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Developing and Using a Multi-Methodological Approach to Study the Coordination of Systems Development Process

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DEVELOPING AND USING A MULTI-METHODOLOGICAL APPROACH TO STUDY THE COORDINATION OF SYSTEMS DEVELOPMENT PROCESS

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Abstract

The multi-methodological approach described in this paper was used to interpret data gathered from a study of the coordination of systems development process. The methodology is based on the empirical theory building case-study approach. We used the principle of within-case and cross-case analysis to interpret the findings in different phases of the study. In all these three phases, both the qualitative and quantitative methods were used to get richer and more reliable understanding from coordination phenomena. The methodology was experienced iterative and adaptive learning process, in which the research themes and questions evolved during its phases. The most challenging part of the research process was the combination of qualitative and quantitative methods, because of the lack of multi-methodological work done in IS discipline so far. The paper calls for more practical guidance for designing and developing these kinds of approaches.

Keywords: IS Research Methods, Multi-methodology, Grounded Theory, Case study

1 INTRODUCTION

The question of which research methods are most appropriate for information systems (IS) research has been a focus of concern for some time. Traditional view has been one of isolationism in which the paradigms are seen as essentially based on assumption that individual researchers should follow a single paradigm. This principle is often justified in terms of superiority of the paradigm. More recently, it has been argued in terms of the need of uniformity within the IS discipline as a whole (Benbasat and Weber 1996). In contrast, Robey (1996) and Mingers (2001) argue that a diversity of research methods and paradigms within the discipline is a positive source of strength. This is justified by the notion that diversity provides a wider range of knowledge upon which to base research and theory. This is especially important in a discipline like IS which deals with real world complexities, the same situation than in organizational studies (Lee 1991). Mingers (2001) further argues that different research methods, especially from different paradigms, focus on different aspects of reality and therefore a richer understanding of a research topic will be gained by combining several methods together in a single research study. This argument has been supported within IS by a number of other authors too, like (Galliers 1993,1994, Landry and Banvile 1992, Lee 1991).

In our research study, we wanted to gain an understanding of how practitioners coordinate the systems development work, as many researchers (e.g. Curtis, Krasner et al. 1988; Orlikowski 1993; Fitzgerald 1998; Glass, Vessey et al. 2002) has called for more empirical studies in order to understand how information systems are developed in today's organizations. Our objective was to overcome the limitations of quantitative and qualitative methods and to look the phenomenon using multi-methodical approach, also call methodological triangulation (Jick 1983). Data and findings from the study have been reported in Ovaska, Rossi and Marttiin (2004), Ovaska and Bern (2004), Ovaska (2004, 2005), Ovaska, Rossi and Smolander (2005).

This paper illustrates how the multi-methodical approach was developed and used to interpret and analyze the actions, conceptions and artefacts of practitioners. This objective was reached by conducting a series of research studies of two systems development projects in a contemporary organization that competes in the information technology business. We studied the early systems development, which we considered to be most important phases related to systems development work. The rest of this article is structured as follows. First we describe the construction of the research methodology. After that the research methodology used is introduced. Next we describe the research process of the study. The discussion of using this methodology by comparing it to framework proposed by Mingers (2001) as well the general experiences in using the methodology is given in the next section. Finally, we summarize the used methodology and discussion.

2 CONSTRUCTING THE METHODOLOGY

The basic notion of systems development, namely systems development as a process that involves real people in real environments (e.g. Lyytinen 1987), formed the ground for constructing our research methodology. To truly understand systems development, it is imperative to study people- systems development practitioners as they solve real development problems in real environments. Therefore, as Rosen (1991) puts it, "to understand social process one must get inside the world of those generating it". This kind of goals favoured interpretive approach that enables researcher to understand human thought and action in social and organizational contexts (Walsham 1995).

