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UNDERSTANDING OF CASE STUDY CONCEPT IN SOFTWARE ENGINEERING

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Abstract-Software engineering is a complex activity that naturally produces variety types of output. The term "case study" is used for a broad range of studies in software engineering. Case studies based on the external and independent observation of a software engineering activity. Collected data can either be defined or collected for the purpose of the case study, or already available data can be used in a case study. There is a need to clarify and unify the understanding of what is meant by a case study, and how a good case study is conducted and reported. Software engineering case study tends to learn towards a positive perspective, especially for explanatory-type studies. In this paper, we define theoretical understanding of case studies in software engineering.
Keywords : Case study, software engineering, Empirical enquiry, Strategy, REVV, Context, Triangulation, Statistical significance.

1. INTRODUCTION

Simply case study refers to a self-experienced and self-reported investigation. In broad sense, case study is an empirical enquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident [1]. Case studies are conducted with the objectives not only increasing knowledge but also bringing about change in the phenomenon being studied. There are different taxonomies used to classify research in software engineering. The term case study is used in parallel with terms like field study and observational study, each focusing on a particular aspect of the research methodology.

1.1 Characteristics Of The Case Study

In order to improve the standards of case studies, some good characteristics to be followed are:

- The study is of a significant topic.
- The study must be considering alternative perspectives on the topic.
- The study must present significant evidence.
- The reports of the case study must be engaging to the reader.
- The case study must respect the ethical, professional, and legal standards relevant to the study

1.2 Major Research Strategies

There are three other major research strategies that are to case studies, surveys, experiments, and action research.

1.3 Survey

It is the "collection of standardized information from a specific population". Some sample surveys provide an overview rather than depth in the studied field [2].

2. EXPERIMENT OR CONTROLLED EXPERIMENT

It is characterized by "measuring the effects of manipulating one variable on another variable" and that "subjects are assigned to treatments by random" [3]. The effect of one specific variable is studied in experiments. Quasi-experiments are similar to controlled experiments, except that subjects are not randomly assigned to treatments.

3. ACTION RESEARCH

Studies involving change are sometimes denoted action research [4]. In software process improvement and technology transfer studies, the research method has clear characteristics of action research, with its purpose to "influence or change some aspect of whatever is the focus of the research"to case study. In IS, where action research is widely used, there is a discussion on finding the balance between action and research [5].

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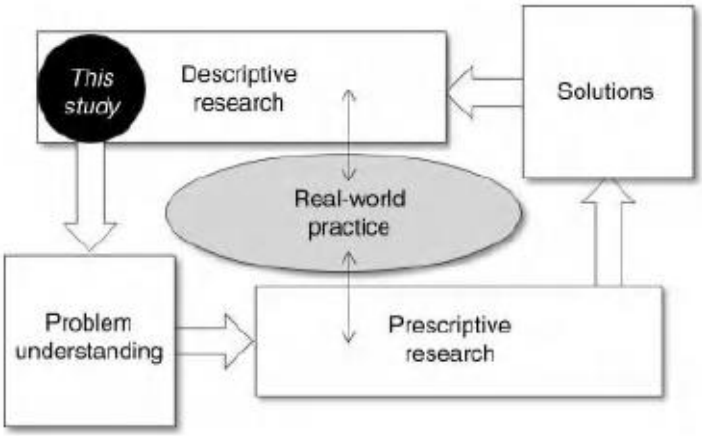

Figure 1: Action research method

4. CASE STUDY PROTOCOL

The case study protocol is used as a repository to keep all information relating to the design and execution of the study. The protocol is also used to guide the data collection and, therefore, ensure that the intended data are collected. The main sections of the case study protocol are given below.

Table 1: Overview of the main section of the REVV case study protocol

Case study protocol	Description
Preamble	Description of the purpose of protocol
General procedures	Overview of research project
Research instruments	Interview guides, questionnaires, and so on
Data analysis guidelines	Detailed description of data analysis procedures
References	Reference list
Appendix	Case study checklists

5. CASE SELECTION STRATEGY

One strategy in choosing the companies in the study context is maximum variation sampling in order to have a context where the results can be generalized. Another strategy is convenience sampling, that is, choosing companies from the industrial collaboration network that the research can gain access to, based on mutual trust. In this study, we chose a combination of both strategies, aiming at a variety of companies with respect to discuss the kind of companies that could be suitable to involve in order reaching our research goals and the possible roles to be interviewed.

