

# Case Studies for Software Engineers

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## Overview

1. **Recognizing Case Studies**
2. **Designing Case Studies**
3. **Publishing Case Studies**
4. **Reviewing Case Studies**

# 1. Recognizing Case Studies

## Overview of this Section

- ⇒ **Introduction**
  - ↳ What is a case study?
  - ↳ What is not a case study?
  - ↳ Why conduct a case study?
- ⇒ **Identification**
  - ↳ How can I tell it's a case study?
- ⇒ **Anatomy**
  - ↳ What are the parts of a case study?
- ⇒ **Critique**
  - ↳ How can I evaluate a case study?

## What is a case study?

- ⇒ **A case study is an empirical research method.**
  - ↳ It is not a subset or variant of other methods, such as experiments, surveys or historical study.
- ⇒ **Best suited to applied problems that need to be studied in context.**
  - ↳ Phenomena under study cannot be separated from context. Effects can be wide-ranging.
  - ↳ How and why questions
- ⇒ **Settings where researcher has little control over variables, e.g. field sites.**
- ⇒ **Effects take time to appear.**
  - ↳ Days, weeks, months, or years rather than minutes or hours.

## What is not a case study?

- ⇒ **Not an exemplar or case history**
  - ↳ In medicine and law, patients or clients are "cases." A review of interesting instance(s) is called a case study.
  - ↳ Not a report of something interesting that was tried on a toy problem
- ⇒ **Not an experience report**
  - ↳ Retrospective report on an experience (typically, industrial) with lessons learned
- ⇒ **Not a quasi-experiment with small n**
  - ↳ Weaker form of experiment with a small sample size
  - ↳ Uses a different logic for designing the study and for generalizing from results

## Why conduct a case study?

- ⇒ **To gain a deep understanding of a phenomenon**
  - ↳ Example: To understand the capability of a new tool
  - ↳ Example: To identify factors affecting communication in code inspections
  - ↳ Example: To characterize the process of coming up to speed on a project
- ⇒ **Objective of Investigation**
  - ↳ Exploration- To find what's out there
  - ↳ Characterization- To more fully describe
  - ↳ Validation- To find out whether a theory/hypothesis is true
- ⇒ **Subject of Investigation**
  - ↳ An intervention, e.g. tool, technique, method, approach to design, implementation, or organizational structure
  - ↳ An existing thing or process, e.g. a team, releases, defects

## When to use case studies

Strategy	Form of Research Question	Requires Control of Behavioral Events?	Focuses on contemporary events?
Experiment	How, why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival Analysis	Who, what where, how many, how much?	No	Yes/No
History	How, why?	No	No
Case Study	How, why?	No	Yes

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## How can I tell it's a case study?

- ⇒ Has research questions set out from the beginning of the study
- ⇒ Data is collected in a planned and consistent manner
- ⇒ Inferences are made from the data to answer the research questions
- ⇒ Produces an explanation, description, or causal analysis of a phenomenon
  - ↳ Can also be exploratory

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## What is a case study?

- ⇒ **A case study is 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.
- ⇒ **The case study inquiry**
  - ↳ Copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result
  - ↳ Relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result
  - ↳ Benefits from the prior development of theoretical propositions to guide data collection and analysis.

## Parts of a Case Study Research Design

- ⇒ **A research design is a “blueprint” for a study**
  - ↳ Deals more with the logic of the study than the logistics
  - ↳ Plan for moving from questions to answers
  - ↳ Ensures that the data is collected and analyzed to produce an answer to the initial research question
  - ↳ Strong similarities between a research design and a system design
- ⇒ **Five parts of a case study research design**
  1. Research questions
  2. Propositions (if any)
  3. Unit(s) of analysis
  4. Logic linking the data to the propositions
  5. Criteria for interpreting the findings

## Part 1: Study Questions

- ⇒ **Case studies are most appropriate for research questions that are of the “how” and “why” variety**
- ⇒ **The initial task is to clarify precisely the nature of the study questions (i.e. make sure they are actually “how” or “why” questions)**
- ⇒ **Examples:**
  - ↳ “Why do 2 organizations have a collaborative relationship?”
  - ↳ “Why do developers prefer this tool/model/notation?”
  - ↳ “How are inspections carried out in practice?”
  - ↳ “How does agile development work in practice?”
  - ↳ “Why do programmers fail to document their code?”
  - ↳ “How does software evolve over time?”
  - ↳ “Why have formal methods not been adopted widely for safety critical applications?”
  - ↳ “How does a company identify which software development projects to start?”

## Types of Case Studies

### ⇒ Explanatory

- ↳ Adjudicates between competing explanations
- ↳ Example: How important is implementation bias in requirements engineering?
  - Rival theories: existing architectures are useful for anchoring, vs. existing architectures are over-constraining during RE

### ⇒ Descriptive

- ↳ Describes sequence of events and underlying mechanisms
- ↳ Example: How does pair programming actually work?
- ↳ Example: How do software immigrants naturalize?

### ⇒ Causal

- ↳ Looks for causal relationship between concepts
- ↳ Example: Requirements errors are more likely to cause safety-related defects than programming errors are
  - See study by Robyn Lutz on the Voyager and Galileo spacecraft

### ⇒ Exploratory

- ↳ Criteria or parameters instead of purpose
- ↳ Example: Christopher Columbus' voyage to the new world
- ↳ Example: What do CMM level 3 organizations have in common?

## Part 2: Study Propositions

- ⇒ Propositions are statements that help direct attention to something that should be examined in the case study, i.e. point to what should be studied
  - ↳ Example: "Organizations collaborate because they derive mutual benefits"
- ⇒ Propositions will tell you where to look for relevant evidence
  - ↳ Example: Define and ascertain the specific benefits to each organization
- ⇒ Some studies may not have propositions - this implies a topic of "exploration"
  - ↳ Note: Even exploratory studies should have both clearly-stated purposes and clearly-stated criteria for success



## Part 3: Unit of Analysis

- ⇒ The unit of analysis defines what a “case” is in a case study
  - ↳ Example: a unit of analysis (case) may be an individual, and the case study may be the life history of that person
- ⇒ Other units of analysis include decisions, social programs, processes, changes
  - ↳ Note: It is important to clarify the definition of these cases as they may be subjective, e.g. the beginning and end points of a process
- ⇒ What unit of analysis to use generally depends on the primary research questions
- ⇒ Once defined, the unit of analysis can still be changed if desired, e.g. as a result of discoveries based on data
- ⇒ In order to compare results with previous studies (or allow others to compare results with yours), try to select a unit of analysis that is or can be used by others

## Examples of Units of Analysis

- ⇒ For a study of how software immigrants naturalize
  - ↳ Individuals
  - ↳ Development team
  - ↳ Organization
- ⇒ For a study of pair programming
  - ↳ Programming episode
  - ↳ Pairs of programmers
  - ↳ Development team
  - ↳ Organization
- ⇒ For a study of software evolution
  - ↳ Modification report
  - ↳ File
  - ↳ System
  - ↳ Release
  - ↳ Stable release

## Part 4: Linking Logic

- ⇒ Logic or reasoning to link data to propositions
- ⇒ One of the least well developed components in case studies
- ⇒ Many ways to perform this, but none as precisely defined as the treatment/subject approach used in experiments
- ⇒ One possibility is pattern matching
  - ↳ Describe several potential patterns, then compare the case study data to the patterns and see which one is closer

## Part 5: Interpretation Criteria

- ⇒ Need criteria for interpreting a study's findings
- ⇒ Also a relatively undeveloped component in case studies
- ⇒ Statistical tests not possible when only single data points are captured (as is the case with single-case studies)
  - ↳ Currently there is no precise way of setting the criteria for interpreting these types of findings