The other objective of selecting the research methods to this study was to focus on different aspects of systems development and therefore to get richer understanding of research topic (Mingers 2001). Yet another goal was also to be more convinced of information accuracy also discussed in (Yin 1994).

Above objectives favoured to select interpretive approach (Walsham 1995) and integrate different methods according to Eisenhardt (1989). In the following, the basic principles of the construction of the research methodology to this study are explained in more detail.

2.1 Research as a process of phases

As Mingers (2001) put the research it "is not a discrete event but a process that has phases, or, rather, different types of activities, which will predominate in at different times". These phases pose different tasks and problems for the researcher.

This research project included three phases: studies on how architecture affects a multi-site development project, studies on how requirements were shaped and interpreted during the systems development and how this process is to be estimated, and a study on how practitioners work with systems development methods. Next it is briefly explained how these three phases shaped the research problem:

Phase one: Studies on how architecture affects multi-site coordination of systems development
The objective of this phase was to clarify the systems development problems related to software architecture and investigate how practitioners cope with these problems in systems development. This phase consisted of two parts: a qualitative study about social complexities and a quantitative study about technical complexities. During the analysis, the problems analyzed in the qualitative study evolved more to coordination and communication problems for which architecture provided a tool. In the quantitative study, the understanding of the architecture as a size predictor in the project cost estimation got its basic shape.

Phase two: Studies of the requirement understanding process
In the beginning of phase two, it was tried to find coordination problems or problems related to software architecture, but we observed that the problems were more related to requirement understanding and organizational conflicts. This observation shaped the research problem towards the interpretation of the requirement understanding process and how this could be measured to get better estimates of the project timetable along with the architecture measures from the phase one. At the end of this phase, the observations so far suggested that methods in the organization played an important role in the case study projects. This led us to shape the study towards the interpretation of the role of methods and their use in the studied organization.

Phase three: Study on how practitioners work with systems development methods
In this phase the comparisons of the results of phase one and phase two according to their similarities and differences (cross-case analysis). During this analysis, it appeared that the coordination and the requirements understanding in the projects were the result of using and adapting methods based on the practitioner's background, experience and the development situation at hand.

2.2 Deep understanding of each case

The importance of within-case analysis was driven by one of the realities of case study research, namely a staggering volume of data. The overall idea was to become intimately familiar with each case as a stand-alone entity according to Eisenhardt (1989).

2.3 Interpretations across cases

The idea behind interpretations across cases or "*cross-case search for patterns*" (Eisenhardt 1989) was to force researchers to go beyond initial impressions, especially through the use of structured and diverse lenses on the data. Our tactics to cross-case analysis was to select a pairs of cases and then to list similarities and differences between each pair.

3 RESEARCH METHODS

A combination of qualitative and quantitative data collection methods were used in every phases of the study, which is according to Eisenhardt (1989) and Yin (1994) typical for theory- building researchers. The relationship between qualitative and quantitative data was two-way: the qualitative data was used for understanding the metrics and their relationships in quantitative analysis and quantitative data was used for the understanding phenomena found in the qualitative study. Mintzberg (1979) describes their relationships in the following way: *"We uncover all kinds of relationships in our hard data, but it is only through the use of this soft data that we are able to explain them"*. In both quantitative studies, the multiple investigators were used in the analysis, but also in the interpretation of the results. They often had complementary insights and different perspectives also on the qualitative studies that gave novel insights into the data, and they also enhance the confidence in the findings (Eisenhardt 1989).

In the first two phases of the research the qualitative data analysis was based on grounded theory (Glaser and Strauss 1967, Strauss and Corbin 1990). The basic idea of the grounded-theory-based data analysis resides in finding conceptual categories and abstractions related to the research goal from data, and combining these categories meaningfully to provide theoretical insight into the phenomenon in question. The qualitative data analysis was performed in three phases following Strauss and Corbin's methodology of open coding, axial coding and selective coding (Strauss and Corbin 1990).