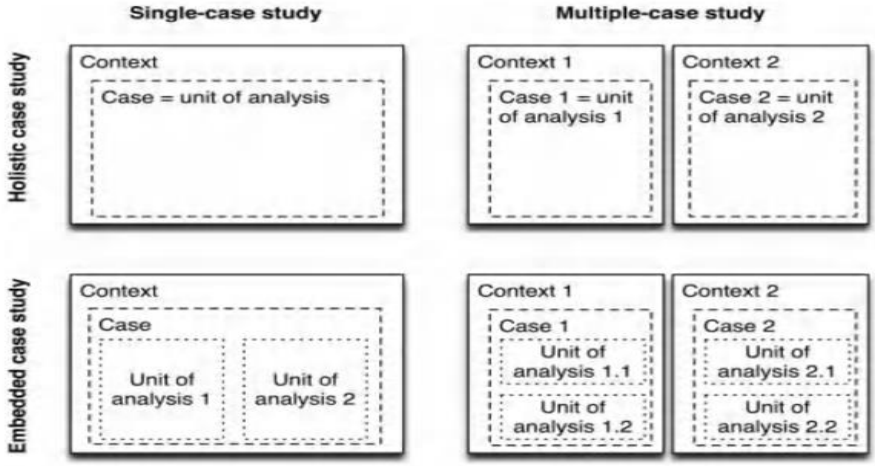

Figure 2: Important case studies

6. DATA ANALYSIS

The data analysis in the case study was carried out in several rounds in an iterative manner. The main three iterations were related to the following:

6.1 Explanatory
Finding out what are happening, seeking new insights, and generating ideas and hypothesis for new research.

6.2 Descriptive
Portraying the current status of a situation or phenomenon.

6.3 Improving
Trying to improve a certain aspect of the studied phenomenon.

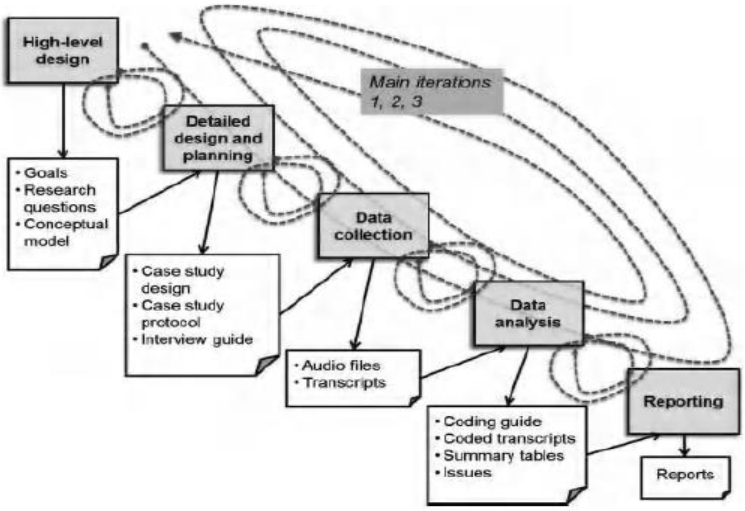

Figure 3: Overview of the steps in three main iterations

6.4 Research Strategy
The data collected in an empirical study may be quantitative or qualitative. Quantitative data involve numbers and classes, while qualitative data involve words, descriptions, pictures, diagrams and so on. Qualitative data are analyzed using statistics, while qualitative data are analyzed using categorization and sorting. Qualitative data are more exact, while qualitative data are 'richer' in what they may express. Case studies tend mostly to be based on qualitative data, but combinations of qualitative and quantitative data often provide better understanding of the studied phenomenon, what is sometimes called 'mixed methods' [6].

Table 2: Overview of research strategy characteristics

	Experiment	Survey	Case study	Action research
Primary objective	Explanatory	Descriptive	Explanatory	Improving
Primary data	Quantitative	Quantitative	Qualitative	Qualitative
Design type	Fixed	Fixed	Flexible	Flexible

6.5 Case Study Research Process
When conducting a case study, there are following five major process steps to be considered.

