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Heli Aramo-Immonen

Project Management Ontology

– The Organizational Learning Perspective



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– The Organizational Learning Perspective

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ABSTRACT

In a recent interview with the Financial Times, the chief executive of Royal Dutch Shell, Mr. Jeroen van der Veer, said he “keeps faith in ‘elephant’ projects” referring to the Russian gas mega-project that Shell had fallen eight months behind schedule with and had cost overruns twice the original estimate. Mr. van der Veer partially blamed industry-wide factors for this such as an increase in raw material prices, more expensive contractors and exchange rate pressure. But he also implied that the original assessment of the project in 2003 had been too optimistic and that the scope of the mega-project had to be revised. The wisdom he said was that *scope changes are basically because you didn't do enough homework in advance*. Even though it is rather easy to feel miserable after such a statement, there is faith left as the chief executive says - if only we had been able to do our homework.

This gives me reason enough to concentrate in this research on the construction of a proactive qualitative decision support aid for mega-project management. The main research topic of the dissertation is organizational learning in the field of project management (PM). This study explores project management by providing a PM ontology for managers. The managerial value of the ontology is, for example, lower potential for time and cost overruns and poor project quality, and higher potential for effective and efficient execution of complex projects.

Project management essentially aims to combine learning and performance within the project organization to serve the project owners' strategy. Therefore a proactive vision and co-evolutionary touch is needed to evolve project processes. Project management in a high pressure environment often means utilizing explicit quantitative methods, usually based on reactive calculations. However, the management of uncertainties and risks demands a versatile, qualitative point of view. With quantitative methods we can “price” the risks. With qualitative methods we are able to realize and shape the risks in advance. Therefore project management is the challenge to move the organization towards the common qualitative and quantitative goals during a project lifecycle, i.e. to support organizational learning throughout a long-lasting project.

This study introduces a project management ontology – a classification of management disciplines for project managers and a project learning model. Knowledge management theory, activity theory, systems theory and various management practices are discussed in the conceptual part of this thesis. The empirical part of the research concerns a multiple-case study conducted in ten project organizations participating in two large mega-projects. The mega-projects were in the offshore industry and shipbuilding industry. Altogether more than fifty project managers and project team members participated in this research. The empirical results are presented at the end of introduction and in the original publications enclosed in this thesis.

Keywords: mega-project, project learning, organizational learning, systems thinking, activity theory, management ontology

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ORIGINAL PUBLICATIONS

- I** Aramo-Immonen, H. and Porkka, P. (2008) Positive trigger for proactive project management improvement, In: Kujala, J. and Iskanius, P. (eds.) *Proceedings of the 13th International Conference on Productivity and Quality Research, ICPQR 2008*, June 25-27, 2008, pp. 61-72, Oulu.
- II** Suominen, A., Jussila, J. J., Koskinen, K. U. and Aramo-Immonen, H. (2008) Requisite variety of expertise in idea generation within a group. In: Huizingh, K.R.E., Torkkeli, M., Conn S. & Bitran I. (eds.) *Proceedings of the XIX ISPIM Conference*, Tours, France, 15-18 June 2008. *)
- III** Aramo-Immonen, H. and Vanharanta, H. (2008) Project management – the task of holistic systems thinking, *Human Factors and Ergonomics in Manufacturing*, Wiley Periodicals Inc., A. Wiley Co. Vol. 19, No. 6, pp. 1-19 (forthcoming).
- IV** Koskinen, K. U. and Aramo-Immonen, H. (2008) Remembering with help of personal notes in project work context, *Journal of Managing Projects in Business*, Vol. 1, No. 2, pp. 193-205, Emerald Group Publishing Limited.
- V** Aramo-Immonen, H., Kantola J., Vanharanta H. and Karwowski W. (2005) Mastering qualitative factors of uncertainty in mega-projects, In: P. Dussauge (eds.) *Proceedings of EURAM2005, The European Academy of Management 4th–7th May 2005*, pp. 170, TUM, Munich.
- VI** Aramo-Immonen, H., Porkka, P. L. and Koskinen, K. U. (2009) The role of formal training in project-based companies. In: K. Kähkönen, A.S Kazi and M. Rekola (eds.), *The Human Side of Projects in Modern Business*, pp. 695-708. Project Management Association Finland (PMAF) in collaboration with, VTT Technical Research Centre of Finland, Helsinki.
- VII** Aramo-Immonen, H. and Porkka, P. L. (2009) Shared knowledge in project-based companies' value chain, *International Journal of Knowledge Management Studies*, Vol. 3 Nos. 3/4, pp. 364-378, Inderscience Publishers.

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1 INTRODUCTION

Project management is an important part of an industrial company's success. Mega-projects are large-scale, complex projects delivered through various partnerships, often affecting both public and private stakeholders (van Marrewijk et al., 2008). Managing these large national and international mega-projects can pose many demanding tasks for project coordinators (van Marrewijk et al., 2008; Sweis et al., 2008; Flyvbjerg, et al., 2003; Aramo-Immonen and Porkka, 2008). The contemporary networked economy has pushed businesses more and more towards project-based performance. Therefore, project management and project learning as a research domain is an important area of current interest.

The objective of this study is to explore project learning from a mega-project partner network view (Figure 1) in order to generate a project management ontology. An ontology is a "formal, explicit specification of a shared conceptualization" (Gruber 1993, p. 199). An ontology provides a shared vocabulary which can be used to model a domain; the type of concepts that exist, and their properties and relations (Arvidsson and Flycht-Eriksson, 2008). In this study the ontology models the domain of mega-project management. This ontology is suggested to help the system integrator (project owner, contractor or end-client) of the mega-project to manage the evolution of a fragmented, complex and long-lasting mega-project during its lifecycle. The overall managerial goal is to boost project delivery accuracy, quality and customer satisfaction.

Project management in a high pressure environment often requires explicit quantitative methods such as economic evaluations. However, the management of uncertainties and risks also demands a versatile qualitative approach. Quantitative methods allow the evaluation of risks, whereas qualitative methods allow the identification of risks and beyond that also the formulation of risks to opportunities in advance. This can be called a proactive approach to project management. Participants to be selected in the mega-project structure (Figure 1) should be able to bear a complementary set of risks and have the ability to evolve during the process. A recent literature study suggests that project stakeholders' opinions are not acknowledged enough (Achtercamp and Vos, 2008; Aaltonen et al., 2008). The

definition of a stakeholder in this study is broad. Stakeholders (both internal and external) are an integral part of a project. They may represent the end-users or clients, from whom requirements will be drawn, but also partners in a networked, fragmented project organization (Figure 1). Stakeholders influence the planning and execution of a project, and finally they enjoy the added value of the completed project (e.g. Liang et al., 2009).

It is important (and somewhat axiomatic) to involve stakeholders in all phases of a mega-project for two reasons. Firstly, experience shows that their involvement in a project significantly increases chances of success by building in a self-correcting feedback loop (Senge, 1990). Secondly, involving them raises confidence in performance and will ease the execution and acceptance of the project at all levels (Aramo-Immonen and Porkka, 2008). Holistic stakeholder management inspires stakeholders. Dialogue between stakeholders delivers excellence at personal and collective levels and connects the deeper level awareness of potential (Ellman and Månsson, 2009). Analyses and workshop results presented in the original publications of this thesis reveal practical implications of such a dialogue.

Project management is more than pure quantitative steering. It is a challenge for the system integrator (or contractor in Figure 1) to move the organization towards the common qualitative and quantitative goals. In the case of the offshore and shipbuilding projects discussed in this research, the ability to learn during the project lifecycle is the key element in the process of creating added value and competitive advantage.

The project learning model introduced in this research is a qualitative decision support system (DSS) for the management of project-based companies. Various decision support systems are available for project portfolio selection, such as risk-benefit ranking grid diagrams, analytic hierarchy processes (AHP), and benchmarking for project management (Levine, 2005; see also e.g. Ghasemzadeh and Archer, 2000; Chu et al., 1996; Luu et al., 2008). There are also various quantitative project analysis methods available, such as those based upon operational research and optimizations of project paths (e.g. Ibbs et al., 2007). The variety of software applications available for project management is wide, for example Critical

Path Scheduling (CPM), Critical Chain Project Management (CCPM), Earned Value Methods (EVM), and Enterprise Resource Planning (ERP) (Levine, 2005). The practical purpose of the model introduced in this research is to assist the management of a company in their formation of a comprehensive view of a mega-project and to provide a foundation for the project learning process. The contribution of this research is its reinforcement of prior research through the examination of individual projects from a variety of qualitative angles. According to Taxen and Lilliesköld (2008), managing a complex project requires common understanding and comprehensibility over formalism and rigor.

The overall endeavor of a project management team is to bring the project strategy and the company strategy together (Turner, 1999; Levine, 2005). The project learning model introduced provides pro-activity for co-evolutionary project management. The co-evolutionary methodology refers to the methodology that supports the simultaneous and joined development of systems, such as management and working systems. Proactive visioning refers to the method of comprehending and perceiving project uncertainties in advance. This model assists the management in answering the question of how to meet customers' requirements by mobilizing and developing competences and resources in the mega-project.

The focus here is on transforming project risk management into project uncertainty management (Ward, 2001). Traditionally, risk management concentrates on avoiding threats. In uncertainty management, the screening is focused on the dynamic commercial, technological and human aspects affecting the project. Factors of uncertainty may include both negative and positive impacts on the project. The conventional perspective on risk evaluation is developed towards the opportunity management approach. Opportunity-driven project management has a considerably more extensive variety of means to gain a competitive advantage on the market.