Also quantitative data analysis with a simple linear regression method was carried out in the first two phases. The quantitative data analysis was hypothesis testing in nature. The hypotheses in both phases were based on the initial findings of the corresponding qualitative studies. In the quantitative analysis, we formulated the metric describing the phenomenon found in the qualitative studies. In the statistical analysis, we used the simple linear prediction model to analyze the correlation between metrics properties and systems development effort. We also used metaphorical analysis (e.g. Lakoff and Johson 1980; Schultze and Orlikowski 2001) to help understand the architecture of the system.

Before going further, a brief description of the case study approach and grounded theory is necessary. A brief description of the quantitative method used in the study is also given.

A case study is a research approach, which focuses on understanding the dynamics present within single settings (Eisenhardt 1989). Bembasat, Goldstein and Mead (1987) give the following definition of case study research:

"A case study examines a phenomenon in its natural setting, employing multiple methods of data collection to gather information from one or a few entities (people, groups, or organizations)"

Case studies can involve either single or multiple cases, and numerous levels of analysis (Yin 1994). Case studies typically combine data collection methods such as archives, interviews, questionnaires and observations. Evidence may be qualitative, quantitative, or both (Eisenhardt 1989; Yin 1994). Finally, case studies can be used to accomplish various aims: to provide a description (Kidder 1982; Eisenhardt 1989), test a theory (Pinfield 1986; Eisenhardt 1989) or generate a theory (eg. Gersick 1988; Eisenhardt 1989). Theory-building case study research can use a priori constructs to help shape the initial design of the theory-building process (Eisenhardt 1989). However, Eisenhardt makes a distinction between within-case analysis and cross-case analysis, which is a specific feature of the theory-building case study research approach (Eisenhardt 1989). Within-case study analysis typically involves detailed case study write-ups for each site. The cross-case analysis compares the data with different techniques across cases, thus improving the researcher's ability to process information in novel ways (Eisenhardt 1989).

Grounded theory is a research method developed originally for social sciences by Glaser and Strauss in the 1960s (Glaser and Strauss 1967). It was later developed further and reinterpreted by the original authors (Strauss and Corbin 1990) and others (e.g. Eisenhardt 1989; Locke 2003). The basic tenet of this approach is that a theory must emerge from data, or in other words, a theory must be grounded in data. Hence the method is more inductive than deductive. As defined by two of its major proponents (Strauss and Corbin 1990), *"the grounded theory is a qualitative research method that uses a systematic set of procedures to develop an inductively derived grounded theory about a phenomenon"* (p. 24). The intent is to develop an account of a phenomenon that identifies the major constructs or categories in grounded theory terms, their relationships, and the context and process, thus providing a theory of the phenomenon that is much more than a descriptive account.

Grounded theory requires that theory is emergent from data, but does not see these as being separate. Data collection, analysis and theory formulation are regarded as reciprocally related, and the approach incorporates explicit procedures to guide them. Research questions are open and general rather than specific hypotheses, and the emergent theory should account for a phenomenon which is relevant and problematic for those involved. Analysis involves three processes from which sampling procedures are derived and which may overlap: *open coding*, where data is broken up to identify relevant categories; *axial coding*, where categories are refined, developed and related; and *selective coding*, where the "core category", or central category that ties all other categories in the theory together, is identified and related to other categories (Glaser and Strauss 1967). Data collection is guided by *theoretical sampling*, or sampling on the basis of theoretically relevant constructs. Two key procedures, asking questions and making comparisons, which Glaser and Strauss call constant comparison (Glaser and Strauss 1967), are specifically detailed to inform and guide analysis and to aid theorizing. Other procedures, such as memo writing and the use of diagrams, are also incorporated as essential parts of the analysis, as are procedures for identifying and incorporating the interaction and process. The need for a high level of theoretical sensitivity on the part of the researcher is explicitly promoted. The method of the grounded theory is iterative, requiring a steady movement between concept and data, as well as comparative, requiring a constant comparison across types of evidence to control the conceptual level and the scope of the emerging theory (Locke 2003).