## Generalizing from Case Study to Theory

- ⇒ “The appropriately developed theory is also at the level at which generalization of the case study results will occur”
- ⇒ Theory for case studies is characterized as **analytic generalization** and is contrasted with another way of generalizing results known as **statistical generalization**
- ⇒ Understanding the difference between these two types of generalization is important

## Analytical and Statistical Generalization

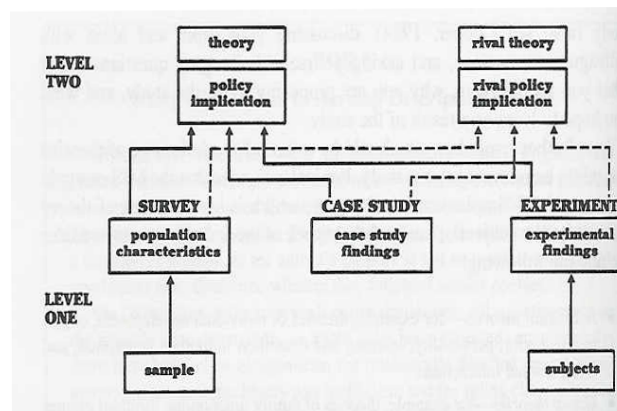


Figure 2.2 Making Inferences: Two Levels

## Statistical Generalization

- ⇒ Making an inference about a population on the basis of empirical data collected about a sample
- ⇒ This method of generalization is commonly recognized because research investigators have quantitative formulas characterizing generalizations that can be made
  - ↳ Examples: significance, confidence, size of the effect, power of test
- ⇒ Using this as a method of generalizing the results of a case study is a "fatal flaw", since cases are not sampling units, nor should they be chosen for this reason
- ⇒ Statistical generalizations are considered a Level One Inference

## Analytical Generalization

- ⇒ Previously developed theory is used as a template with which to compare the empirical results of the case study
- ⇒ If 2 or more cases support the same theory, replication may be claimed
- ⇒ Results may be considered more "potent" if 2 or more cases support the same theory but don't support the same rival theory
- ⇒ Analytical generalizations are considered a Level 2 Inference
- ⇒ Aim toward analytical generalization in doing case studies
  - ↳ Avoid thinking in terms of samples when doing case studies

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## How can I evaluate a case study?

- ⇒ Using the same criteria for other empirical research
- ⇒ **Construct Validity**
  - ↳ Concepts being studied are operationalized and measured correctly
- ⇒ **Internal Validity**
  - ↳ Establish a causal relationship and distinguish spurious relationships
- ⇒ **External Validity**
  - ↳ Establish the domain to which a study's findings can be generalized
- ⇒ **Experimental Reliability**
  - ↳ Demonstrate that the study can be repeated with the same results

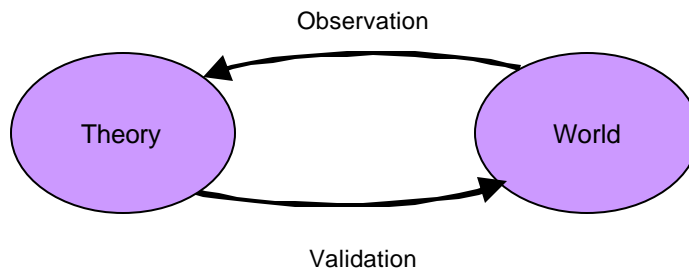
## 2. Designing a Case Study

## Overview of this Section

- ⇒ **Background**
  - ↳ Scientific Method
  - ↳ Role of Theory
  - ↳ Empirical Approaches
  - ↳ Concepts and Terminology
- ⇒ **Designing a Case Study**
  - ↳ Planning
  - ↳ Data Collection
  - ↳ Data Analysis
- ⇒ **Evaluation**
  - ↳ Validity and Threats to Validity

## Scientific Method

- ⇒ No single “official” scientific method  
<http://www.sit.wisc.edu/~crusbult/methods/science.htm>
- ⇒ However, there are commonalities



## High School Science Version

1. Observe some aspect of the universe.
2. Invent a tentative description, called a *hypothesis*, that is consistent with what you have observed.
3. Use the hypothesis to make predictions.
4. Test those predictions by experiments or further observations and modify the hypothesis in the light of your results.
5. Repeat steps 3 and 4 until there are no discrepancies between theory and experiment and/or observation.

## Some Characteristics of Science

- ⇒ Explanations are based on observations
  - ↳ A way of thinking
  - ↳ Relationships are perceptible in a way that has to make sense given accepted truths
- ⇒ Creativity is as important as in art
  - ↳ Hypotheses, experimental designs
  - ↳ Search for elegance, simplicity

## Some Definitions

- ⇒ A model is an abstract representation of a phenomenon or set of related phenomena
  - ↳ Some details included, others excluded
- ⇒ A theory is a set of statements that provides an explanation of a set of phenomena
- ⇒ A hypothesis is a testable statement that is derived from a theory
  - ↳ A hypothesis is not a theory!
- ⇒ In software engineering, there are few capital-T theories
  - ↳ Many small-t theories, philosophers call these *folk theories*



## Science and Theory

- ⇒ Science seeks to improve our understanding of the world.
- ⇒ Theories lie at the heart of what it means to do science.
  - ↳ Production of generalizable knowledge
  - ↳ Scientific method <-> Research Methodology <-> Proper Contributions for a Discipline
- ⇒ Note to self: theory provides orientation for data collection

## Definition of Theory

- ⇒ A set of statements that provide a causal explanation of a set of phenomena
  - ↳ Logically complete
  - ↳ Internally consistent
  - ↳ Falsifiable
- ⇒ Components: concepts, relations, causal inferences
- ⇒ More than straight description
- ⇒ Example: Conway's Law- structure of software reflects the structure of the team that builds it

## Empirical Approach

### Research Methodology

Question  
Formulation

Solution  
Creation

Validation

## Empirical Approaches

### ⇒ Three approaches

- ↪ Descriptive
- ↪ Relational
- ↪ Experimental

## Empirical Approaches

### ⇒ Descriptive

- ↳ Goal: careful mapping out a situation in order to describe what is happening
- ↳ Necessary first step in any research
  - Provides the basis or cornerstone
  - Provides the what
- ↳ Rarely sufficient - often want to know why or how
- ↳ But often provides the broad working hypothesis

## Empirical Approaches

### ⇒ Relational

- ↳ Need at least two sets of observations so that some phenomenon can be related to each other
- ↳ Two or more variables are measured and related to each other
- ↳ Coordinated observations -> quantitative degree of correlation
- ↳ Not sufficient to explain why there is a correlation

## Empirical Approaches

### ⇒ Experimental

- ↳ Focus on identification of causes, what leads to what
- ↳ Want "X is responsible for Y", not "X is related to Y"
- ↳ Experimental group versus control group
- ↳ Watch out for problems

## Concepts and Terminology

- ⇒ Predictor and criterion variables
  - ↳ Example: assessment predicting performance
- ⇒ Construct - an abstract idea that is used as an explanatory concept
  - ↳ Example: need for social approval
- ⇒ Reliable measurement - consistency
- ⇒ Validity in various forms

## Concepts and Terminology

### ⇒ Aspects of empirical reasoning

- ↳ Empirical principles: accepted truths justified on the basis of observations
- ↳ Deductive-statistical reasoning - universal laws
- ↳ Inductive-statistical reasoning - probabilistic assertions
  - They deal with uncertainty
  - They are not absolute, invariant rules of nature

### ⇒ Behavioral sciences are not sufficient to determine exactitude

- ↳ Human values and individual states of mind
- ↳ Unique nature of the situation which is usually not static
- ↳ Historical and social factors

## Validity

### ⇒ In software engineering, we worry about various issues:

- ↳ *E-Type systems:*
  - Usefulness - is it doing what is needed
  - Embodying important required characteristics - is it doing it in an acceptable or appropriate way
- ↳ *S-Type programs:*
  - correctness of functionality - is it doing what it is supposed to do
  - Embodying important required characteristics - are the structures consistent with the way it should perform

### ⇒ In empirical work, worried about similar kinds of things

- ↳ Are we testing what we mean to test
- ↳ Are the results due solely to our manipulations
- ↳ Are our conclusions justified
- ↳ What are the results applicable to

### ⇒ The questions correspond to different *validity* concerns

- ↳ The logic of demonstrating causal connections
- ↳ The logic of evidence

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## How Many Cases?