The project organizations that participated in this research and their view of the qualitative features of a mega-project were evaluated. Each individual's assessment was collected through the evaluation of various statements which describe the project's features. The assessment consisted of 150 statements describing the ontology of 40 features that affect a project's success. The classification of the

project management ontology is based upon the literature study and interviews carried out in project organizations. In the process, the project performer evaluates the current state of the project and its desired state. The gap between the states describes the proactive vision, which is the potential for development in each project management feature. During the research, a database of 16,200 evaluation responses was compiled. This provides a comprehensive information resource for statistical calculations in this research and also for future review.

1.1 Problem formulation and research questions

The research idea evolved during the writer's industrial career in project-based companies in 1988–2002. The expanding dynamics of business and especially increasing outsourcing has created fragmented, decentralized organizations which are often project-based. The success of such collaborations appeared to be dependent upon various qualitative features. Behind this versatile management system lie the problems of recognition of the most important success factors (Suominen et al., 2008) and organization of project learning (Aramo-Immonen et al., 2009). This was transformed into the following research questions:

- How can qualitative project management features be prioritized to focus on the development of project processes?
- How can project learning be integrated into project processes?

The first question is pertinent to fragmented and complex mega-project organizations because the importance of management features is rarely visible. It is difficult for a system integrator (representing the project owner) to identify features which could be improved and which affect a project's success, but that exist invisibly in a fragmented partnership network (Figure 1). In this study the researcher seeks to resolve the problem of how to collect the necessary data from the organization and how to prioritize the development potential found.

The second research question relates to the first. When the important development potential is identified it has to be utilized in order to improve the level of project performance. The latest research results show that people in project organizations are not keen on formal training (Aramo-Immonen et al., 2009). With a heavy workload

and under constant pressure, there is no time to reflect (i.e. to learn). This research problem is about how to create a learning environment inside the project processes. One motivation behind the study was the need for an extended capability to steer and develop the mega-project during its lifecycle. The holistic management of big, complex and long-lasting mega-project execution is a practical problem. Traditionally, a wide range of quantitative methods exists for project evaluation. Yet though the quantitative study of the subject in question (mega-projects) is important, it is only the tip of the iceberg when it comes to a large, fragmented mega-project. Evidently powerful, continuous qualitative methods are needed in the study of this field.

The original publications (e.g. Koskinen and Aramo-Immonen, 2007 and 2008) and the ISPIM2008 conference (Suominen et al., 2008) provide answers to the following knowledge management research questions supporting the relevancy of the research:

- Does the project organization need external memory aids in order to learn and share knowledge?
- Is there any motivation to share knowledge in the project organization?
- Does requisite variety in a project group have an impact on idea generation?

Answers to these questions support the need for a project management ontology, a learning model, and the systems development introduced in the rest of the original publications and results (Chapter 4). In the next chapter the research domain of a mega-project is defined.

1.2 The mega-project context

The Project Management Institute (PMI) provides us with a materialistic definition of a project. According to the Project Management Body of Knowledge (PMI, 2000), a project is a temporary endeavor to create a unique product or service. From the project learning angle in the concept of a project, the cognitive perspective has to be included (Bredillet, 2008); the project is human capital and financial resources organized in a novel way to undertake a unique scope of work within time and cost constraints, achieving quantitative and qualitative objectives (Turner, 1999).

There is no exact definition for the concept of a mega-project. It can be described as a large, usually long-lasting project. Typically, the project organization is complex, diversified and fragmented, possibly globally located (van Marrewijk et al., 2008). Williams (2002) mentions two dimensions of complexity in a project: structural complexity and uncertainty. Structural complexities in a mega-project are size, number of elements and interdependence of elements (e.g. organizational units, scope, supply network, and infrastructure). Uncertainty appears in fuzzy goals and in the ambiguity of methods (Azim, 2009). Mega-projects might have long, complicated and cybernetic value and supply chains which consist of different expert functions. Kerzner (2003) characterizes mega-projects as having continuous organizational restructuring; hence each subproject goes through a different lifecycle phase. Kerzner also emphasizes that training in project management is a critical success factor for the mega-project (Kerzner, 2003 p.323). From the economic point of view, mega-projects vary from large to gigantic; in other words, it is possible to refer to very large, public or industrial real investment projects. In the literature, mega-projects are categorized as public, private, or a combination of both, termed hybrid (Flyvbjerg, et al., 2003, p.9).

Public mega-projects are financed by the government and decisions are made by politicians. Power play usually characterizes the development of public mega-projects instead of commitment to deliberative ideals,. These mega-projects are typically deeply influenced by public opinion and surrounding society. In democratic societies the opinions of civic organizations, such as environmental movements, have a significant influence on public mega-projects. The motives behind a public project can be non-commercial and of a public utility, but at the same time mega-projects should be implemented profitably. Typical examples of public mega-projects are in healthcare and infrastructure, such as railway, bridge and highway projects (Flyvbjerg, et al., 2003).

Private mega-projects are financed privately and managed according to their owners' desires. Motives are usually purely commercial. Examples of private mega-projects are shipbuilding, oil rig construction and other construction projects (Flyvbjerg, et al., 2003).

Hybrid mega-projects can be described as a combination of private and public mega-projects. Most mega-projects are so complicated that they are essentially hybrid. Even privately governed global projects are to a great extent dependent on various stakeholders' opinions, guided by public opinion. Infrastructural projects such as building a nuclear power plant, paper mill or oil rigs often can be considered as hybrid (Flyvbjerg, et al., 2003; Marrewijk et al., 2008).

The definition of the fragmented, diversified mega-project organization (Figure 1) is very similar to recent definitions of the virtual organization. The virtual organization advocates collaboration, alliance, partnership and similar ideas. Closely linked to a web-age virtual organization are terms like flexibility, opportunism, improved utilization of resources, and the collection of core competencies (Barnes and Hunt, 2001). These terms are also linked to a decentralized project organization functioning in geographically separate locations. The general impact of information technology applications is reviewed in the contemporary literature on managerial roles, organizational culture, decision-making streams and education (Barnes and Hunt, 2001).

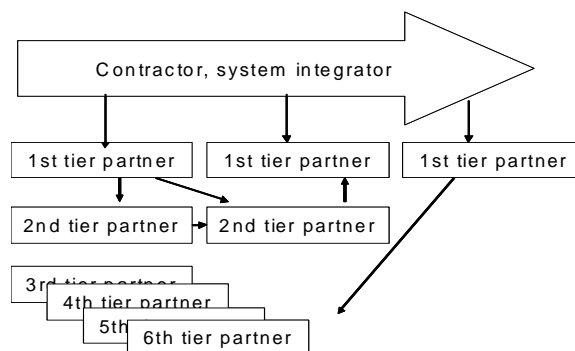


Figure 1. Illustration of the simplified model of a mega-project structure

An important issue for decentralized organizations is mutual trust. Organizational learning processes require a high level of trust within the organization (Koskinen, 2001; Nonaka et al., 2000). Information and knowledge flows are vital parts of communication and collaboration, but trust is also required for the creation of innovation processes and in sharing benefits and risks. According to Li (2005), social capital is a set of relational resources embedded in relationships that positively influence firm conduct and performance. Li also states that social capital is

constructed from three components, namely a structural, relational, and cognitive dimension. The structural dimension captures the network position or organizational level; the relational dimension is represented by trust; and the cognitive dimension is the shared vision between units (c.f. Li, 2005).

According to Artto and Wikström (2005), project business is defined as the part of business that relates directly or indirectly to projects, with the purpose of achieving the objectives of a firm or several firms. This study has adopted this definition (Table 1), suggesting that the unit of analysis in project research should vary from a single-project firm to a multiple-project firm setting.

Table 1. The project business framework with four distinctive research areas (Piila et al., 2008)

	One Firm	Many Firms
One Project	Management of project	<i>Management of project network</i>
Many Projects	<i>Management of project – based firm</i>	Management of business network

From the viewpoint of the mega-project contractor (or the system integrator in Figure 1), the focus is on the management of the project network (Table 1, upper right corner). However, the partner network (Figure 1) managing a project-based firm has to be considered simultaneously (Table 1, lower left corner).

1.3 Summary

In this research ten case companies involved in two case projects were chosen from the 1st- and 2nd-tier network partners because these ‘system suppliers’ have their own project management and project execution processes (Figure 1). Lower level network partners were not chosen as they are typically sub-suppliers and do not carry out project management.

The practical research results indicate that a mutually understood and shared vision could be one of the key success factors to mega-project performance. The *project learning model* including the *project management ontology* (introduced in Chapter 4) assists the management in the creation of a shared vision and trust between the stakeholders of a project. This trust is a part of toleration of the project's uncertainty, since trust reinforces motivation and willingness to accept vulnerability based on positive expectations of a partner's intentions of behavior (c.f. Li, 2005).

The empirical data were collected during 2006-2008. A database consisting of 16,200 data inputs from the ten project organizations was compiled from this. The data presented in this thesis is only the tip of the iceberg of that collected; nevertheless this research has been able to thoroughly explore mega-project management from the organizational learning perspective and has gained new knowledge for further academic study. The empirical results are examined in Chapter 5.

The next chapter presents the mixed methodology utilized. The interrelation between the original publications and research project is clarified and finally the research methods are discussed.

2 RESEARCH METHODOLOGY

Quite recently mixed methods research has been accepted among research designs as the third main stream beside the purely qualitative and purely quantitative research methods. Mixed methods research is an approach to inquiry that combines or associates both qualitative and quantitative forms (Creswell, 2009). It involves both collecting and analyzing quantitative and qualitative data (Creswell and Plano, 2007). Mixed methods designs provide researchers, across research disciplines, with a rigorous approach to answering research questions. In the case of holistic analysis of complex systems, such as the mega-project, this is a relevant approach. To put both forms of data (qualitative and quantitative) together as a distinct research design or methodology is new. Thus the idea of mixing the data, the specific types of research designs, the notation system, terminology, diagrams of procedures, and challenges and issues in using different designs are features that have emerged within the past decades (see e.g. Denzin, 1978; Creswell and Plano, 2007).