- Case study design
- Preparation for data collection
- Collecting evidence
- Analysis of collected data
- Reporting

7. RELATED WORK
Case study in software engineering is an empirical enquiry that draws on multiple sources of evidence to investigate one instance of a contemporary software engineering phenomenon within its real life context cannot be clearly specified. Fenton and pfleeger [7] identify four factors that affect the choice between experiment and case study: level of control, difficulty of control, level of replication, and cost of replication. Easterbrook et al. call case studies one of the five "classes of research methods" [8]. Zelkowitz and Wallace propose a terminology that is somewhat different from what is used in other fields, and categorize project monitoring, case study, and field study as observational methods [9]. Alexander and Potters [10] study of formal specifications and rapid prototyping.

Curtis et al.'s [11] field study of software design activities and Swanson and Beath's [12] multiple case study of software maintenance. Seaman published guidelines on qualitative research [13]. Sim et al. arranged a workshop on the topic, which was summarized in empirical software engineering [14], Wohlin et al.provided a brief introduction to case studies among other empirical methods [15], and Dittrich et al. edited a special issue of information and software technology on qualitative software engineering research [16]. Sjoberg et al. [17] write that in the typical software engineering situation actors apply technologies in the performance of activities on an existing or planned software-related product or interim products.
Glass et al. [18] describe software engineering as an intellectually intensive, non routine activity, and walz et al. [19] describe software engineering as a multi agent cognitive activity. Klevin and myers define three types of case studies depending on the research on the research perspective: positive, critical, and interpretive [20]. A positive case study searches evidence for formal propositions, measures variables, tests hypothesis, and draws inferences from a sample to a stated population, which is close to the natural science research model [21].A critical case study aims at social and at being emancipator, that is, identifying different forms of social, cultural, and political domination that may hinder human ability. An interpretive case study attempts to understand phenomena through the participants' interpretation of their context, which is similar to rob son's explanatory and descriptive types.

8. METHODS

8.1 Inductive And Deductive Approaches

8.1.1 Inductive Approaches

Empirical research may be inductive, meaning that theory is induced from the observations inductive research, the researcher first observes with an open mind, identifies patterns in the observations, sets up tentative hypothesis, and finally relates them to existing theory or develops new theory.

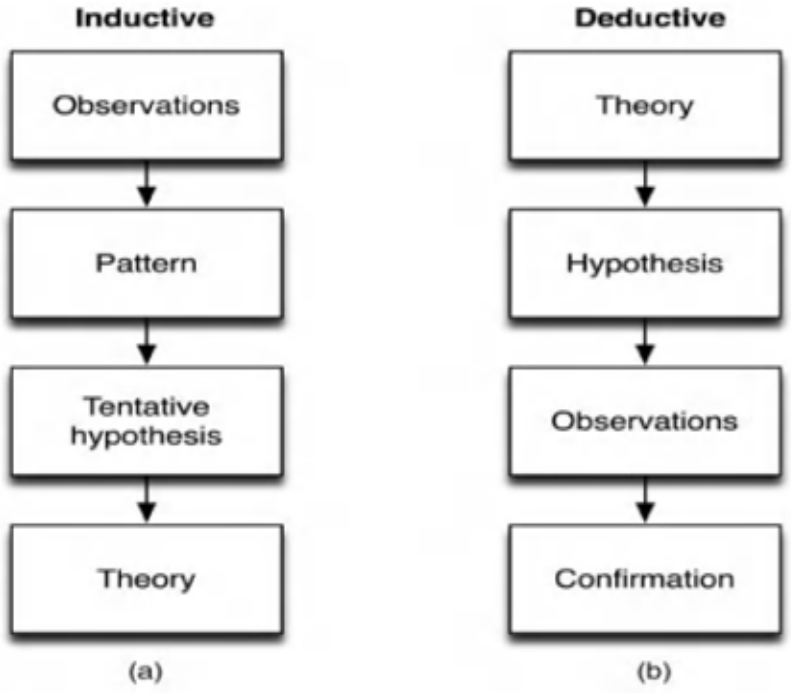

Figure 4: inductive (a) and deductive (b) approaches to empirical research

8.2 Deductive Approach

The deductive research starts with existing theory, sets out hypothesis for the research, and finally makes observations.

8.3 Triangulation

Triangulation is important to increase the precision and strengthen the validity of empirical research. Triangulation means taking multiple perspectives towards the studied object and thus providing a boarder picture. The need for triangulation is obvious when relying primarily on qualitative data, which is broader and richer, but less precise than quantitative data. Four different types are:

- Source triangulation- using more than one data source or collecting the same data at different occasions.
- Observer triangulation: using more than one observer in the study.
- Methodological triangulation – combining different types of data collection.
- Theory triangulation – using alternative theories or viewpoints.