The quantitative analysis method was chosen based on the study question and chosen data, as recommended in (Chelimsky 1992). The research aim was a correlation analysis and the method was a simple linear regression model. We used this simple linear regression model to calculate the correlation between the metrics of the system and the development effort. The other purpose of the quantitative analysis was to demonstrate the use of metrics in project timetable estimation. In this method, it is assumed that the correlation is linear between metrics, and the systems development effort is linear. We chose this linear model because of the small sample of data and also to demonstrate how prediction can happen with this kind of simple model. In reality, the systems development is not linear, and the effort estimation should happen with non-linear methods (Venkatachalam 1993). We could get sufficiently reliable results for the correlation analysis although for the effort estimation this analysis was only the first attempt to estimate the project timetable and effort.

4 RESEARCH PROCESS

In this section the research process is explained. Figure 1 explains the flow of research phases and tasks. After that the process is explained in a more detailed level.

4.1 Preparing for the study

The beginning of theory-building studies includes an initial definition of the research question, a selection of cases and crafting instruments and protocols (Eisenhardt 1989).

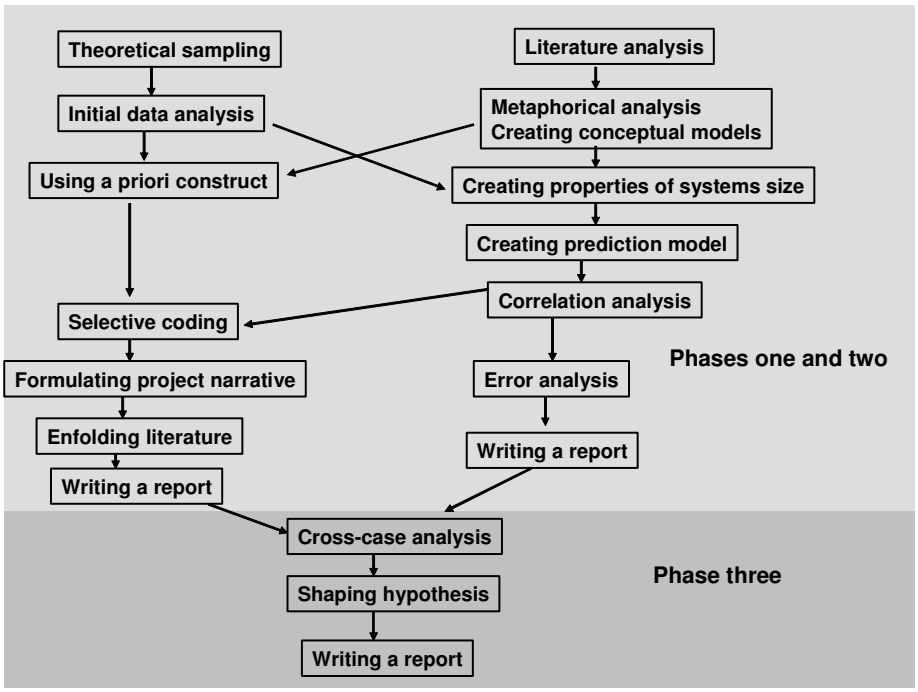

Figure 1. Research process

Following Eisenhardt's principle of within-case and cross-case analysis, each of the phases of the study had the research questions of it's own. The following table (Table 1) summarizes the research questions of each three phases.

Phase one	Phase two	Phase three
What kind of coordination problems related to software architecture was present during the systems development?	How were software requirements shaped and interpreted during systems development?	How practitioners use systems development methods in projects?
How did these problems differ in the same-site and multi-site environments?		How methods support systems development practitioners in projects?