To gain a holistic view of the research domain it is necessary to use approaches that systematically explore the new avenues of research that methodological diversity affords. Methodological styles reflect not only differences in technique (such as qualitative versus quantitative procedures), but also different views of the epistemology of science and its ultimate goals and contributions to human thought and endeavor (Brewer and Hunter, 1989, p. 26). Denzin (1978) discusses triangulation as an important part of research design. He has identified four basic types of triangulation (Denzin and Lincoln, 2007, p. 391):

1. Data triangulation: the use of a variety of data sources in a study
2. Investigator triangulation: the use of several different researchers or evaluators
3. Theory triangulation: the use of multiple perspectives to interpret a single set of data
4. Methodological triangulation: the use of multiple methods to study a single problem

If we assess this research through triangulation typology, we can conclude that all four types of triangulation are represented. First, the researcher compiled a database of 16,200 responses to qualitative research statements. Each individual evaluation is valuable qualitative information for the researcher, thus also statistical evaluation is possible by converting the linguistic scale to a numerical form as with the Likert scale (Blalock, 1968; Aramo-Immonen and Porkka, 2009). Second, the empirical study is based on a multiple-case study instead of one single case. Each case company can be studied both separately and as part of a network. According to Eisenhardt and Graebner (2007), the multiple-case method provides rich qualitative evidence supporting research conclusions. Third, in this particular research project several researchers conducted partial projects (e.g. Aramo-Immonen et al., 2005; Suominen et al., 2008; Aramo-Immonen et al., 2009; Aramo-Immonen and Vanharanta, 2008). Fourth, the mixture of methods used in the research process varied from self-assessment (multiple-choice questions), workshop observations (action research), and Friedman tests (statistical analysis, e.g. Conover, 1999).

According to theory triangulation, the research domain was studied from the angle of economic science, design science and systems development. These areas will be introduced in the following chapters. The researcher's contribution and research process will also be introduced.

2.1 Economic science

The five common research approaches used in economic science are listed in Table 2: concept analytic, nomotetic, decision methodological, action research, and constructive research (Neilimo and Näsi 1980; Kasanen et al., 1991). Here the research approach is normative, and the acquisition of knowledge is empirical. The method is partially constructive and action-oriented (case studies), hence a descriptive conceptual study of the qualitative features of project management disciplines is also presented. The *construction*, namely a *qualitative analysis*, is built in the decision model designed for mega-project management. The application architecture employed is the choice of the researcher. The substance of the analysis is an artifact, a classification of the qualitative features affecting mega-project success. This classification can also be termed an ontology. This artifact is the product of the

conceptual analysis of the researcher and of the hermeneutical interaction between the researcher and the actors in the mega-project environment.

Table 2. Business economics research approaches (Neilimo and Näsi, 1980; Kasanen et al., 1991; Bailey, 1994; Gummesson, 2000)

Business economics research approaches	
Concept analytic	Both the positivistic and hermeneutic comprehension of science. Its objective is to create a concept system which assists in the description of different phenomena and creates instructions for present and future actions. In this research, the project knowledge taxonomy is mostly descriptive and empirical, but it also has normative characteristics.
Nomotetical	Consists mostly of the positivistic comprehension of science. The purpose of this research approach is to explain the causes of phenomena and occurrences subject to the constraints of laws.
Decision methodological	Consists of mostly positivistic comprehension of science. The objective of this research strategy is to create a solution method which is based upon mathematics and logic.
Action research	Consists primarily of the hermeneutic comprehension of science. Its purpose is to understand and describe problems or situations which are difficult to explain with a positivistic method. Problems in the situations where action research is utilized are usually holistic and it is difficult to separate them into specific sub-parts of the problem. This research approach is both descriptive, normative and empirical. One of the objectives is to produce critical knowledge from a system and to change the system after that. The objective of action research is to identify a hidden theory in the research target and see whether it is possible to support it with empirical research. The catalytic role of the researcher is vital for the process in action.
Constructive research	The objectives of this research strategy are normative and they create a method for problem solutions. It combines elements of decision methodological research and of the action research strategy and design science. The empirical study connects the research strategy to a practical situation. The research strategy is usually a case study.

The project management ontology discussed is based upon a conceptual analysis. Concepts are abstract notations or symbols; they assist the solidification, structuring and illustration of both phenomena and their characteristics at the qualitative level (Olkkonen, 1993).

The case study method (Kasanen et al., 1991; Olkkonen, 1993; Eisenhardt and Graebner, 2007) was applied to collect data. According to Olkkonen (1993), the results obtained through the case study method are often new hypotheses or theories, explanations of change or development processes, even normative instructions which propose revised guidance. The material and its processing are empirical, although often the material is formed from a small number of cases.

However, it is worth emphasizing that for this study the data were collected from *ten* project organizations. The multiple-case method provides rich qualitative evidence supporting the research conclusions (Eisenhardt and Graebner, 2007). The linearity of the result graphs indicates broader generalizability than in a single case study. Affecting features, such as organizational culture, management style or work atmosphere in a single case, can be eliminated from multiple-case results.

2.2 Design science

The method of design science is developed within information technology research. While natural science explains how and why things are, design science is concerned with devising artifacts to attain goals. In other words, natural science attempts to understand reality whereas design science attempts to create artifacts that serve human purposes (March and Smith, 1995). Instead of producing general theoretical knowledge, design science produces and applies solution-oriented knowledge. This is typical of operations research, systems development and management science. Theories are expected to explain how and why systems work within their operating domain (March and Smith, 1995). The theoretical framework in this research is formed from organizational behavior theories: knowledge management, activity theory, systems dynamic and theories of organizational learning. Tables 3 and 4 list the research activities and outputs in design science.

Table 3. Design science research activities (March and Smith, 1995)

Design science research activities	
Build	The objective is to build an artefact to perform a specific task. These artifacts then become the object of study. Artifacts are constructs, models, methods and instantiations. The research question is "does it work?".
Evaluate	The objective is to evaluate the artifact. Evaluation requires the development of the measurement of artifacts. The research question is "how well does it work?".
Theorize	Discussed theories explicate the characteristics of the artifact and its interaction with the environment that results in the observed performance. This requires an understanding of the natural laws governing the artifact and of those governing the environment in which it operates. The interaction of the artifact with its environment may lead to theorizing about the internal working of the artifact itself or about the environment.
Justify	If a generalization of theory is given, the explanation has to be justified. For artifacts based on mathematical formalism or whose interaction with the environment is presented mathematically, this can be done by utilizing mathematics and logic to prove posited theorems. Justification for non-mathematically represented IT artefacts follows the natural science methodologies governing data collection and analysis.

The design science research activities used in this study are as follows: 1) the artifact designed in this research was a decision model with a built-in qualitative analysis; 2) evaluation of the artifact was conducted via case studies in a mega-project environment; 3) the theories discussed explicate the characteristics of the decision model. However, this solution-oriented research provides no direct generalization of theory. Hence the research is qualitative; the justification is made according to the natural science methodology (e.g. surveys, case experimentations and observation) (Ackoff, 1962).

The design science research outputs (Table 4) in this research are: 1) a project management ontology (construct of concept classification), 2) an organizational learning model (decision model), 3) an analysis tool (qualitative evaluation method), and, 4) the tool's instantiation in case organizations (its implementation in a mega-project environment).

Table 4. Design science research outputs (March and Smith, 1995)

Design science research outputs	
Constructs	Concepts from the vocabulary of the domain. They constitute a conceptualization used to describe the problems in the domain. They form the specialized language and shared knowledge of a discipline.
Model	A set of propositions or statements expressing relationships among constructs. A solution component to an information requirement determination task and a problem definition component to an information system design task. An example of this is expert systems where knowledge is modeled as a set of production rules or frames.
Method	A set of steps (a guideline) utilized to perform a task. Methods are based upon a set of constructs (a language) and a representation (a model) of the solution space.
Instantiation	The realization of an artifact in its domain. Instantiations operationalize constructs, models and methods. It demonstrates the feasibility and effectiveness of the model or method it contains. It is an empirical discipline. Instantiations provide working artifacts.

2.3 Systems development

In the case of complex systems, such as mega-project organizations, the multimethodological approach will generate holistic knowledge of the research area. The methods discussed and employed in this research are complementary in the multidimensional domain. These research approaches are required to investigate aspects of the research questions and to execute the objective of the design task of this study (namely the project learning model).

As regards systems development, this research is applied, developmental, and exploratory (Nunamaker et al., 1990; Bailey, 1994; Ackoff, 1962); *applied* as a solution-oriented, problem-solving approach; *developmental* in order to search for a construction or model for a better course of action in the system; and *exploratory* (formulative) to identify problems for a more precise investigation. The systems development research approach is explained in Table 5.

Table 5. Systems development research approach (Nunamaker et al., 1990)

Systems development - a multimethodological approach to research	
Theory building	Includes the development of new ideas and concepts and the construction of a conceptual framework, new methods or models. Theories are usually concerned with generic system behavior. Because of emphasis on generality, the outcome of theory building has limited practical relevancy to the target domain. Theories may be utilized to suggest research hypotheses, guide the design of experiments, and conduct systematic observations.
Experimentation	Research strategies such as laboratory and field experiments; computer and experimental simulations. Experimental designs are guided by theories and facilitated by systems development. Results may be utilized to refine theories or/and to improve
Observation	Research methodologies such as case studies, field studies and sample surveys. Observation assists the researcher to arrive at generalizations, which helps focus later investigations. Research settings are natural, therefore holistic insights may be gained and results are more relevant to the domain. Sufficient contextual and environmental conditions are to be reported to enable judgement of the limitations of conclusions.
Systems development	Consists of five stages: concept design, the construction of the system architecture, prototyping, product development and technology transfer. Multiple methodologies appear to be complementary, providing valuable feedback to one another. To gain a holistic understanding of a complex research area such as mega-project management systems, a multimethodological approach is effective.