- ⇒ **Number of literal replications**
  - ↳ Its a discretionary, judgmental choice that depends on the certainty you want to have about your multiple-case results
  - ↳ As with statistical significance measures, there is greater certainty with a larger number of cases
  - ↳ 2 or 3 may be sufficient if they all have very different rival theories and the degree of certainty required is not high
  - ↳ 5, 6, or more may be needed for higher degree of certainty
- ⇒ **Number of theoretical replications**
  - ↳ Consider the complexity of the realm of external validity
  - ↳ If you are uncertain about effects of external conditions on your case study results, you may want to include more cases to address the impacts of these conditions in your study
  - ↳ If external conditions are not thought to produce much variation in the phenomenon being studied, a smaller number of theoretical replications may be used

## Case Study Designs

⇒ 4 types of designs based on a 2x2 matrix

- ↳ Type 1 - single-case (holistic) designs
- ↳ Type 2 - single-case (embedded) designs
- ↳ Type 3 - multiple-case (holistic) designs
- ↳ Type 4 - multiple-case (embedded) designs

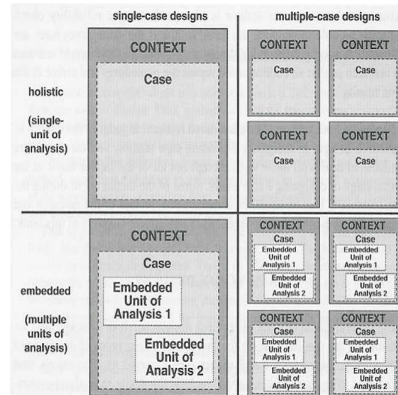


Figure 2.4 Basic Types of Designs for Case Studies (page 40)

## Rationale for Single-Case Designs

⇒ As you might guess, a single-case design uses a single case study to address the research questions

⇒ 5 reasons to use a single-case design

- ↳ The single case represents the *critical case* in testing a well-formulated theory
  - Example: the case meets all of the conditions for testing the theory thoroughly
- ↳ The single case represents an *extreme or unique case*
  - Example: a case with a rare disorder
- ↳ The single case is the *representative or typical case*, i.e. informs about common situations/experiences
- ↳ The single case is *revelatory* - it is a unique opportunity to study something that was previously inaccessible to observation
- ↳ The single case is *longitudinal* - it studies the same single case at two or more different points in time

## Holistic vs. Embedded Case Studies

- ⇒ The same case study can involve more than one unit of analysis if attention is given to subunit(s) within the case - this is called an *embedded* case study
  - ↳ Example: a case study about a single organization may have conclusions about the people (subunits) within the organization
- ⇒ If the case study examines only the global nature of one unit of analysis (not any subunits), it is a *holistic* design
  - ↳ Example: a case study about an organization

## Holistic Designs

- ⇒ **Strengths**
  - ↳ Advantageous when no logical subunits can be defined
  - ↳ Good when the relevant theory underlying the case study is holistic in nature
- ⇒ **Weaknesses**
  - ↳ Can lead to abstract studies with no clear measures or data
  - ↳ Harder to detect when the case study is shifting focus away from initial research questions



## Embedded Designs

### ⇒ Strengths

- ↳ Introduces higher sensitivity to “slippage” from the original research questions

### ⇒ Weaknesses

- ↳ Can lead to focusing only on the subunit (i.e. a multiple-case study of the subunits) and failure to return to the larger unit of analysis

## Multiple-Case Designs

- ⇒ If the same study contains more than a single case, it is a multiple-case design

### ⇒ Advantages

- ↳ Evidence is considered more compelling
- ↳ Overall study is therefore regarded as more robust

### ⇒ Disadvantages

- ↳ Rationale for single-case designs usually cannot be satisfied by multiple cases
- ↳ Can require extensive resources and time

## Replication in Multiple-Case Studies

- ⇒ When using multiple-case studies, each case must be carefully selected so that it either:
  - ↳ Predicts similar results (*literal replication*)
  - ↳ Predicts contrasting results but for predictable reasons (*theoretical replication*)
- ⇒ If all cases turn out as predicted, there is compelling support for the initial propositions
- ⇒ Otherwise the propositions must be revised and retested with another set of cases
- ⇒ With replication procedures, a theoretical framework must be developed that states the conditions under which a particular phenomenon is likely to be found (a literal replication) and the conditions when it is not likely to be found (a theoretical replication)
  - ↳ This framework is used to generalize to new cases

## Replication Logic vs. Sampling Logic

- ⇒ Consider multiple-cases analogous to multiple experiments (NOT analogous to multiple subjects within an experiment or multiple respondents in a survey)
- ⇒ This *replication logic* used in multiple-case studies must be distinguished from the *sampling logic* commonly used in surveys
  - ↳ Sampling logic requires defining a pool of potential respondents, then selecting a subset from that pool using a statistical procedure
  - ↳ Responses from the subset are supposed to accurately reflect the responses of the entire pool
  - ↳ This procedure is used to determine the prevalence or frequency of a particular phenomenon
- ⇒ Sampling logic is not for use with case studies
  - ↳ Case studies are not the best method for assessing the prevalence of phenomenon
  - ↳ Case studies would have to cover both the phenomenon of interest and its context, yielding a larger number of potential variables, and thus requiring an impossible number of cases
  - ↳ Sampling logic simply cannot be used for all types of empirical investigations

## Replication Approach for Multiple-Case Studies

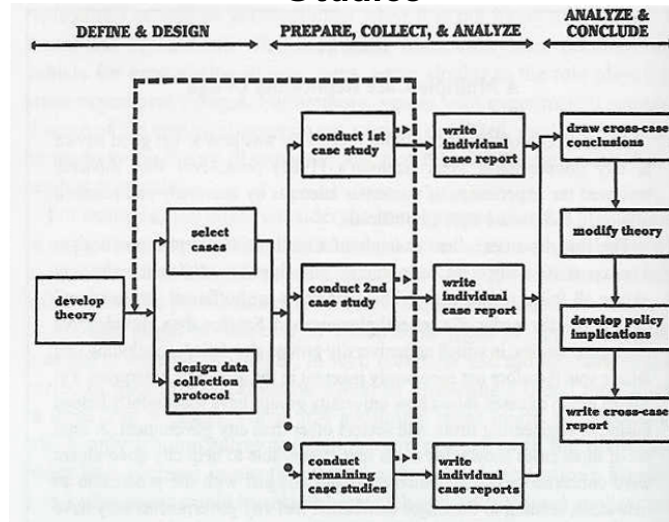


Figure 2.5 Case Study Method (page 50)

## Rationale for Multiple-Case Designs

- ⇒ Multiple-case designs are useful when literal or theoretical replications would provide valuable information for the study
- ⇒ More results that back your theory typically adds more credibility to your case study