Table 1. Research questions in each three phases of the study

The selection of cases relied on the theoretical sampling principle (Glaser and Strauss 1967), in which cases are chosen as extreme situations and polar types in which the process of interest is "transparently observable". The sampling plan of the current study was designed to be built around projects displaying problems in systems development, big problems that caused delays to the project's timetable. Within these projects in the studied organization, we chose projects of polar types: one project had problems inside the project, the other problems with the customer; one was smaller and the other one bigger; they both produced service platforms for different business areas. The analysis revealed that the projects had even more different features, such as the orientation, attitudes and experience of the participants, and the communication between participants that extended the emergent theory (Eisenhardt 1989). To facilitate iteration and comparison, which is an inevitable feature of the grounded theory method (Locke 2003), these two projects were analyzed one by one.

4.2 Data collection

During the studies, most of the data was collected from project extensive documentation based on the dynamic process of data collection (Glaser and Strauss 1967), where samples were extended and focused according to the emerging needs of the theoretical sampling. In both case projects, the project documentation data was complemented with interviews among project participants.

The interviews were all tape-recorded and completely transcribed. The length of the interviews varied from half an hour (focused interviews) to two hours (group interview). Several hundreds of pages of project documentation, the transcribed interviews and 170 000 lines of source codes were analysed during the studies.

The data for the quantitative statistical analysis in both phases one and two was collected from the architecture and component design specifications, source code, project management database and bills from subcontractors. In the project management database, the data included the time spent on each task by the project participants. These tasks were divided according to phases used in projects. In the cases where foreign consultants were involved in the development work, the development effort data was taken from the subcontractors' bills.

4.3 A priori constructs

Specification of a priori constructs can help shape theory-building research (Eisenhardt 1989). This is also identified later in the grounded theory approach as a form of seed category (Miles and Huberman 1984). In phase one, a notion of the common object from Malone and Crowston's coordination theory (Malone and Crowston 1990; Malone and Crowston 1994) was used to interpret the coordination in the project. In phase two, the concept of a technology frame of reference (Orlikowski and Gash 1994) was used to interpret the requirement understanding in the project. Quantitative studies in phases one and two included hypotheses testing studies, and the interpretations from the qualitative studies were used as a priori constructs.

4.4 Initial data analysis

The analysis started of open coding according to (Strauss and Corbin 1990). Open coding started with the identification of problems and deviations related to project progress, using mainly project meeting minutes and the group interview. We further used specification documents to help pinpoint the problems. Based on open coding phase, we made an initial axial coding to find the categories for the quantitative analysis. In the phase one, we found coordination and architecture problems and in the phase two requirements understanding problems. These initial categories formed the hypothesis for quantitative analysis.

4.5 Data analysis

In the more thorough axial coding phase, we used a notion of common object as a seed category (Miles and Huberman 1984) based on Malone and Crowston's coordination theory (Malone and Crowston 1990; Malone and Crowston 1994) to help in the interpretation of coordination problems in the project. The analysis also included memoing, where hypotheses and important general observations from the data were recorded (Strauss and Corbin 1990).

In the quantitative analysis, we used metaphorical analysis (Lakoff and Johson 1980; Schultze and Orlikowski 2002) to help understand the architecture of the system.

In the phase two, we formed three conceptual models of both subsystems. Through these models we were able to grasp how the subsystems evolved through different phases of systems development. The

content of these conceptual models suggested to us that the other subsystem's requirements changed considerably during the process. This led us into investigating further why this subsystem's requirements changed so much, while the other subsystem's requirements remained stable.

Based on project material, interviews and analysis we formulated the project narrative to trace the phenomena found in each two phases. In the quantitative analysis, we formulated the metric describing the identified phenomena in the projects. In the statistical analysis, we used the same simple prediction model in each two phases one of the study. The other metrics needed were chosen based on simplicity and wide usage. Using this prediction model, we calculated the correlation between metrics chosen and the development effort. In the end of the process, we formulated the model errors to determinate the reliability of our prediction model and analyzed the results.