In summary, the research approach matrix is mapped in Appendix 1. The connection between different stages of the research process and the original publications (indicated with Roman numbers I-IX) are also systematized in the appendix.

2.4 The research process and limitations of the study

The common underlying research topic in all original publications is the management of learning in project organizations in order to gain successful project results (Figure 2). Interrelated topics are project managers' personal memory aids (IV) and the idea generation capability of project members (II). The process of planning the research, executing the empirical study, and documenting the results occurred in 2004-2009.

The connection between the reported results, research methods and original publications is shown in Figure 2.

Scientific Approach	Original Publications	
Economic science, concept analytical and nomotetical Empirical research Survey questionnaire	Remembering with help of personal notes in project work context, <i>Journal of Managing Projects in Business</i>	IV 2008
Economic science, concept analytical and nomotetical Empirical research Empirical test	Requisite variety of expertise in idea generation within a group ISPIM2008	II 2008
Economic science, concept analytical, constructive and decision methodological Design science and systems development Analysis of empirical data and action research	* Mastering qualitative factors of uncertainty in mega-projects, EURAM2005	V 2005
Economic science, concept analytical Systems development, observation Statistical analysis of empirical data and action research	* Shared knowledge in project-based companies' value chain, <i>International Journal of Knowledge Management Studies</i>	VII 2009
Economic science, concept analytical Systems development, observation Statistical analysis of empirical data and action research	* The role of formal training in project-based companies, <i>The Human Side of Projects in Modern Business</i>	VI 2009
Economic science, concept analytical, constructive and decision methodological Design science and systems development Analysis of empirical data and action research	* Project management – the task of holistic systems thinking, <i>Human Factors and Ergonomics in Manufacturing</i>	III 2008
Economic science, constructive and decision methodological Design science and systems development	* Positive trigger for proactive project management improvement, ICPQR2008	I 2008

Figure 2. Connection between scientific-approach research methods used and original publications *) Correspondent author Aramo-Immonen, H.

This study was limited to the qualitative research of the mega-project network organization. Quantitative methods were limited to a selection of relevant statistical calculations. An empirical study was conducted in two large case mega-projects. Limitations of a case study always lie in the generalizability of results (Gummesson, 2000; Eisenhardt and Graebner, 2007; Siggelkow, 2007; Olkkonen, 1993). This research did not attempt to construct any new general project management theory based on the research results. However, the multiple-case study on the ten project-based companies participating in the two mega-projects provided interesting empirical results of qualitative mega-project management characteristics. These multiple-case results also have general value (Eisenhardt and Graebner, 2007) as discussed in Chapters 4 and 5. On the basis of these results, a learning model for a

project-based organization is introduced. These empirical results may be valuable to further discussion on general project management theories.

Science can be defined as a process of inquiry. This can be distinguished by three procedures: answering questions, solving problems, and/or developing more effective procedures for the first two. Science both informs and instructs (Ackoff, 1962). In order to answer questions, the researcher requires tools, techniques and methods considered to be scientific (Table 6).

Table 6. Scientific tools, techniques and methods (Ackoff, 1962; Bailey, 1994; Gummesson, 2000; Blalock and Hubert, 1968)

Scientific tools; techniques and methods	
Tools	Instruments utilized in scientific inquiry. Mathematical symbols and formulas, computers and software, thermometers etc ; in social sciences concepts and taxonomies; in action research scholars themselves as actors.
Techniques	Scientific course of action. Means of utilizing scientific tools. Eg. conceptual techniques, classification techniques, sampling techniques. The researcher decides about selecting the technique.
Methods	Methods are the rules of choice. In case studies, field studies, and sample surveys selecting the set of tools is ruled by the
Methodology	The study of scientific methods. The logic of science.

This research represents the applied sciences. The research questions posed are an immediate problem in research in the domain, i.e. in the mega-project management environment. Multiple methods were applicable to this research. To gain a holistic understanding of the complex object of research, here the mega-project management system, a multimethodological research strategy was relevant (Nunamaker et al., 1990). The research domain of industrial management is economic science. However, this study also has features of design science, systems development and social science.

The research approach was qualitative. In the field of management science, project management has been acknowledged as an object of independent research only quite recently. There has been an army of consultants and plenty of fads available in this

field, but fewer real professional approaches supported by the scientific community (Görög and Smith, 1999; Turner, 1999; Kerzner, 2003; Levine, 2005). Acquisition of a variety of qualitative methods in project management science is needed. Qualitative research consists of several aspects simultaneously. It is multiparadigmatic in its focus, and its value is its multimethodological approach. The interpretive understanding of human experience is crucial (e.g. Turner, 2003; Denzin and Lincoln, 2003). Qualitative implies an emphasis on qualities of entities and processes. Meanings are not examined in terms of quantity, amount, intensity or frequency. However, in the tradition of positivist economic science (the domain of industrial management and engineering), statistical measures and documents are utilized as a means of locating groups of subjects within a larger population (Denzin and Lincoln, 2003). Hence, qualitative research results and the reporting of the results in the “quantitative” form as graphs have to be distinguished carefully. The result remains qualitative. This research is qualitative in the domain of organizational behavior and management and it employs survey tools and classification methods derived from the social sciences (Bailey, 1994; Blalock and Hubert, 1968).

This research is hermeneutical. The researcher can be seen as a research instrument in the process of gaining insight into and the significance of the concepts and the causality of the management features modeled in the study (Gummesson, 2000; Nunamaker et al., 1990; Ackoff, 1962). The researcher’s preunderstanding of the fields studied (first-hand preunderstanding), as well as the capability to search and obtain new information via intermediaries (second-hand preunderstanding), is essential for research of this type (Gummesson, 2000). The challenge is to gain a holistic view of the subject. The hermeneutic approach process uses open lateral thinking, whereas in the positivistic approach the researcher, thinking vertically, attempts to gain an exact result for a limited research objective (Gummesson, 2000). The solution-orientated study of the qualitative features of the complicated, fragmented and networked construction of the mega-project organization’s functions requires lateral thinking in order to gain a comprehensive view of the issue.

The design science method was utilized to design the project learning model. Models have inputs and outputs. Inputs can be described as the outline of possible choices of action, whereas the output variable represents the index (or the quantitative measure)

of the value of alternative choices to the decision-maker. Focus in this research is on modeling a qualitative decision situation. In this domain, the choice available to the decision-maker cannot be presented with a quantitative variable. Hence the choice is between discrete qualitative alternatives (Ackoff, 1962).

The systems development method closely resembles design science; however, it focuses on the development of the system itself. In this research, strategies such as experimental simulations are guided by theories of organizational behavior and facilitated by systems development. The results may be employed to improve systems (Nunamaker et al., 1990).

2.5 Researcher's contribution

Applied research in the domain of mega-project organizations in the context of the offshore and marine industries requires the researcher's basic understanding of these fields. Asking relevant research questions and applying valid research methodologies to address research tasks in such broad systems requires both the researcher's holistic understanding and involvement (Nunamaker et al., 1990; Gummesson, 2000).

A computer program based on the previously developed Evolute architecture was used as a platform for the qualitative analysis in this study (Kantola et al., 2005). The decision to choose this architecture was natural since this research started as part of a larger research program in 2004-2005 (Aramo-Immonen et al., 2005). In this research group the Evolute architecture was utilized in different applications and based on this the chosen tool was tested, validated and verified (see e.g. Aramo-Immonen et al., 2005; Kantola et al., 2005, Karwowski and Vanharanta, 2005; Paajanen et al., 2004a; Paajanen et al., 2004b; Kantola and Karwowski, 1998). The Evolute architecture is considered as a division of the tool in this research.

Researcher's Contribution	Original Publications	
Selection of sample project organizations Planning the survey questionnaire Collection and documentation of empirical data Evaluation of the empirical results	Remembering with help of personal notes in project work context, <i>Journal of Managing Projects in Business</i>	IV 2008
Selection of sample project organizations Planning the empirical test Collection and documentation of empirical data Evaluation of the empirical results and conclusions	Requisite variety of expertise in idea generation within a group ISPIM2008	II 2008
Conceptual analysis and theoretical framework Classification of the project management ontology Designing and constructing the empirical analysis Evaluation of the empirical results and conclusions	Mastering qualitative factors of uncertainty in mega-projects, EURAM2005	V 2005
Conceptual analysis and theoretical framework Classification of the project management ontology Designing and constructing the empirical analysis Evaluation of the empirical results and conclusions	Shared knowledge in project-based companies' value chain, <i>International Journal of Knowledge Management Studies</i>	VII 2009
Conceptual analysis and theoretical framework Collection and documentation of empirical data Designing and constructing the empirical analysis Evaluation of the empirical results and conclusions	The role of formal training in project-based companies, <i>The Human Side of Projects in Modern Business</i>	VI 2009
Conceptual analysis and theoretical framework Collection and documentation of empirical data Designing and constructing the empirical analysis Evaluation of the empirical results and conclusions	Project management – the task of holistic systems thinking, <i>Human Factors and Ergonomics in Manufacturing</i>	III 2008
Conceptual analysis and theoretical framework Collection and documentation of empirical data Designing and constructing the empirical analysis Evaluation of the empirical results and conclusions	Positive trigger for proactive project management improvement, ICPQR2008	I 2008

Figure 3. Researcher's contribution to original publications

The decision to choose two case mega-projects was based upon the researcher's understanding and practical knowledge of the marine industry, gained through a 15-year career in this sector. The ten case organizations were selected from hundreds available, according to the theoretical sampling of the cases (Olkkonen, 1993; Eisenhardt and Graebner, 2007; Siggelkow, 2007). This selection of the multiple-case organizations was solely carried out by the researcher, whose contribution to original publications is listed in Figure 3. Appendix 1 maps the publications in the different stages of the research process.