## Multiple-Case Designs: Holistic or Embedded

- ⇒ A multiple-case study can consist of multiple holistic cases or multiple embedded cases, depending on the type of phenomenon being studied and the research questions
- ⇒ Note there is no mixing of embedded and holistic cases in the same multiple-case study
- ⇒ It is also important to note that for embedded studies, subunit data is NOT pooled across the subunits, but is used to draw conclusions for the subunit's case only

## Selecting Case Study Designs - Single or Multiple?

- ⇒ If you have a choice and the resources, multiple-case designs are preferred
  - ↳ Analytic conclusions independently arising from two cases will be more powerful than from a single case
  - ↳ The differences in context of multiple cases that have common conclusions provide for expanded generalizability of findings
  - ↳ If two deliberately contrasting cases are selected and findings support the hypothesized contrast, the results represent theoretical replication and strengthen external validity
- ⇒ Single-case studies are often criticized due to fears about uniqueness surrounding the case
  - ↳ Criticisms may turn to skepticism about your ability to do empirical work beyond a single-case study
  - ↳ If you choose single-case design, be prepared to make an extremely strong argument justifying your choice for the case

## Selecting Case Study Designs - Closed or Flexible?

- ⇒ A case study's design can be modified by new information or discovery during data collection
- ⇒ If you modify your design, be careful to understand the nature of the alteration:
  - ↳ Are you merely selecting different cases, or are you also changing the original theoretical concerns and objectives?
  - ↳ Flexibility in design does not allow for lack of rigor in design

## Collecting the Evidence

- ⇒ Six Sources of Evidence
- ⇒ Three Principles of Data Collection

## Six Sources of Evidence

- ⇒ Documentation
- ⇒ Archival Records
- ⇒ Interviews
- ⇒ Direct Observation
- ⇒ Participant -observation
- ⇒ Physical Artifacts

## Documentation

- ⇒ Letters, memos, and other written communication
- ⇒ Agendas, announcements, meeting minutes, reports of events
- ⇒ Administrative documents - proposals, progress reports, summaries and records
- ⇒ Formal studies or evaluations of the same site
- ⇒ Newspaper clippings, articles in media or newsletters
- ⇒ Example: Classifying modification reports as adaptive, perfective or corrective based on documentation

↳ Audris Mockus, Lawrence G. Votta: Identifying Reasons for Software Changes using Historic Databases. ICSM2000: pp. 120-130

## Archival Records

- ⇒ Service records- clients served over a period of time
- ⇒ Organizational records- org. charts and budgets
- ⇒ Maps and charts- layouts
- ⇒ Lists of names and relevant articles
- ⇒ Survey data - census records
- ⇒ Personal records - diaries, calendars, telephone lists
  
- ⇒ Example: Study of parallel changes to source code was based on revision control logs
  - ↳ Dewayne E. Perry, Harvey P. Siy, Lawrence G. Votta: Parallel changes in large-scale software development: an observational case study. ACM Trans. Softw. Eng. Methodol. 10(3): 308-337 (2001)

## Interviews

- ⇒ Open-ended interviews- address facts of a matter, opinions about an event
- ⇒ Focused interview- short period of time typically an hour, same approach as open-ended.
- ⇒ Formal survey- produces quantifiable data
  
- ⇒ Example: Used semi-structured interviews to understand the effect of distance on coordination in teams
  - ↳ Rebecca E. Grinter, James D. Herbsleb, Dewayne E. Perry: The geography of coordination: dealing with distance in R&D work. GROUP 1999: pp. 306-315

## Direct Observation

- ⇒ Field visits- creates opportunity for direct observation
- ⇒ Photographs of site
  - ↳ Need permission in order to proceed
- ⇒ Can be used to calibrate self-reports
  - ↳ Example: Informal, impromptu interactions
- ⇒ Example: Followed software developers around to characterize how they spend their time
  - ↳ Dewayne E. Perry, Nancy A. Staudenmayer, Lawrence G. Votta: People, Organizations, and Process Improvement. IEEE Software 11(4): 36-45 (1994)

## Participant-observation

- ⇒ Not a passive observer, in contrast to direct observation, but actually participate in setting
- ⇒ Useful for large organizations or small groups
- ⇒ Observe participant bias "inside" when actively participating during the case study
- ⇒ Example: Seaman participated in 23 code inspections over period of five months at NASA/Goddard Space Flight Center's Flight Dynamics Division
  - ↳ Carolyn B. Seaman, Victor R. Basili: Communication and Organization: An Empirical Study of Discussion in Inspection Meetings. IEEE Trans. Software Eng. 24(7): 559-572 (1998)



## Physical Artifacts

- ⇒ Technological tool, instrument, or device
- ⇒ Artifacts can be collected or observed as part a field visit
- ⇒ Works of art or types of physical evidence
- ⇒ Example: Diachronic study of art records to determine whether right-handedness was a recent or old trait
  - ↳ Two rival hypotheses: Physiological predisposition vs Social/environmental pressure
  - ↳ Tested by counting unimanual tool usage in art representations
  - ↳ 1200 examples from 1500 BC to 1950, world sources
  - ↳ 92.6% used right hand
  - ↳ Geo/historical distribution uniformly high
  - ↳ Seems to support physiological interpretation that right-handedness is an age-old trait

## Six Sources of Evidence: Strengths and Weaknesses

Source of Evidence	Strengths	Weaknesses
Documentation	<ul style="list-style-type: none"> <li>➤ Stable - can be reviewed repeatedly</li> <li>➤ Unobtrusive - not created as a result of the case study</li> <li>➤ Exact - contains exact names, references, and details of an event</li> <li>➤ Broad coverage - long span of time, many events, and many settings</li> </ul>	<ul style="list-style-type: none"> <li>➤ Retrievability - can be low</li> <li>➤ Biased selectivity, if collection is incomplete</li> <li>➤ Reporting bias - reflects (unknown) bias of author</li> <li>➤ Access - may be deliberately blocked</li> </ul>
Archival Records	{same as above for documentation} <ul style="list-style-type: none"> <li>➤ Precise and quantitative</li> </ul>	{same as above for documentation} <ul style="list-style-type: none"> <li>➤ Accessibility due to privacy reasons</li> </ul>
Interviews	<ul style="list-style-type: none"> <li>➤ Targeted - focuses directly on case study topic</li> <li>➤ Insightful - provides perceived causal inferences</li> </ul>	<ul style="list-style-type: none"> <li>➤ Bias due to poorly constructed questions</li> <li>➤ Response bias</li> <li>➤ Inaccuracies due to poor recall</li> <li>➤ Reflexivity - interviewee gives what interview wants to hear</li> </ul>

Yin, R.K. (2002). Case Study Research: Design and Methods (3rd ed.). Thousand Oaks, CA: Sage Publications, p. 86.

## Strengths and Weaknesses Cont'd

Source of Evidence	Strengths	Weaknesses
Direct Observations	<ul style="list-style-type: none"> <li>➤ Reality - covers events in real time</li> <li>➤ Contextual - covers content of event</li> </ul>	<ul style="list-style-type: none"> <li>➤ Time consuming</li> <li>➤ Selectivity - unless broad coverage</li> <li>➤ Reflexivity - event may proceed differently because it is being observed</li> <li>➤ Cost- hours needed by human observers</li> </ul>
Participant Observations	{same as above for direct observation} <ul style="list-style-type: none"> <li>➤ Insightful into interpersonal behavior and motives</li> </ul>	{same as above for direct observation} <ul style="list-style-type: none"> <li>➤ Bias due to investigator's manipulation of events</li> </ul>
Physical Artifacts	<ul style="list-style-type: none"> <li>➤ Insightful into cultural features</li> <li>➤ Insightful into technical operations</li> </ul>	<ul style="list-style-type: none"> <li>➤ Selectivity</li> <li>➤ Availability</li> </ul>

Yin, R.K. (2002). Case Study Research: Design and Methods (3rd ed.). Thousands Oaks, CA: Sage Publications, p. 86.

