrics

Interviews

- The researcher asks questions to the subjects
  - It is usually a one-to-one talk
- Interview questions are based on the research questions
- Open and closed questions can be used
  - Open questions: allow broad answers
  - Closed questions: limited set of alternatives

Structure of Interviews

- Interviews can be classified as
  - Unstructured: questions are formulated or adapted during the interview
  - Semi-structured: questions are planned in advance, but they are not necessarily asked in the same order. Additional questions are allowed
  - Structured: all questions are planned in advance and asked in the same order

Observations

- Observations can be used to investigate how software engineers conduct their tasks

	Degree of interaction with the researcher	Awareness of being observed
Cat. 1	High	High
Cat. 2	High	Low
Cat. 3	Low	High
Cat. 4	Low	Low

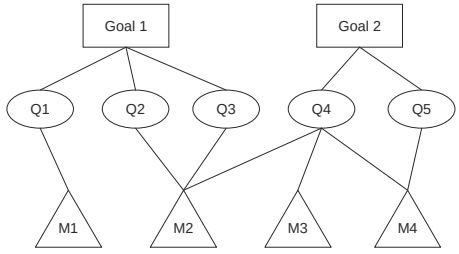
Archival Data

- Archival data is an independent type of data collection
- Different types of documents can be analyzed
  - Meeting minutes, requirements documents, failure reports, etc.
- It is important to considered that the documents were not developed exclusively for the case study

Metrics

- Metrics complement the case study with quantitative data
  - Archival data focuses on qualitative data
- Metrics can be defined (or selected) based on the GQM method
- Some measurements can already be available
  - Other should be collected to address specific questions of the case study

GQM Example



Data Analysis

Types of Data Analysis

- Quantitative Analysis
  - It usually includes descriptive statistics, correlation analysis, predictive models, and hypothesis testing
- Qualitative Analysis
  - Its goal is to derive conclusions from data, tracking them to evidence

Quantitative Analysis

- Descriptive statistics are used to understand the data
  - They rely on values, standard deviations, histograms, and scatter plots
- Correlation analysis and predictive models aim to relate later measures with an earlier software property

Quantitative: Hypothesis Testing

- Hypothesis testing is conducted to determine if results are significant
  - That is, if there is a significant effect of one or several independent variables on one or several dependent variables
- Significance tends to be low in a single case study due to the size of the data set

Qualitative Analysis

- Qualitative analysis can be carried out in parallel with data collection
  - New insights in the analysis can trigger further data collection
- More than one researcher conducting the analysis is important to minimize bias

Validity

- Validity denotes the trustworthiness of the results
  - To what extent the results are true and not biased by subjective points of view
- Validity must be addressed during all phases of the case study
- Aspects of validity
  - Construct, Internal, External, and Reliability (Conclusion)

Construct and Reliability

- Construct validity reflects to what extent the measures really represent what the researcher has in mind
  - Metrics should match the research questions
- Reliability (conclusion) reflects to what extent the data and analysis are dependent on the specific researchers
  - If another researcher replicate the study, results should be the same

Internal and External

- Internal validity is related to causal relations
  - One factor really affects the investigated factor? Is there a third factor that the researcher is not aware of?
- External validity reflects to what extend it is possible to generalize the findings
  - The findings are relevant to other cases
  - Can results be extended to cases with common characteristics?

Reporting the Results

Reporting

- The report communicates the findings of the case study
  - It is also the source of information to judge the quality of the study
- Characteristics that a report should have
  - Tell what the study was about
  - Communicate a clear sense of the case
  - Tell the history: what was done, who and how
  - Provide data and track them to the conclusions

Report Structure

- The most common and accepted structure includes
  - Problem
  - Related Work
  - Methods (case study design)
  - Analysis
  - Conclusions

Case Studies and Other Methods

Combining Methods

- A case study may contain elements of other research methods
  - Survey may me conducted within a case study
  - Literature review may precede it
  - Ethnographic methods can be used for data collection in a case study

Ethnographic Studies

- The experimenter observe the actual environment of a project
  - It often focuses on cultural practices
  - It has long duration
  - It relies on large amount of observation data
- A ethnographic study can be seen as a specialized type of case study

Survey vs. Case Study

- Survey is usually done in retrospect
  - Case study is done while a project is executed
- The purpose of surveys is to understand the population
  - Case Study targets a particular project

Case Study vs. Experiment

- The level of control is lower in a case study
- Case studies are most observational
- Experiments are more controlled

Comparative Table

	Survey	Case Study	Experiment
Design Type	Fixed	Flexible	Both
Qualitative / Quantitative	Both	Both	Quantitative
Execution Control	No	No	Yes
Control of Measure	No	Yes	Yes
Costs	Low	Medium	High
Replication	High	Low	High

Bibliography

- C. Wohlin et al. **Experimentation in Software Engineering**, Springer. 2012.
  - Chapter 5 – Case Studies