2.6 Summary

Both the mixed methods approach and triangulation were discussed in this chapter. Furthermore the chapter introduced the economic science, design science and systems development research approaches. The tools and techniques considered were described shortly and the connection between the original publications and

methodology was discussed. Each original publication includes a more comprehensive discussion concerning the methodology utilized.

Finally, this chapter has clarified the researcher's contribution to each original publication. Typically, in the domain of industrial engineering, several researchers are involved in research. This is relevant in practice in order to be able to conduct empirical research in real settings. However, of the seven original publications listed, the researcher has been the correspondent author of five and has contributed considerably to them all.

3 THEORETICAL FRAMEWORK

The research approach is transdisciplinary and therefore several supporting theories have been utilized (Figure 4). The practices of project management are based on general business management theories, such as business process management (Garvin, 1998; Argyris, 1982), supply chain management, value chain management (Day, 1999; Heikkilä, 2005; Keeney, 1996), and different business models. It is well known that it is difficult to identify one general project management theory (Turner, 1999); Chapter 3 therefore introduces several theories related to project management disciplines and to project learning.

The theoretical framework for this research is formed from organizational behavior theories: knowledge management (Soo et al., 2002; Hansen, 1999; Carlucci et al., 2004), activity theory (Engeström, 2000; Engeström, 2001; Kuutti, 1995; Bendy and Karwowski, 2004), systems dynamic (Zadeh, 1973; Jackson, 2004; Senge, 1990), and theories of organizational learning (Nonaka et al., 2000, Nonaka et al., 1998; Argyris, 1982; Argyris and Schön, 1978).

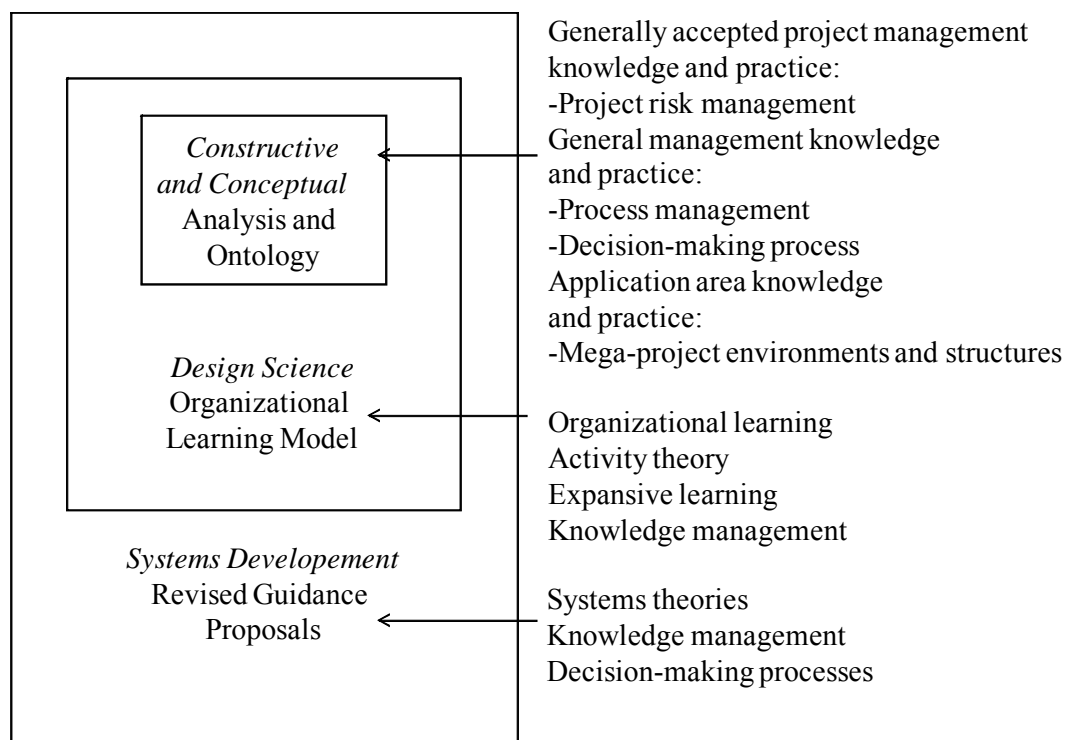


Figure 4. Theoretical framework and body of knowledge in connection to research process

The theories discussed below are the basis for the model designed in this research. Knowledge management theories were chosen to support the research topic of organizational learning. Activity theory is related to expansive learning and organizational behavior, which are interrelated with the learning model introduced. The discussion of process management is relevant since the aim is to integrate project learning into work processes. Finally, communication and metaphoric thinking are vehicles for knowledge transfer in the project organization.

3.1 Organizational learning

In view of developing corporate competitiveness, learning provides an absolutely necessary asset while being one of the major elements in change processes (c.f. Argyris, 1990; Shcön, 1974; Argyris and Shcön, 1978; Senge, 1990; Flood, 1999). Recent research has acknowledged the impact of learning on project-based company success (e.g. Bredillet, 2008; Goh and Ryan, 2008). Knowledge in itself is difficult to measure but nevertheless has a tangible effect on the achievement of results (Ibbs et al., 2007; Soo et al., 2002; Goh and Ryan, 2008). A problem faced by the system integrator is how to make the transition from material values to immaterial values, which tends to be difficult to gauge. Later in this chapter single-loop and double-loop learning (Argyris, 1982) will be discussed.

A distinction must be made between information and knowledge. Information is data, a signal in fact, received by a person (Ackoff, 1989). Knowledge or know-how is either explicit information processed by learning, understanding or application, or empirical tacit knowledge (Nonaka et al., 1998; Nonaka et al., 2000). It is also essential to know how to use information to achieve desired results. In addition, even if it is difficult to measure knowledge and amounts of information, studies suggest that these properties can be measured indirectly and, above all, that they must be managed (Ibbs et al., 2007; Soo et al., 2002; Goh and Ryan, 2008). All too rarely data and information are processed in a way that would allow them to be used to support decision making and to achieve an intended outcome. This is particularly significant in a project organization wishing to avoid errors made in any previous projects and hoping to make operations more efficient (Soo et al., 2002, p. 129) (cf. the double loop-learning mechanism to be discussed).

Competitive edge depends on the ability to create, transfer, use, integrate and expand knowledge capital (Prahalad and Hamel, 1990). New knowledge can only be created by combining information in a unique way and, by these means, creating something new. This makes it difficult to attain and use knowledge in decision making, or to work it into new products, services and processes.

Project learning is a success factor for professional project management (Koskinen and Aramo-Immonen and Porkka, 2008). In traditional project management literature, project learning is often regarded as a “lessons learned”-type retrospective study of the project. These debriefings are focused on information such as costs, timelines and other quantitative data. However, Nonaka (2000) argues that most of the organization’s knowledge lies in the tacit knowledge carried by human beings in “know-how” or “know-why” forms (first as procedural or heuristic knowledge and later as experiences and an understanding of causality) (Nonaka, 2000). Remarks on how knowledge is captured or how knowledge is diffused within the organization are seldom found in contemporary literature (Schindler and Eppler, 2003).

Organizational learning is commonly recognized as a major contributing factor to an organization’s capability to produce added value and maintain a competitive position in the market (c.f. Carlucci et al., 2004; Chakravarthy et al., 2003). Creation of new information is based on shared views and mental models within the organization (Senge, 1990). In the organizational process of learning, four primary processes can be discerned: the acquisition of knowledge and its interpretation, dissemination, and retention (storage) of information (Garvin, 1998). These four constituent areas are closely linked to the communication and behavioral processes important in a learning cycle (Nonaka, 2000). In a project organization, which moves from one project to another, the organization’s ability to learn deserves special attention. This idea can be formulated neatly as how to prevent the reoccurrence of errors in an organization which is in a state of flux. As for preventing errors, transferring tacit and empirical information from one project to another is an essential factor (Koskinen et al., 2002).

Nonaka introduces a learning cycle known as the SECI process. There are four modes in the conversion of knowledge: (S) Socialization, conversion from tacit

knowledge to tacit knowledge. This occurs mostly through shared experiences; (E) Externalization, conversion from tacit knowledge to explicit knowledge. When tacit knowledge is articulated as an explicit form to be shared by others, it becomes the basis of new knowledge; (C) Combination, the conversion of explicit knowledge into more complex and systematic sets of explicit knowledge. Explicit knowledge is collected from an organization and then combined or processed to form new knowledge; and (I) Internalization, the conversion of explicit knowledge into tacit knowledge (Nonaka, 2000).

Project learning enables a company to develop its project competences and to sustain its competitive advantage. Mastering the project learning cycle could save a significant amount in costs incurring from redundant labor and the repetition of mistakes. Particularly in a project with a long lifecycle, such as a shipbuilding or an offshore project, amnesia can exist already during the project. According to Schindler, factors which explain this amnesia are related to four humanly typical elements, namely *time*, *motivation*, *discipline*, and *skills* (Schindler and Eppler, 2003). Due to time pressure, project learning can be classified as a low priority task, and because of shortsightedness, organizations can be blind to the importance of learning, and this can be ignored due to a lack of competence in the management of the project learning cycle.