## Principles of Data Collection

- ⇒ Use Multiple Sources of Evidence
- ⇒ Create a Case Study Database
- ⇒ Maintain a Chain of Evidence

**These principles can be applied to  
all six data collection methods**

## Multiple Sources of Evidence

### ⇒ Triangulation (four types for evaluation)

- ↳ Data sources (data triangulation)
- ↳ Different evaluators (investigator triangulation)
- ↳ Perspective to same data (theory triangulation)
- ↳ Methods (methodological triangulation)

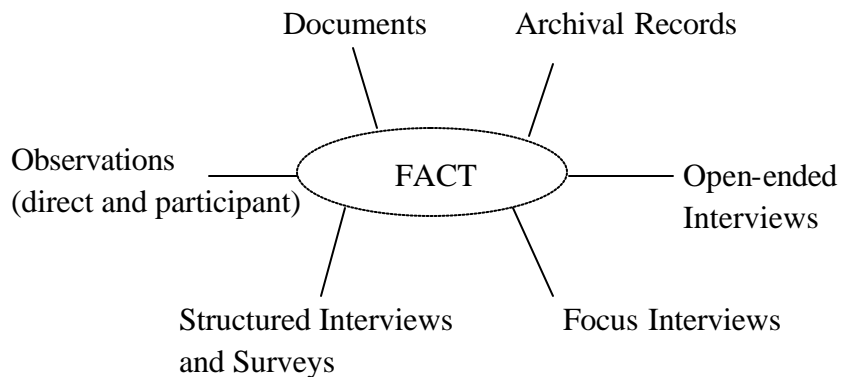
### ⇒ Encourages evidence collection from more than one source in order to show same facts and/or findings

### ⇒ Example: Different approaches were used collect data about how developers spend their time.

- ↳ Dewayne E. Perry, Nancy A. Staudenmayer, Lawrence G. Votta: People, Organizations, and Process Improvement. IEEE Software 11(4): 36-45 (1994)
  - > Collected cross-sectional and direct observation data
- ↳ Marc G. Bradac, Dewayne E. Perry, Lawrence G. Votta: Prototyping a Process Monitoring Experiment. IEEE Trans. Software Eng. 20(10): 774-784 (1994)
  - > Collected longitudinal data

## Multiple Sources of Evidence

### Convergence of Evidence (Figure 4.2)



## Case Study Database

### ⇒ Case study notes

- ↕ From interviews, documents, etc.
- ↕ Categorized, complete

### ⇒ Case study documents

- ↕ Annotated bibliography of the documents- facilitates storage, retrieval, help later investigators share the database

### ⇒ Tabular materials

- ↕ Collected or created and can be stored

### ⇒ Narratives

- ↕ Supported answers to the questions
- ↕ Connect pertinent issues

The database performs a formal assembly of evidence

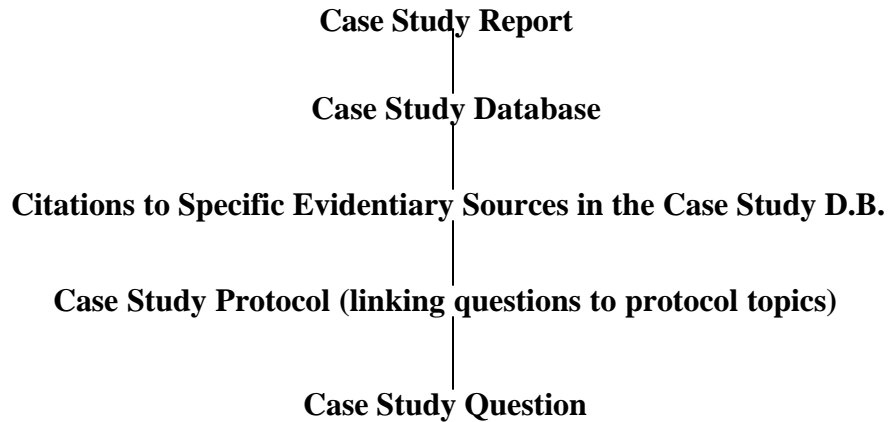
## Chain of Evidence

### ⇒ Forms explicit links between

- ↕ Questions asked
- ↕ Data collected
- ↕ Conclusion drawn

## Chain of Evidence

### Maintaining Chain of Evidence (Figure 4.3)



## Data Analysis

- ⇒ Analytic Strategies
- ⇒ 3 general strategies
- ⇒ 5 specific analytic techniques
- ⇒ Criteria for high quality analysis

## Characteristics of Case Study Analysis

- ⇒ Data analysis consists of examining, categorizing, tabulating, testing and recombining both quantitative and qualitative evidence to address the initial propositions of a study
- ⇒ Analyzing case study evidence is difficult because strategies and techniques have not been well defined
- ⇒ Every case study should have a general analytic strategy to define priorities for what to analyze and why

## Criteria for High Quality Analysis

- ⇒ Present all the evidence
- ⇒ Develop rival hypotheses
- ⇒ Address all major rival interpretations
- ⇒ Address most significant aspect of the case study
- ⇒ Use prior or expert knowledge

## Objectives of Analytical Study

- ⇒ Produce high quality analyses
- ⇒ Present all evidence and separate them from any interpretation
- ⇒ Explore alternative interpretations

## Needs for Analytic Strategies

- ⇒ Investigations on how the evidence is to be analyzed easily become stalled
- ⇒ Analytic tools can only be helpful if the investigators know what to look for
- ⇒ Analytic strategies are needed to address the entire case study since verbatim and documentary texts are usually the initial phase

## Benefits of Analytic Strategies

- ⇒ Put the evidence in preliminary order and treat the evidence fairly
- ⇒ Prevent false starts
- ⇒ Save time
- ⇒ Produce compelling analytic conclusions
- ⇒ Rule out alternative interpretations
- ⇒ Help investigators use tools and make manipulations effectively

## Three General Strategies

1. Relying on Theoretical Propositions
2. Thinking about Rival Explanations
3. Developing a Case Description



## General Strategy

### 1. Relying on Theoretical Propositions

- ⇒ Shapes the data collection plan and gives priorities to the relevant analytic strategies
- ⇒ Helps to focus attention on certain data and to ignore other useless data
- ⇒ Helps to organize the entire case study and define alternative explanations to be examined

## General Strategy

### 2. Thinking About Rival Explanations

- ⇒ Defines and tests rival explanations
- ⇒ Relates to theoretical propositions, which contain rival hypotheses
- ⇒ Attempts to collect evidence about other possible influences
- ⇒ The more rivals the analysis addresses and rejects, the more confidence can be placed in the findings

## General Strategy

### 3. Developing a Case Description

- ⇒ Serves as an alternative when theoretical proposition and rival explanation are not applicable
- ⇒ Identifies
  - ↳ an embedded unit of analysis
  - ↳ an overall pattern of complexity to explain why implementation had failed

## Five Specific Analytic Techniques

1. Pattern Matching
2. Explanation Building
3. Time-Series Analysis
4. Logic Models
5. Cross-Case Synthesis

**Note:** They are intended to deal with problems of developing internal and external validity in doing case studies

## Analytic Technique

### 1. Pattern Matching

- ⇒ Pattern matching compares an empirically based pattern with a predicted one
- ⇒ If the patterns coincide, the results can strengthen the internal validity of the case study