4.6 Cross-case analysis

In phase three, we used cross-case analysis to interpret the final results in this study (Eisenhardt 1989). We searched for cross-cased patterns to compare the multi-site and same-site development by listing their similarities and differences (Eisenhardt 1989). We selected pairs of cases and listed similarities and differences between each pair. In this phase, the number of cases was actually three because one of the case projects consisted of two subprojects.

From the within-case analysis, the cross-case analysis and overall impressions, tentative tenses and concepts and their relationships begin to emerge, which is called hypothesis shaping (Eisenhardt 1989). The idea is that researchers constantly compare emergent theory and "raw" data – iterating towards a theory with closely fit data (Eisenhardt 1989).

4.7 Finishing and reporting the studies

Eisenhardt (1989) distinguishes the phase "enfolding literature". By this phase Eisenhardt means the comparison of the findings with similar and conflicting literature. The aim of this phase is to raise confidence, creative thinking, and the validity, generalizability and conceptual level of the findings. Yin (Yin 1994) refers to this as "analytic generalization" to distinguish it from the more typical statistical generalization that generalizes from a sample to a population. In phase one, the main comparisons were done with Malone and Crowston's (Malone and Crowston 1990; Malone and Crowston 1994) coordination theory, explained in Ovaska, Rossi and Marttiin (2004) and cost estimation literature, explained in Ovaska and Bern (2004) and Ovaska (2004). The comparisons of phase two were made with traditional requirement engineering approaches and existing sociotechnical approaches to requirement elicitation, especially the concept of a technological frame. These are all explained in Ovaska, Rossi and Smolander (2005). Both these provided conflicting and similar concepts and patterns, which both provided an alternative and more creative view to our findings. In phase three, the findings were compared to a few empirical studies of the role of methods in systems development, explained in Ovaska (2005).

5 DISCUSSION

In this section the methodology used is discussed by comparing it to multi-methodological guidelines set out by Mingers (2001). The guidelines suggest that in designing research one should consider the following domains:

- *The context of the research* – in particular the relationships between the research situation and task, the methods and theories available, and the researchers' own competencies and commitments

- *The dimensions of the research situation* – in particular, the material, social and personal aspects

In the following these domains are explained in more detail along with the comparison our multi-methodological approach to it. Finally, we summarize the general experiences of using the methodology and its limitations.

5.1 The context of the research

According the Mingers (2001) guidelines, the first step in a research project is to design the research methodology for that particular study. This includes deciding which methods are appropriate and how they will be linked together. Mingers developed a particular framework describing different research designs. The methodology used in this study lies on the most close to dominant type of design in which one method is the main approach with contributions from the others. The qualitative methods were our main method in all phases contributed from qualitative statistical analysis. The reasons for such a design were formed from the nature of systems development as a social process (see section 2). Mingers propose the other aspects in research context domain: the selection of cases, the role of the researcher and the situation, the role of researcher and methods, and the role of methods and situation, also discussed in Walsham (1995).

The professional and scientific background of principal researcher provides some explanations for understanding the selection of the research method and also the role of the researcher in the interpretive research process. Because of her educational background in engineering, she also wanted to get some 'hard evidence' of the projects, maybe to become more assured of the reliability of the research. So, she wanted to carry out some statistical, quantitative calculations that would support the qualitative work. During the learning process in the research work the quantitative calculations faded into the background and shifted more towards an interpretive approach.