Argyris (1978) has introduced the concepts of single-loop and double-loop learning. Single-loop learning refers to eliminating a problem by correcting it immediately. An example of this is an error in a production drawing that would lead to the manufacture of a faulty product. The employee identifying the error amends the situation immediately by performing the corrective action as best seen. However, the same error will be repeated in the following project since the faulty drawing itself was not corrected. For Argyris, double-loop learning means organizational learning. When becoming aware of the drawing error, the employee requires the drawing to be amended in order to prevent the error from being repeated. This involves dealing with the variable controlling of the operation (Figure 5).

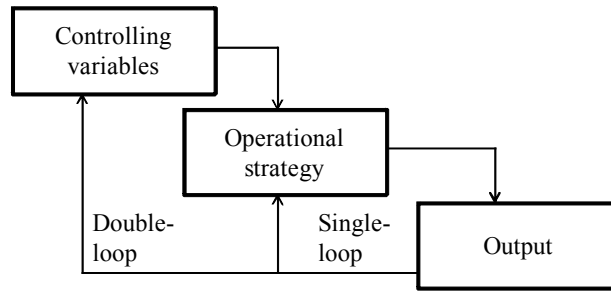


Figure 5. Single-loop and double-loop learning (Argyris and Schön, 1978)

Argyris has found organizations to learn in two different situations. Firstly, organizations learn when they achieve their specified goals, in other words, when there is a clear connection between the planned procedures and the achieved result. Secondly, an organization learns when a discrepancy between an intended action and its realization is identified and the issue is corrected; in other words, failure is turned into success (Argyris, 1982, p. 48).

The concepts of single- and double-loop learning are important in the project context as they deal with preventing errors from one project to another. However, the organizational learning Argyris (1982) describes is somewhat too reactive. It represents a “lessons learned” approach to project business. Therefore, the concept of contemporary expansive learning is introduced in the following chapter. This study uses the concept of the learning cycle (Nonaka, 2000) in the project learning model introduced here.

3.2 Expansive learning and activity theory

Activity theory distinguishes between temporary, goal-directed actions and durable, object-oriented activity systems (Vygotsky, 1986; Engeström, 2000) In the case of the management of a prolonged mega-project, the latter are discussed. This chapter examines expansive learning and the knowledge-sharing arena as a part of the learning process.

An organization’s creation and utilization of knowledge as a productivity booster is not a spontaneous phenomenon. According to the socio-cultural, historical activity theory, there has to be a triggering action, such as the conflictual questioning of the

existing standard practice in the system, in order to generate expansive learning (Engeström, 2000; Nonaka, 1998). Expansive learning produces culturally new patterns of activity. The object of expansive learning activity is the entire system (here the project) in which learners (project members) are working (Engeström 2000, Engeström, 2001). Figure 6, below, illustrates the system structure of collective activity according to Engeström.

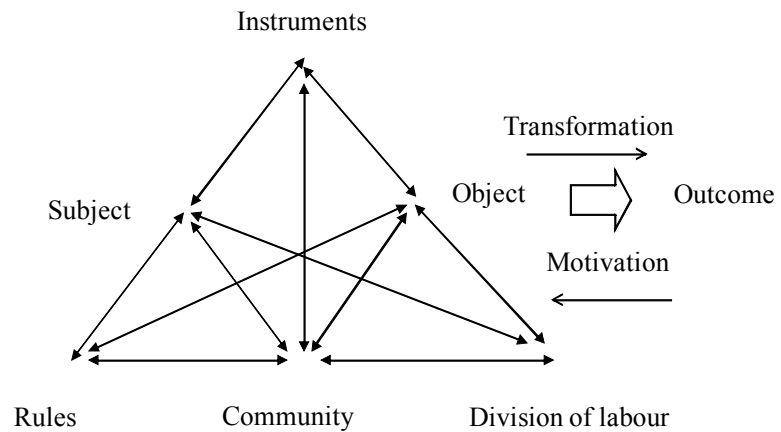


Figure 6. System of collective activity (adapted from Engeström, 2000, p. 962)

This study adopts the idea that the problem with management decisions often lies in the assumption that orders can be given from above to somebody to learn and to create new knowledge (Engeström, 2000). Instead of command, knowledge-sharing arenas for knowledge generation in the organization are required. While Argyris (1982) shows that there is a connection between achieved results and the learning process, Engeström (2000) suggests that the motivation to learn is embedded in the connection between the outcome and object of activity. The object of the collective activity is transformed towards the practical outcome (see bold arrow in Figure 6). Achieving the practical results through this transformation creates the motivation to change (learn).

In the empirical study presented in Chapter 5, the project performers analyze the project management features from their personal point of view. The attitude is positive and the method focuses on the performers' own motivation and orientation. This is a positive trigger (instead of the conflictual triggering action mentioned

above) for performance development (Dyck et al., 2006). The discussion of the results of the analysis, together with structured workshops, creates a fruitful environment for the organization's collective ability to evolve and to create useful organizational shared knowledge (Blackler, 1993). The structured workshop acts as a knowledge-sharing arena (Edgington et al., 2004; Paajanen et al., 2004; Von Krogh, 2003).

In order to meet customer requirements, a project organization has to make transformations which are not yet there. In other words, the organization has to learn and operate simultaneously. Traditional learning theories (e.g. Argyris, 1982) have little to offer in such a situation. Isaacs (1993) has introduced the concept of triple-loop learning in which the capability of learning to learn is embedded. In other words: learning from double-loop learning. Yet expansive learning at work produces new forms of work activity (Engeström, 2001). This notion is central to this study. The project learning model utilizes the idea of learning by doing. An essential component of expansive learning is shared knowledge. This accumulates in the explicit form, such as rules and instruments (artifacts and tools), and in the tacit form of cultural, historical, social, experience-based knowledge. This collective type of contemporary learning requires knowledge-sharing arenas as a field for growing (Jackson and Klobas, 2008).

Knowing what others know is a necessary component for coordinated action to take place (Koskinen and Aramo-Immonen, 2007). In order to produce new knowledge, and through it added value, knowledge-sharing arenas have to be available. This seems to be important particularly in project contexts. Part of project knowledge is embedded in human minds in the tacit, experience-based form. Project organizations lack explicit formal structures that support knowledge transformation. The knowledge-sharing arena can be a shared context (Nonaka, 2000), but also a structured workshop (Engeström, 2001), project meeting or other form of face-to-face communication for project members. Knowledge-sharing arenas serve two types of knowledge conversion: socialization and externalization. In the conversion from tacit to tacit knowledge, socialization is processed by sharing experiences and constructing a shared vision through discussions; whereas in the conversion from tacit to explicit knowledge, externalization is processed by codifying the discussions

in the minutes of the meeting and by creating mutually agreed rules and instructions. The knowledge-sharing arena supports the creation of a mutual, professional language and causally improves the communication between different departments and stakeholders. It also acts as a stage for organizational learning as explained in this chapter.

To summarize, the learning capability and expansive learning of a project organization are key issues in building a company's intellectual capital. Knowledge management (see Chapter 3.3) provides managerial tools to deal with knowledge creation and organizational memory (knowledge storages). Recent research results show that the metal industry is knowledge intensive and that there is a direct relation between the amount of intellectual capital and the rate of productivity/profitability (Kujansivu, 2008).

3.3 Knowledge management

The mega-project context forms a network organization. Knowledge management in such an entity has the typical features discussed below. Yet the concept of a network is vague. It is a metaphor of a consortium of many collaborative ventures or relationships (Wijk et al., 2003). The concept of knowledge management contains a paradox in itself. From the definition of knowledge, it follows that the knowledge cannot really be managed as such. However organizations can enable knowledge management activities in various forms (Von Krogh, 2003). Among its other definitions, "knowledge management" is a metaphor for activities such as capturing, sharing and creating knowledge (Von Krogh, 2003), or accumulating, protecting and leveraging knowledge (Chakravarthy et al., 2003). Knowledge management activities are closely linked to organizational learning processes and therefore in steering value creation in knowledge-intensive organizations (project-based organizations here) (Schindler, 2003; Chakravarthy et al., 2003; Jashapara, 2004; Ching and Jie, 2000; Choo, 1998).

Networks can be classed into three different types when examining project network knowledge management: social networks, external networks and internal networks. The structure of any social organization can be thought of as a network (Wijk et al.,

2003). This research focuses on external and internal networks in the mega-project environment.

3.3.1 Knowledge management in external networks

Organizations in the mega-project context form an external network expanding the traditional make-or-buy decisions with decisions to co-operate. The products and knowledge domains of companies will differ. Knowledge management perspectives aim to gain access to new knowledge and internalize or combine that knowledge (Hansen, 1999; Nonaka et al., 1998; Simonin, 1999). Companies in a network may have the complementary knowledge necessary for productions or even new innovations. Learning in external networks is often competitively motivated; the competition may result in learning races (Wijk et al., 2003).

Hamel (1991) conducted a case study of nine alliances between companies and found that learning outcomes were dependent on the intentions (desire to learn), transparency (openness and potentiality to learn), and receptivity (absorptive capacity to learn) of companies. Hamel concluded that individual learning became collective learning when a mechanism for the composition of individual learning existed and when learning was transferred across organizational boundaries (Hamel, 1991). In light of these studies, it was found in this research that there is a lack of such mechanisms in project-based organizations (e.g. Koskinen and Aramo-Immonen, 2007; Koskinen and Aramo-Immonen, 2008). The results also showed that inter-partner communication was not appreciated enough among project managers (see Chapter 5).