#### Types of pattern matching:

1. Nonequivalent dependent variables as a pattern
2. Rival explanations as patterns
3. Simpler patterns

## Pattern Matching

### 1. Nonequivalent dependent variables as a pattern

- ↳ Quasi-experiment may have multiple dependent variables (variety of outcomes)
- ↳ If, for each outcome, the initially predicted values have been found, and at the same time alternative "patterns" of predicted values (including those deriving from methodological artifacts or threats to validity) have not been found, strong causal inferences can be made

### 2. Rival explanations as patterns

- ↳ Each case has certain type of outcome, and the investigation has to be focused on how and why this outcome occurred
- ↳ This analysis requires the development of rival theoretical propositions, articulated in operational terms
- ↳ Each rival explanation involves a pattern of independent variables that is mutually exclusive: If one explanation is to be valid, the others cannot be

### 3. Simpler Patterns

- ↳ There may be only 2 different dependent (or independent) variables, pattern matching is possible as long as a different pattern has been stipulated for these 2 variables
- ↳ The fewer the variables, the more dramatic the different patterns will have to allow any comparisons of their differences

## Analysis Technique

### 2. Explanation Building

- ⇒ Analyzes the case study data by building an explanation about the case
- ⇒ Stipulates a presumed set of causal links, which are similar to the independent variables in the use of rival explanations
- ⇒ Has mostly occurred in narrative form
- ⇒ May lead to starting a cross-case analysis, not just an analysis of each individual case
  
- ⇒ Disadvantage: may drift away from original focus

## Explanation Building

- ⇒ Series of iterations in building explanation
  1. Making initial theoretical statement
  2. Comparing the findings of the initial case against such a statement
  3. Revising the statement
  4. Comparing other details of the case against the revision
  5. Comparing the revisions to the facts of 2<sup>nd</sup>, 3<sup>rd</sup> or more cases
  6. Repeating the process if needed

## Analysis Techniques

### 3. Time Series Analysis

- ⇒ The objective of time series analysis is to examine relevant "how" and "why" questions about the relationship of events over time
- ⇒ Time series analysis can follow intricate patterns
- ⇒ The more intricate the pattern, the firmer the foundation for conclusions of the case study

#### Three types of Time Series Analyses:

- ↳ Simple Time Series
- ↳ Complex Time Series
- ↳ Chronologies

## Time Series Analysis

### 1. Simple Time Series

- ⇒ Trace changes over time
- ⇒ Single variable only, so statistical analysis of data is possible
- ⇒ Match between a trend of data points compared to
  - ↳ significant trend specified before investigation
  - ↳ rival trend specified earlier
  - ↳ any other trend based on some artifact or threat to internal validity

## Time Series Analysis

### 2. Complex Time Series

- ⇒ Contain multiple set of variables (mixed patterns) which are relevant to the case study
- ⇒ Each variable is predicted to have different pattern over time
- ⇒ Create greater problems for data collection, but lead to elaborate trend that strengthens the analysis
- ⇒ Any match of a predicted with an actual time series will produce strong evidence for an initial theoretical proposition

## Time Series Analysis

### 3) Chronologies

- ⇒ Trace events over time
- ⇒ Sequence of a cause and effect cannot be inverted
- ⇒ Some events must be followed by other events on a contingency basis after an interval of time
- ⇒ Cover many different types of variables
- ⇒ Goal is to compare chronology with that predicted by the explanatory theory

## Analysis Technique

### 4. Logic Models

- ⇒ Stipulate a complex chain of events over time
- ⇒ Events are staged in repeated cause-effect-cause-effect patterns
- ⇒ Match empirically observed events to theoretically predicted events
  
- ⇒ Four types of logic models:
  - ↳ Individual-Level Logic Model
  - ↳ Firm or Organizational-Level Logic Model
  - ↳ An alternative configuration for an Organizational-Level Logic Model
  - ↳ Program-Level Logic Model

## Logic Models

- A) Individual-level logic model
  - ↳ Assumes the case study is about an individual person
- B) Firm or organizational-level logic model
  - ↳ Traces events taking place in an individual organization
- C) An alternative configuration for an organizational-level logic model
  - ↳ Encounters dynamic events that are not progressing linearly
  - ↳ Changes may reverse course and not just progress in one direction (Transformation and reforming)
- D) Program-level logic model
  - ↳ Analyzes data from different case studies by collecting data on rival explanations

## Analysis Technique

### 5. Cross-Case Synthesis

- ⇒ Case study consists of at least 2 cases
- ⇒ Using multiple case studies will
  - ↳ Treat each individual case study as a separate study
  - ↳ Have to create word tables that display data from individual cases according to some uniform framework
  - ↳ Examine word tables for cross-case patterns
  - ↳ Rely strongly on argumentative interpretation, not numeric properties
  - ↳ Be directly analogous to cross-experiment interpretations

## Overview of this Section

- ⇒ Background
  - ↳ Scientific Method
  - ↳ Role of Theory
  - ↳ Empirical Approaches
  - ↳ Concepts and Terminology
- ⇒ Designing a Case Study
  - ↳ Planning
  - ↳ Data Collection
  - ↳ Data Analysis
- ⇒ **Evaluation**
  - ↳ Validity and Threats to Validity



# Validity

- ⇒ 4 primary types of validity
  - ↳ Construct Validity
  - ↳ Internal Validity
  - ↳ External Validity

# Construct Validity

- ⇒ Are we measuring what we intend to measure
  - ↳ Akin to the requirements problem: are we building the right system
  - ↳ If we don't get this right, the rest doesn't matter
- ⇒ Constructs: abstract concepts
  - ↳ Theoretical constructions
  - ↳ Must be operationalized in the experiment
- ⇒ Necessary condition for successful experiment
  
- ⇒ Divide construct validity into three parts:
  - ↳ Intentional Validity
  - ↳ Representation Validity
  - ↳ Observation Validity

## Construct Validity

### ⇒ Intentional Validity

- ↳ Do the constructs we chose adequately represent what we intend to study
- ↳ Akin to the requirements problem where our intent is *fair scheduling* but our requirement is FIFO
- ↳ Are our constructs specific enough?
- ↳ Do they focus in the right direction?
- ↳ Eg, is it *intelligence* or *cunningness*

## Construct Validity

### ⇒ Representation Validity

- ↳ How well do the constructs or abstractions translate into observable measures
- ↳ Two primary questions:
  - > Do the sub-constructs properly define the constructs
  - > Do the observations properly interpret, measure or test the constructs

### ⇒ 2 ways to argue for representation validity

- ↳ **Face validity**
  - > Claim: on the face of it, seems like a good translation
  - > Very weak argument
  - > Strengthened by consensus of experts
- ↳ **Content validity**
  - > Check the operationalization against the domain for the construct
  - > The extent to which the tests measure the content of the domain being tested - ie, cover the domain
  - > The more it covers the relevant areas, the more content valid
- ↳ Both are nonquantitative judgments

## Construct Validity

### ⇒ Observation Validity

- ↳ How good are the measures themselves
- ↳ Different aspects illuminated by
  - Predictive validity
  - Criterion validity
  - Concurrent validity
  - Convergent validity
  - Discriminant validity

### ⇒ Predictive Validity

- ↳ Observed measure predicts what it should predict and nothing else
- ↳ E.g., college aptitude tests are assessed for their ability to predict success in college

### ⇒ Criterion Validity

- ↳ Degree to which the results of a measure agree with those of an independent standard
- ↳ Eg, for college aptitude, GPA or successful first year

## Construct Validity

### ⇒ Concurrent Validity

- ↳ The observed measure correlates highly with an established set of measures
- ↳ Eg, shorter forms of tests against longer forms