8.4 Data Collection

In order to properly study software engineering the case study researcher must consider a wide range of types of data collection that either gather the naturally produced data or that generate new data. It is important to carefully decide which data to collect and how to collect the data. It is advantageous to use several data sources, and several types of one single data source. We have reviewed five main types of data collection: interviews: interviews focus groups, observation, archival data and metrics.

9. DATA COLLECTION APPROACHES

9.1 Interviews

Data collection through interviews is one of the most frequently used and most important sources of data in case studies in software engineering. Almost all case studies involve some kind of interviews, either for primary data collection or as validation of other kinds of data. An interview can be carried out in many different ways, but essentially a researcher talks to an interviewee attempts to answer. Interview question may be open, that is, allowing and inviting a broad range of answer and issues from the interviewee, or closed, offering a limited set of alternative answers. Interviews may be divided into unstructured, structured, and fully structured interviews. In an unstructured interview, questions are formulated in open way as general concerns and interests from the researcher. In a semi structured interview, questions are planned, but they are not necessarily asked in the same order as they are listed. In a fully structured interview all questions are planned in debit in advance and all questions are asked in the same order as in the plan.

Table 3: Overview of interview types

	Unstructured	Semi structured	Fully structured
Typical foci	How individuals qualitatively experience the phenomenon	How individuals qualitatively and quantitatively experience the phenomenon	Researcher seeks to find relations between constructs
Interview questions	Interview guide with areas to focus on	Mix of open and closed questions	Closed questions
Objective	Explanatory	Descriptive and explanatory	Descriptive and explanatory

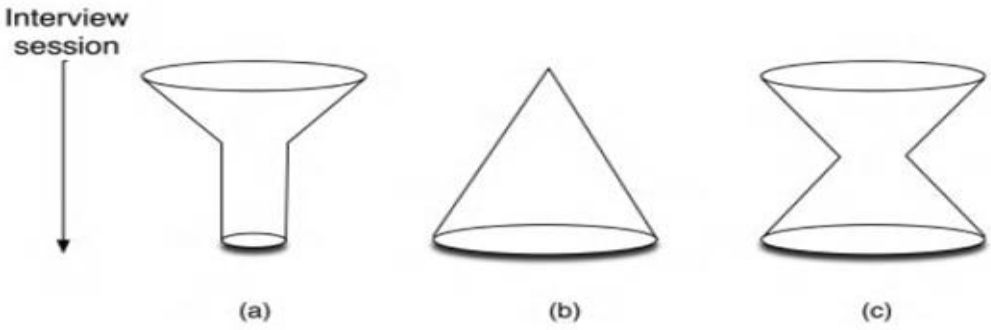

Figure 5: General principles for interview sessions: (a) funnel, (b) pyramid, and (c)timeglass

9.2 Focus Groups

In a focus group, data collection is conducted with several people at the same time in a session resembling an interview. According to Robson another advantage is that there is a natural quality control in this kind of session. It should also be noted that there is limited time at a meeting time at a meeting and that is not possible to discuss to many topics and too complex topics in detail.

9.3 Observations

Observations can be conducted in order to investigate how a certain task is conducted by software engineers. There are many different approaches for observation. One approach is to monitor a group of software engineers with a video recorder and later on analyze the recording. Another alternative is to apply a “think aloud” protocol. Approaches for observations can be divided into categories, depending on whether the interaction of the researcher is high or low, and whether the awareness of the subjects is high or low. An advantage of observations is that they may provide a deep understanding of the phenomenon that is studied.