Furthermore Simonin (1999) has found that ambiguity has a negative impact on knowledge transfer between organizations. Elements of the ambiguity of knowledge are tacitness (Koskinen, 2001), asset specificity, complexity, experience, partner protectiveness, cultural distance, and organizational distance (Simonin, 1999). Between loosely coupled partners (alliances) Simonin found that:

1. The effects of tacitness and the ambiguity of knowledge were independent of the duration of the partnership
2. The effects of complexity and experience disappeared in older partnerships
3. The cultural and organizational distance disappeared in younger partnerships

From these results it can be concluded that a reduction in the ambiguity of knowledge would affect the capability of knowledge transfer between organizations the most. In the case of project-based organizations, the project management ontology (Chapter 4.1) and knowledge-sharing arenas (Chapter 4.2) are introduced as a partial solution to this.

3.3.2 Knowledge management in internal networks

Ashby's (1957) law of requisite variety suggests that the variety of internal units has to meet or extend the variety of the external system. The amount of appropriate selection that can be performed is limited by the amount of information available. Thus, the greater the variety within a system, the greater the ability to reduce variety in the system's environment through regulation (Ashby, 1957; e.g. Suominen et al., 2008). The following chapter therefore focuses on organizations' internal network knowledge management.

In view of developing corporate competitiveness, learning proves a crucial asset while being one of the major elements in the process of change (Argyris, 1982; Van den Ven et al., Boyatzis, 2006). Knowledge in itself is difficult to measure. Nevertheless, it has a tangible effect on the achievement of results. A problem faced by project-based companies is how to transform material values to immaterial values, which tends to be difficult to measure. When examining the process of knowledge management in corporate management, researchers encounter a common belief which can be summarized as, "if it can't be measured, it can't be managed". Even if it is difficult to measure knowledge, studies suggest that these properties can be measured indirectly (Soo et al., 2002). Competitive edge depends on the ability to create, transfer, use, integrate, and expand knowledge capital (Goh and Ryan, 2008; Chakravarthy et al., 2003; Hansen et al., 1999). New knowledge can only be created by combining information in a unique way, thus creating something new. This impedes the acquisition and use of knowledge in decision making and its application to new products, services and processes (Soo et al., 2002).

Firstly, a source of information and knowledge on which individual know-how is based is required. These internal and external sources of the organization must be accessible to the individual through a network. Even though personal notes and

references are important, a knowledge-sharing arena and organizational memory are necessary in order to create a shared context (Koskinen and Aramo-Immonen, 2008; Nonaka et al., 2000). This can be measured by the degree of networking of the individual and the organization. Secondly, the individual and the organization have to possess the capacity and ability to absorb information (Ashby, 1957; Palonen, 2003). The general capacity for adopting information refers to the ability to recognize, absorb and combine information. Thirdly, the process of decision making has to be of a high standard. The organization's problem-solving ability promotes the creation of new information. Information and knowledge have to be utilized comprehensively (for instance, by analyzing greater numbers of alternatives), in consensus (e.g. a commonly shared opinion), in a creative manner and by creating new information (e.g. new ways of thinking, new ideas, new processes). Accordingly, clear interdependency exists between knowledge management and a company's success (Soo et al., 2002).

To summarize, this feature of the inaccessibility of knowledge value creation forms the classical *problem of the black box* (Ashby, 1957). Thus a certain relation between knowledge management and a project's success can be seen. It is difficult to identify the causal linkage in reality. Therefore, this study introduces an isomorphic system (Aramo-Immonen and Vanharanta, 2009) representing a method that emulates reality. Instead of learning from past project experiences afterwards, the isomorphic representation of project execution during the project is scrutinized. This is a proactive method and it allows the project organization to learn during a prolonged mega-project.

3.4 Maintaining systems and systems theories

A system view of project management is a relevant approach for a scholar because a networked mega-project structure with a significant amount of interfaces between different subprojects can be seen as a multi-project system (Remington and Pollack, 2007; Aramo-Immonen and Vanharanta, 2009; Faulconbridge, 2003; Kerzner 2003). The general system can be illustrated as a chain of inputs, processes and outputs (Sadler-Smith, 2006). In the case of a project as a system, the system inputs are the required resources (financial, labor, time etc.). The system processes are project

management tasks and project execution. The system outputs are the results of a project (products, services etc.). With such an extremely simplified model it is possible to imagine that the results of a project occur as a consequence of the project activities (steered by the project management). The results of a project comply with the critical success factors (system critical parameters) established for the project (Gardiner, 2005; Jackson, 2004). The systems theory brings structure and order to an otherwise chaotic environment. By using the systems theory, different layers, subsystems, processes, and activities may be distinguished within a project. Samuelson's (Samuelson, 1978; Samuelson, 1981; Paajanen et al., 2004a) general concept of organizational management and a functioning system is one example of this. The parts of the system are a control system (e.g. accounting, quality assurance), a working system (e.g. production, distribution), an information system (e.g. information and communication technology), and a support system (e.g. purchase, logistics).

Traditional operational research (OR) is based on mathematical modeling involving merely a few (measurable) variables in a linear relationship with each other (Checkland, 1981; Checkland and Holwell, 1998; Churchman et al., 1957). OR represents hard systems thinking. A mega-project can be considered as a complex, multiple-loop, non-linear system (Haines, 2000; Anderson and Johnson, 1997; Miller, 1978). It is also a social system where human actors have a strong impact on decision making (Turner, 2003). In systems of this type the OR is far too simplistic thinking. It loses a genuine managerial touch and does not provide a holistic view (Forrester, 1958; Jackson, 2004). Instead of hard systems thinking, the soft systems thinking methodology is appropriate here. Peter Senge popularized system dynamics (Senge, 1990). Jackson crystallizes the idea as follows:

“According to the theory of system dynamics, the multitude of variables existing in complex systems become causally related in feedback loops that themselves interact. The systemic interrelationships between feedback loops constitute the structure of the system, and it is this structure that is the prime determinant of system behaviour” (Jackson, 2004, p. 66).

For project management, the aim of system dynamics is to provide an understanding of the structure of complex systems to ensure that behavior corresponds with the goals of a project. The idea is to reinforce positive feedback loops in order to boost overall performance. The notion of such a loop is vital for organizational learning. Feedback loops are a salient part of the project learning model introduced.

3.5 The decision-making process

The decision-making aid developed in this study is designed to reduce the number of uncertain factors in a decision-making process. The application compares the assessments made by the decision-makers of the current situation and the optimum vision they can imagine. Even if the qualitative factors affecting decision making are inexact and/or suggestive, their significance to the formation of the decision is indisputable. This chapter examines the differences between alternative-focused and value-focused thinking, and how this affects decision making.

By its very nature, decision making in the project context is of the “risk analysis” type (Turner, 2003; Miller and Lessard, 2001). A decision is affected by the strategy selected by the company, the present competition, and the available resources (Görög, 1999). Decision making is decentralized and is influenced by the needs reflected by the involved stakeholder groups. In such situations, decision making has traditionally been facilitated first by short-listing the best options (i.e. those appearing to be the best at face value) and, second, by selecting the most appropriate ones from among these. This mode of thinking tends to limit decision making to readily available alternatives (AFT, Alternative-Focused Thinking), which may not actually present the best possible options (Keeney, 1996). This alternative-focused model of decision making is *reactive*, since it limits the selection to predefined alternatives before all options have been assessed. Thus, the ensuing decision-making situation turns into forced problem solving, signifying a loss of possibilities inherent in decision making. As a procedure, alternative-focused decision making is a “quick and dirty” way of acting when facing difficult strategic questions and being indifferent to their repercussions (Brännback, 1996).

Values provide the foundation for culture and for almost everything we deal with. Therefore, decision making should also be a *proactive* process designed in line with Value-Focused Thinking (VFT). The value-focused decision-making model emphasizes the assessment of alternatives before a decision is made. The objective is to identify the potential related to decision making. Keeney suggests a four-stage model: (1) Values should be expressed in writing. Qualitative values affecting decision making are assessed in a logical and systematic way. (2) The decision must always be made before measures affecting the decision making are introduced. (3) The written outcome from the qualitative analysis will be used when formulating the options for available decisions. (4) Decision-making options are utilized as new opportunities for development (Brännback, 1996; Keeney, 1996).

In summary, decision making should be proactively focused and based on the assessment of alternatives before the process takes place. The analysis method introduced in this research provides these properties (Aramo-Immonen et al., 2005).

3.6 Communication and the use of metaphors

Communication processes include the way information is transferred between individuals and groups. In a decentralized, network-driven and complex organization, communication plays a special and significant role (Palonen, 2003). The efficiency of communication is dependent upon the quality and richness of the data transfer and information processing between individuals. Furthermore, the way people and groups share information with one another and agree on joint methods of action and objectives affects the efficiency of communication.

Communication is not a simple process. In addition to knowledge and information, also emotions, beliefs, attitudes and assumptions are communicated in parallel. On the other hand, in addition to written and spoken language, people communicate by body gestures, facial expressions, gesticulation, voice intonation, rhythm of speech and by omitting significant parts of their speech (Garvin, 1998, p. 39). Flood and Carson (1988) have introduced “rich pictures” as a tool for mutual communication in soft systems methodology (SSM, e.g. Checkland and Scholes, 1990). Rich pictures are actual drawings that allow the various features of a problem situation to be set

down pictorially (Jackson, 2003). The richness of communication is also affected by the tool utilized for communication. From the project organization's learning point of view, face-to-face communication has been found to be the most effective way of transferring tacit, empirical information (Koskinen et al., 2002, p. 281).

The objective of communication is to reach a consensus, a shared view, rather than just transmit disseminated information. To be effective, communication must be socially acceptable and the parties involved must use a common language and set of symbols (Palonen, 2003). On the other hand, a specialized and highly developed professional language may pose an obstacle to mutual understanding (Aramo-Immonen and Vanharanta, 2009). In a multinational organization, the lack of common professional terminology is perceived to be a great difficulty. The involved stakeholder groups may find it hard to understand one another and information may not seep into the organization from the outside. Unofficial communities will arise and the flow of information between these may be free, while in some cases factional limits may obstruct it (sticky information). In a complex network-driven community (such as in a mega-project organization) even factors related to motivation may impede communication. This can be exemplified by an unwillingness to absorb information from outside the organization or the maintenance of an individual's position artificially through the concealing of relevant information (Palonen, 2003).