### ⇒ Convergent Validity

- ↳ Observed measure correlates highly with other observable measures for the same construct
- ↳ Utility is not that it duplicates a measure but is a new way of distinguishing a particular trait while correlating with similar measures

### ⇒ Discriminant Validity

- ↳ The observable measure distinguishes between two groups that differ on the trait in question
- ↳ Lack of divergence argues for poor discriminant validity

## Internal Validity

- ⇒ Are the values of the dependent variables solely the result of the manipulations of the independent variables?
- ⇒ Have we ruled out rival hypotheses?
- ⇒ Have we eliminated confounding variables?
  - ↳ Participant variables
  - ↳ Experimenter variables
  - ↳ Stimulus, procedural and situational variables
  - ↳ Instrumentation
  - ↳ Nuisance variables
- ⇒ Confounding sources of internal invalidity
  - ↳ **H: History**
    - events happen during the study (eg, 9/11)
  - ↳ **M: Maturation**
    - older/wiser/better between during study
  - ↳ **I: Instrumentation**
    - change due to observation/measurement instruments
  - ↳ **S: Selection**
    - differing nature of participants
    - effects of choosing participants

## Internal Validity

- ⇒ Demonstrating that certain conditions are in fact the cause of other conditions, i.e. conditions not mentioned or studied are not the actual cause
  - ↳ Example: if a study concludes that there is a causal relationship between X and Y without knowing some third factor Z may have actually caused Y, the research design has failed to deal with threats to internal validity
- ⇒ Internal validity applies to explanatory and causal studies only, not to descriptive or exploratory studies
- ⇒ It is important to challenge any inferences you make during your study as any incorrect inferences may detract from internal validity

## External Validity

### ⇒ Two positions

- ↳ The generalizability of the causal relationship beyond that studied/observed
  - Eg, do studies of very large reliable real-time systems generalize to small .COM companies
- ↳ The extent to which the results support the claims of generalizability
  - Eg, do the studies of 5ESS support the claim that they are representative of real-time ultra reliable systems

## External Validity

- ⇒ Establishing the domain to which a study's findings can be generalized
  - ↳ i.e. are the study's findings generalizable beyond the immediate case study?
- ⇒ Case studies have been criticized for offering a poor basis for generalization since only single cases are studied
  - ↳ This is contrasting case studies (which rely on analytical generalization) with survey research (which relies on statistical generalization), which is an invalid comparison
- ⇒ Generalization of the theory must be tested by replicating the findings over several different cases.

## Reliability

- ⇒ Demonstrating that the operations of a study can be repeated with the same results
  - ↳ Note: the repetition of the study should occur on the same case, not “replicating” the results on a different case
- ⇒ “The goal of reliability is to minimize the errors and biases in a study”
- ⇒ A prerequisite for reliability testing is documented procedures for the case study
- ⇒ A good guideline is to perform research so that an auditor could follow the documented procedures and arrive at the same results

## Tactics to Address Quality in Case Study Design

Tests	Case Study Tactic	Phase of research in which tactic occurs
Construct validity	● Use multiple sources of evidence	data collection
	● Establish chain of evidence	data collection
	● Have key informants review draft case study report	composition
Internal validity	● Do pattern-matching	data analysis
	● Do explanation-building	data analysis
	● Address rival explanations	data analysis
	● Use logic models	data analysis
External validity	● Use theory in single-case studies	research design
	● Use replication logic in multiple-case studies	research design
Reliability	● Use case study protocol	data collection
	● Develop case study database	data collection

Figure 2.2 Case Study Tactics for the Four Design Tests (page 34)

## 3. Publishing Case Studies

## Overview of this Section

- ⇒ Targeting Case Study Reports
- ⇒ Composition Styles for Case Studies
- ⇒ General Guidelines from Software Engineering
- ⇒ Sample Paper Outlines

## Targeting Case Study Reports

- ⇒ **Case studies tends to have a more diverse set of potential audiences than other research methods**
  - ↳ Each audience has different needs, no single report will serve all audiences simultaneously
  - ↳ Therefore, may need more than one version of a case study report
- ⇒ **Case study report itself is a significant communication device**
  - ↳ Case study can communicate research-based information about a phenomenon to a variety of non-specialists
  - ↳ Practitioners like case studies, so context is important
- ⇒ **Orient the case study report to an audience**
  - ↳ The preferences of the potential audience should dictate the form of your case study report
  - ↳ Greatest error is to compose a report from an egocentric perspective
  - ↳ Therefore, one must identify the audience before writing a case study report
  - ↳ Recommendation: examine previous case study reports that have successfully communicated with the identified audience

## Formats for Written Case Study Reports

- ⇒ **Classic single-case study**
  - a single narrative is used to describe and analyze the case
- ⇒ **Multiple-case version of this classic single case**
  - individual cases are presented in separate chapters
  - also contain chapters that contain cross-case analysis
- ⇒ **Non-traditional narrative (single or multiple)**
  - use question-and-answer format
- ⇒ **Cross-case analysis (multiple-case studies only)**
  - entire report consist of cross-case analysis
  - each chapter would be devoted to a separate cross-case issue
- ⇒ **Note: Format should be identified during the design phase of case study**



## Sequences of Studies

- ⇒ **The best empirical studies are performed as part of a sequence**
  - ↳ Each going deeper or shedding light on a different aspect of a problem
  - ↳ Can deploy different tactics, strategies, methods
- ⇒ **Rationales to use case study as part of a larger, multimethod study**
  1. To determine whether converging evidence might be obtained even though different methods has been used
  2. After analyzing data collected by other methods, case study might be able to illustrate an individual case in greater depth
  3. Case study may be used to elucidate some underlying process which another method is used to define the prevalence or frequency of such processes

## Composition Structures for Case Studies

1. **Linear-Analytic Structures**
  - ↳ Standard approach
2. **Comparative Structures**
  - ↳ Entire study is repeated two or more times
3. **Chronological Structures**
  - ↳ Evidence are presented in chronological order
4. **Theory building Structures**
  - ↳ Each chapter reveal a new part of a theoretical argument
5. **"Suspense" Structures**
  - ↳ The outcome of the case study is presented in the initial chapter, then followed by the "suspenseful" explanation of the outcome
6. **Unsequenced Structures**
  - ↳ The sequence of sections or chapters assumes no particular importance
  - ↳ When using this structure, the investigator should make sure that a complete description of the case is presented. Otherwise, he/she may be accused of being biased

## Issues in Reporting

### ⇒ 1. When and How to Start Composing?

- ↳ Start composing early in the analytic process
- ↳ Bibliography, methodological and descriptive data about the cases being studied are the sections which could be written early in the process

### ⇒ 2. Case Identities: Real or Anonymous?

- ↳ Anonymity issue can be at two levels: entire case and individual person within a case
- ↳ Most desirable option is to disclose the identities of both the case and individuals
- ↳ Anonymity is necessary when:
  - > Using the real name will cause harm to the participants
  - > The case report may affect the subsequent action of those that are studied
- ↳ Compromises that can be made:
  - > Hide individual identity but identify the case
  - > Name the individuals but avoid attributing any particular point of view or comment to a single individual
  - > The publish report is limited to the aggregated evidence
- ↳ Only if these compromises are impossible then the investigator should consider making the entire case study and the informants anonymous

## Issues in Reporting

### ⇒ 3. The Review of the Draft Case Study: A Validating Procedure

- ↳ There should be a draft report and it should be reviewed not just by peers, but also by the participants and informants in the case
- ↳ The reviewers may disagree with the conclusion and interpretations, but not the actual facts of the case
- ↳ This process increases the construct validity of the study and reduced the likelihood of falsely reporting an event

## General Guidelines from SE

Barbara A. Kitchenham, Shari Lawrence Pfleeger, Lesley M. Pickard, Peter W. Jones, David C. Hoaglin, Khaled El Emam, and Jarrett Rosenberg, "Preliminary Guidelines for Empirical Research in Software Engineering," IEEE Transactions on Software Engineering, Vol. 28, No 8, August 2002.