Although the principal researcher did not work on the chosen projects, she acquired 'deep familiarity' (Nandhakumar and Jones 1997) with the research context and its actors during the five years working in that company. During the observation period, she was fully involved in the activities of the company. During the analysis period, she was not involved in the activities, but had full access to all project documents gaining access to information that would not otherwise have been divulged. The used data in the study was mainly documents gathered during the projects. Without her personal experience in the company it would have been difficult to interpret the local meanings, dominant perceptions, tacit knowledge and non-verbal communication (Nandhakumar and Jones 1997) from the documentation. Without the deep familiarity with the research context and its actors, it would not be possible to gain additional insight in the actors' interpretations, their motivation and perspectives (Nandhakumar and Jones 1997) in the focused interviews carried out during the study. Her role as a researcher was somewhere between an outside observer and involved researcher (Walsham 1995); it can be called an 'involved observer' participating in the work of the company before the analysis period.

5.2 The dimensions of the research situation

Mingers' (2001) framework describes also the multidimensionality of the research situation. According to Mingers (2001), each research situation is the combination of three worlds: the material world, the social world and the personal world. Each domain has different modes of existence and different epistemological possibilities as followed:

- *The material world* is outside and independent of human beings characterized as objective in the sense that it is independent of the observer although our observations and descriptions of it are not. Our relationship to this world is one of *observation*.
- *The personal world* is the world of our own individual interpretations, experiences, thoughts and beliefs. We do not observe it, but *experience* it.
- *The social world* is the world that we share with others in a particular social system and *participate* in it.

In comparing our research situation and methodology to this framework, all these worlds were present in some extent. The study covered material aspects, such as architecture as a predictor of system size or requirement creep as a measure of requirement evolution. The interpretive analysis of documentation and interviews explored the meaning of coordination and requirements understanding for particular individuals; and the grounded theory and group interviews revealed the social aspects of coordination and requirements understanding.

5.3 General experiences

In general, we experienced the methodology highly iterative and adaptive learning process, in which the research themes and questions evolved during its phases.

The most challenging part of the research was the combination of quantitative and qualitative methods, mainly because of the lack of the empirical frameworks to guide the work. Some studies in IS discipline have used multi-methodological approaches, such as Markus (1994), Ngwenyama and Lee (1997), Trauth and Jessup (2000) and Ormerod (1995) but the literature around the theme is quite scarce, also discussed in Mingers (2003). Therefore the frameworks, also other than Mingers (2001) would be helpful in designing and developing this kind of research.

5.4 Limitations of the methodology

A critical issue for researchers concerns the generalizability of the results of their work, and Yin (Yin 1994) notes that this issue is often raised with respect to case studies. Different arguments for the generalizability of case study research have been given (Eisenhardt 1989; Dutton and Dukerich 1991; Yin 1994; Walsham 1995). It is argued that in case study research, the identified concepts and categories are compared to theoretical concepts and patterns (see section 4.7), unlike in statistical generalization from a sample to a population. Still, due to the nature of this study, in which the understanding of method use was interpreted on the basis of separate phenomena found in one organization, the generalization of the use of methods may be limited. Therefore, the understanding gained in these studies provides a basis for understanding similar phenomena in the same settings rather than enabling the understanding of phenomena in other contexts.

6 SUMMARY

This paper has described the multi-methodological approach to study coordination of systems development process. The methodology is based on the empirical theory building case-study approach. We used the principle of within-case and cross-case analysis to interpret the findings in different phases of the study. In all these three phases, we used both qualitative and quantitative methods to get richer and more reliable understanding from coordination phenomena.

The three phases of the study have provided a rich picture of different aspects of systems development. In the first phase of the study, we examined the role of architecture in coordination and cost estimation in a multi-site software development from quantitative and qualitative viewpoints. The second phase involved two studies, one qualitative and the other quantitative, on the evolving

requirement understanding process and the measurement of this process. The third phase was a study based on the first two studies on the role of methods and how practitioners work with them using principle of cross-case analysis.

We experienced the methodology highly iterative and adaptive learning process, in which the research themes and questions evolved during its phases. The most challenging part of the research process was the combination of qualitative and quantitative methods, because of the lack of multi-methodological work done so far. Therefore the frameworks, such as Mingers (2001) would be helpful in designing and developing multi-methodological approaches.

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