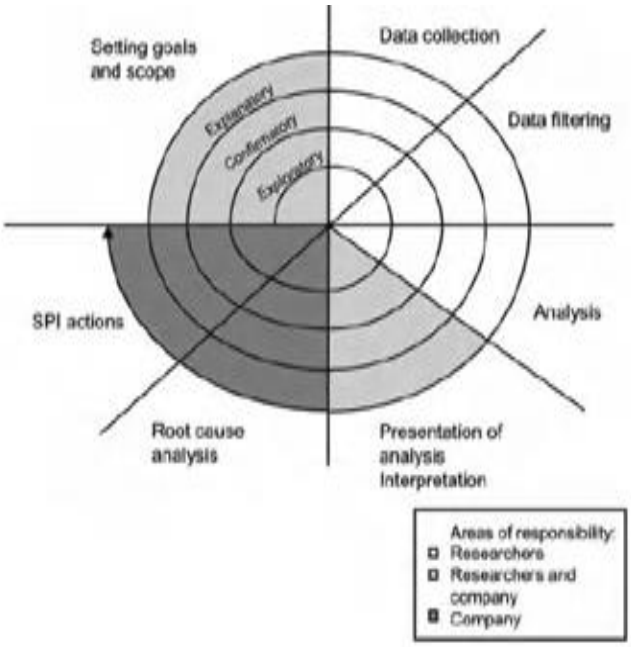

Figure 6: Process model for iterative case studies

9.4 Archival Data

Archival data refers to data that is available in archives. Archival data is a third-degree type of data that can be collected in a case study. Some archival data, such as meeting minutes, could contain a mixture of qualitative and quantitative data, and the researcher may need to separate out these different kinds of data in an appropriate way so that they can be analyzed using appropriate analysis techniques.

9.5 Metrics

Software measurement is the process of representing software entities, like processes, products, and resources, in quantitative numbers. It is an advantage if the definition of what data to collect can be based on a goal-oriented measurement technique, such as the Goal Question Metric method (GQM).

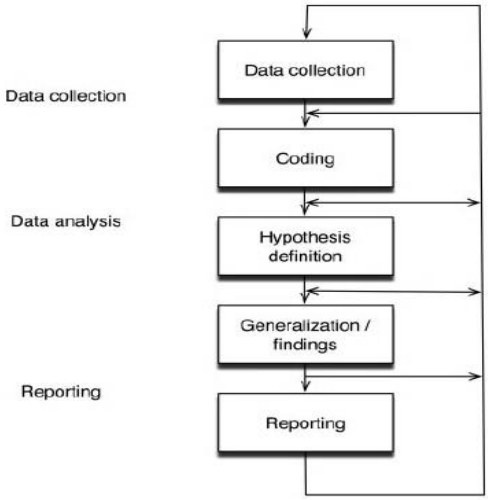

Figure 7: Main steps in data analysis

10. FORMATS AND STRUCTURES FOR A REPORT

Four main formats for reporting a case study are:

- A narrative describing and analyzing a single se study.
- The description and analysis of more than one case.
- The presentation of one or more cases in a question and answer form.
- A cross-case description and analysis of multiple case studies.

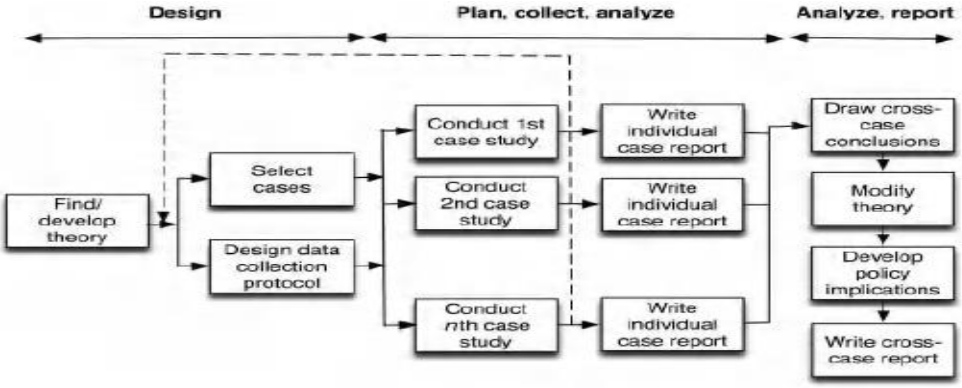

Figure 8: Example process for multiple case studies

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12. CONCLUSION

A case study will never provide conclusions of statistical significance. On the contrary, many kinds of evidence, figures, statements, and documents are linked together to support a strong and relevant conclusion. They conclude on the basis of empirical evidence from the case study that "a multiple data source case study is more trustworthy than a comparable single data source case study." Conclusions can be drawn across replicated quantitative studies using meta analysis. We hope that defining a set of basic concepts can help establish a standard of terminology in the empirical software engineering research community. We also identify characteristics of the case study strategy, to help researchers choose a feasible research strategy for a specific research situation.

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