- ⇒ Experimental Context
- ⇒ Experimental Design
- ⇒ Conducting the Experiment and Data Collection
- ⇒ Analysis
- ⇒ Presentation of Results
- ⇒ Interpretation of Results

## Sample Paper Outline 1

Oliver Laitenberger, Thomas Beil, and Thilo Schwinn, "An Industrial Case Study to Examine a Non-Traditional Inspection Implementation for Requirements Specifications," *Empirical Software Engineering: An International Journal*, vol. 7, no. 4, pp. 345-374, 2002.

- |  |   |
|--|---|
| <ol style="list-style-type: none"> <li>1. Introduction</li> <li>2. The Traditional Inspection Approach             <ul style="list-style-type: none"> <li>2.1 Software Inspection Basics</li> <li>2.2 Inspection Challenges                 <ul style="list-style-type: none"> <li>2.2.1 The Defect Detection Activity...</li> <li>2.2.2 The Defect Collection Activity...</li> </ul> </li> </ul> </li> <li>3. Changes to the Inspection Implementation at DaimlerChrysler             <ul style="list-style-type: none"> <li>3.1 Case Study Environment</li> <li>3.2 Defect Detection Approach</li> <li>3.3 Defect Collection Approach</li> </ul> </li> </ol> | <ol style="list-style-type: none"> <li>4. Analysis Approach             <ul style="list-style-type: none"> <li>4.1 Some Misconceptions in Inspection Data Analysis</li> <li>4.2 A Model for Explaining the Number of Defects Detected</li> <li>4.3 Measurement</li> <li>4.4 Analysis Approach</li> </ul> </li> <li>5. Results             <ul style="list-style-type: none"> <li>5.1 Descriptive Statistics</li> <li>5.2 Correlation and Regression Analysis</li> <li>5.3 Path Analysis Results</li> </ul> </li> <li>6. Threats to Validity             <ul style="list-style-type: none"> <li>6.1 Threats to Internal Validity</li> <li>6.2 Threats to External Validity</li> </ul> </li> <li>7. Conclusion</li> </ol> |
|--|---|

## Sample Paper Outline 2

Susan Elliott Sim and Richard C. Holt, "The Ramp-Up Problem in Software Projects: A Case Study of How Software Immigrants Naturalize," presented at Twentieth International Conference on Software Engineering, Kyoto, Japan, pp. 361-370, 19-25 April, 1998.

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|--|--|
| <ol style="list-style-type: none"> <li>1. Introduction</li> <li>2. Method             <ol style="list-style-type: none"> <li>2.1 Research Setting</li> <li>2.2 Data Collection</li> <li>2.3 Data Analysis</li> </ol> </li> <li>3. Results             <ol style="list-style-type: none"> <li>3.1 Mentoring                 <ol style="list-style-type: none"> <li>3.1.1 Evidence</li> <li>3.1.2 Implications</li> </ol> </li> <li>3.2 Difficulties Outside of the Software System                 <ol style="list-style-type: none"> <li>3.2.1 Evidence</li> <li>3.2.2 Implications</li> </ol> </li> <li>3.3 First Assignments                 <ol style="list-style-type: none"> <li>3.3.1 Evidence</li> <li>3.3.2 Implications</li> </ol> </li> <li>3.4 Predictors of Job Fit                 <ol style="list-style-type: none"> <li>3.4.1 Evidence</li> <li>3.4.2 Implications</li> </ol> </li> </ol> </li> </ol> | <ol style="list-style-type: none"> <li>4. Applications of the Patterns</li> <li>5. Conclusions</li> <li>Appendix A: Question Sets</li> <li>Appendix B: Variables Used in Analysis</li> </ol> |
|--|--|

## Sample Paper Outline 3

Dewayne E. Perry, Harvey P. Siy, and Lawrence G. Votta, "Parallel Changes in Large Scale Software Development: An Observational Case Study," presented at Twentieth International Conference on Software Engineering, pp. 251-260, 19-25 April 1998.

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|--|---|
| <ol style="list-style-type: none"> <li>1. Introduction</li> <li>2. Related Work             <ol style="list-style-type: none"> <li>2.1 Configuration Management</li> <li>2.2 Program Analysis</li> <li>2.3 Build Coordination</li> <li>2.4 Empirical Evaluation</li> </ol> </li> <li>3. Study Context             <ol style="list-style-type: none"> <li>3.1 The System Under Study</li> <li>3.2 The 5ESS Change Management Process</li> </ol> </li> </ol> | <ol style="list-style-type: none"> <li>4. Data and Analysis             <ol style="list-style-type: none"> <li>4.1 Levels of Parallel Development</li> <li>4.2 Effects of Parallel Development on a File</li> <li>4.3 Interfering Changes</li> <li>4.4 Multilevel Analysis of Parallel Development</li> <li>4.5 Parallel Versions</li> </ol> </li> <li>5. Validity</li> <li>6. Summary and Evaluation             <ol style="list-style-type: none"> <li>6.1 Study Summary</li> <li>6.2 Evaluation of Current Support</li> <li>6.3 Future Directions</li> </ol> </li> </ol> |
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## 4. Reviewing Case Studies

## Overview of this Section

⇒ Characteristics of Exemplary Case Studies

## What Makes an Exemplary Case Study?

- ⇒ The exemplary case study goes beyond the methodological procedures
- ⇒ Mastering the techniques does not guarantee an exemplary case study

## Characteristics of an Exemplary Case Study

- ⇒ **1. The Case Study Must Be Significant**
  - ↳ The case should be unusual and of general public interest
  - ↳ The issue are nationally important, either in theory or practical terms
  - ↳ Prior to selecting a case study, the contribution should be described in detail assuming that the intended case study were to be completed successfully
- ⇒ **2. The Case Study Must be "Complete"**
  - ↳ Completeness can be characterized in at least three ways:
    - > The boundaries of the case are given explicit attention
    - > Exhaustive effort is spent on collecting all the relevant evidence
    - > The case study was not ended because of nonresearch constraints

## Characteristics of an Exemplary Case Study

### ⇒ 3. The Case Study Must Consider Alternative Perspectives

- ↳ The case study should include consideration of rival propositions and the analysis of the evidence in terms of such rivals
- ↳ This can avoid the appearance of a one-sided case

### ⇒ 4. The Case Study Must Display Sufficient Evidence

- ↳ The report should include the most relevant evidence so the reader can reach an independent judgment regarding the merits of the analysis
- ↳ The evidence should be able to convince the reader that the investigator "knows" his or her subject
- ↳ The investigator should also show the validity of the evidence being presented

### ⇒ 5. The Case Study Must Be Composed in an Engaging Manner

- ↳ A written case study report should be able to entice the reader to continue reading

## Case Study as a Research Method

### ⇒ The case study is a distinct research method with its own research designs

- ↳ It is not a subset or variant of research designs used for other strategies (such as experiments)

### ⇒ Scientific

- ↳ Synergistic relationship between theory and data
- ↳ Starting a case study requires a theoretical orientation, which drives data collection

### ⇒ Useful for answering "how" and "why" questions

- ↳ In contrast to who, what, when, how many, how much
- ↳ How, why = explanatory, descriptive

### ⇒ Does not require control over events

- ↳ More observational

### ⇒ Focus on contemporary events

- ↳ Less historical