A metaphor is a "word" that describes an object as equal to a second object in a certain way. Thus, the first object can be economically described because implicit and explicit attributes from the second subject are used to enhance the description of the first. Few words, emotions and associations from one context are associated with objects and entities in a different context. In a more understandable definition, metaphors compare two things and are used as communication vehicles.

A conceptual metaphor refers to understanding one idea in terms of another. A conceptual domain can be any coherent organization of human experience. It is an underlying association. The regularity with which different languages employ the same metaphors, which often appear to be perceptually based, has led to the hypothesis that the mapping between conceptual domains corresponds to neural mappings in the brain (Feldman and Narayanan, 2004).

Lakoff and Johnson (1980) argue that metaphors can create social realities for us. The use of war metaphors in economics and management has created an ontology of “battlefield” vocabulary in this domain (e.g. Porter, 1985). Certain words like enemy, strategy, thread, sacrifices, priorities, and forces, for example, are used. Another example is the “man as machine” metaphor. This expresses the mechanical apprehension of the human being rather than the organic view. The metaphor used shapes the conceptual meanings of the domain. The metaphor can be understood as a cognitive mode of thought, parallel to a mode of language. Metaphors project structures from the source domain to the object domain.

A root metaphor is the underlying worldview that shapes an individual’s understanding of a situation. Examples are understanding the organization as a living system (Miller, 1978; Aramo-Immonen et al., 2005), or the management of an organization as a neural system (Churchland, 2002; Aramo-Immonen and Vanharanta, 2009). A root metaphor is not necessarily an explicit device in language, but a fundamental, often unconscious, assumption (Goatly, 2006; Goatly, 1997). If metaphors are seen as conceptual in nature, they are also principal vehicles of understanding (Lakoff and Johnson, 1980).

“Since we understand situations and statements in terms of our conceptual system, truth for us is always relative to that conceptual system. Likewise, since an understanding is always partial, we have no access “to whole truth” or to any definitive account of reality” (Lakoff and Johnson, 1980 p. 180).

To summarize, it is essential to measure communication processes and the nature, direction and quality of conversational flows taking place between individuals and groups (Garvin, 1998) (see Chapter 4). Bridging the understanding of different stakeholders in a project environment requires an agreement on the common language system as well as good communication. As the mutual understanding is processed through communication, the classification of concepts is relevant. In order to share knowledge, an ontology of management domain concepts is a valid solution.

3.7 Project risk and uncertainty management

Risks related to economic activities are controlled by a number of quantitative methods. In the case of project operation risks, these methods tend to be vague and often endogenous (Flyvbjerg, 2003; Miller and Lessard, 2001, p. 437). As a result, risk analyses of stakeholder groups in a complex organization tend to be fuzzy by nature (Liang et al., 2009). Information may be insufficient and part of it is based on estimations. Risk analyses based entirely on quantitative methods give an all too limited view of the risks involved in a project. These fail to recognize uncertainty factors related to stakeholder group risks (Ward and Chapman, 2001).

Risk management of a mega-project poses a notable challenge. For example, resource allocation under uncertainty is difficult (Laslo and Goldberg, 2008). This research applies a proactive qualitative approach to project risks. The principle is to estimate, in advance, the qualitative risk factors involved in a project from the viewpoints of different stakeholder groups and compare these views to one another.

Uncertainty management is the exploration and understanding of the underlying causes of threats and opportunities (Ward and Chapman, 2001). As to the management of uncertainties involved in a project, a distinction must be made between relevant uncertainties in the given project setting and those that can be ignored. Uncertainty factors related to a project can be classified, for instance, in the following manner: factors of uncertainty related to the working environment, values, and decision making (Ward and Chapman, 2001). Ward and Chapman emphasize that uncertainty management is a significant issue in project operation during the lifecycle of an entire project. The following discussion focuses on five causes of project uncertainty: (1) variation in estimates, (2) uncertainty in the origin of estimates, (3) uncertainty in planning and logistics, (4) uncertainty in objectives and priorities, and (5) uncertainty in the relations between the parties involved (Ward and Chapman, 2001).

Variation in estimates: Variations in estimates concerning the parameters of the project's scope, duration and quality is an obvious factor of uncertainty. This variation can be caused by one or more of the following: lack of clear specifications;

newness or lack of experience in the particular field; complexity or the number of interacting factors, and insufficient understanding concerning processes which affect the project's progress (Ward and Chapman, 2001). The single biggest cause of substantial excesses in costs in mega-projects is an unrealistic estimate of the expenses involved (Flyvbjerg et al., 2003; Lampel, 2001, p. 472).

Uncertainty in the origin of estimates: The unreliability of estimates used in forecasts and calculations is an important source of uncertainty. The lack of statistical information often necessitates basing the estimates on subjective assessments. When estimating the project at its tendering stages, it is natural that not all details are known. Identification of the known unknowns and recognition of the so far unknown unknowns is essential (Davenport and Prusak, 2000; Ward and Chapman, 2001).

Uncertainty in planning and logistics: The significance of specifying project interfaces carried out at the pre-planning and planning stages is significant with regard to the uncertainty factors materializing at the implementation stage. In comparison to other types of mega-projects, technical risks related to offshore projects are deemed great (Miller and Lessard, 2001).

Uncertainty in objectives and priorities: Bearing in mind the project organization's functionality, dissemination of information concerning the objectives and procedures in line with the specified strategy does not suffice. The parties involved must understand the requirements of other participants and keep their own objectives clear in mind. These points of view allow unifying objectives and measures by means of which the desired result will be achieved (Ward and Chapman, 2001). The ways of seeing time consumption, expenses and quality vary at various stages of a project's lifecycle.

Uncertainty in the relations between the parties involved: All the companies included in this study shared the view that one of the greatest challenges faced by a decentralized project organization is the management of relations between the parties involved.

In practice, the management of uncertainties involves identifying risks and estimating probabilities, consequences and repercussions of a given risk (Turner, 1999). True management of uncertainties is pursued by making advance preparations for the impending situation (cf. proactivity). Operational planning must be based on a realistic assessment concerning available possibilities and the pursuit of a successful result.

The reactive approach, i.e. waiting until problems accumulate up to the point of becoming uncontrollable, leads to a continuous, expensive and resource-consuming 'fire-brigade mode of operation'. Reactive operations lead to looking for reasons and threats that give rise to problem situations. This, in turn, leads to a constant hunt for external threats or 'enemies' (Senge, 1990). Dimensioning the operation based on thinking in terms of threats will inevitably lead to an outcome which is a far from the optimum achievable.

Proactivity, i.e. making advance preparations for uncertainties, is far too often reactivity in disguise (Senge, 1990). Aggressive combat against perceived threats is not proactivity. True proactivity becomes apparent in the way of approaching problems. This involves an analytical way of thinking and making decisions, not emotive problem solving. The learning model designed in this study and the application utilized provide a method based on the idea of proactive assessment, whereby the desired state is compared to the project's current state. The gap between these two is the measure of the required tension, which can be used as a guideline for planning and decision making (Aramo-Immonen et al., 2005).

3.8 Project process management

Traditionally, processes have either been seen to form a mere sequence of work events in production operation, or in terms of a core or supporting processes closely linked with the organization. However, processes can also be viewed from a wider perspective as the core products of a project organization. Added value is created through the ability to mobilize and make available resources required by implementation of the project. Projects change in more ways than one and the organization, or consortium (network), carrying them out is also subject to alteration.

From the system integrator's (contractor's) point of view, the central issue is to manage the processes by means of which these modifiable elements can be used to create and realize the project's outcome. This chapter examines organizational, work, behavioral, change, management, and knowledge management processes in the project management context.

For thinking in terms of processes, failing to see the forest for the trees is typical. There is a tendency to cling to individual goals or functions or to the organization as a whole. When widening the scope of thinking in terms of processes, two main processes can be discerned: organizational processes and management processes (Garvin, 1998). Organizational processes include those related to work, behavior, and change. Respectively, the management processes can be further divided into those related to steering, negotiations, sales, supervision, and control. However this review lacks the knowledge management process added in Table 7.

Table 7. Integrated model of the division of processes in a dynamic management environment (adapted from Garvin, 1998, p. 33; Bredillet et al., 2008)

Processes in a Dynamic Business Environment	
Organizational Processes	Work Processes - Functional Processes -Administrative Processes Behavioral Processes -Decision-making Processes -Communication Processes -Organizational Learning Processes
Managerial Processes	Guideline Processes Negotiating and Sales Processes Control and Supervision Processes Knowledge Management Processes

The concept of *work processes* is easy to understand in terms of a sequence of functions linked to one another and carried out through an inter-organizational network. Work processes can be divided into operative and administrative. One central goal with these is to maximize the time used to create added value in production-related tasks (Garvin, 1998). Work processes can be considered as a

structural component of production operations. A product is manufactured according to a specified schedule in a given location. The operation includes clearly defined inputs and outputs. The functions have a clear beginning and end, i.e. an interface in which the functions are interlinked (Davenport, 1993). The concept of work process also includes the idea of internal customership. The processes must produce added value for internal and external customers (Harrington, 1991). Identifying internal customer relations in a complex project organization requires explicit interface planning and the clear division of responsibilities. Work processes can be seen in terms of flow of information and work in an organizational setting. These processes link together the roles of departments and actors in a complex organization (Garlbraith and Kazanjian, 1986).

Behavioral processes are based on organization theories and group dynamics with the basic idea being a uniform organizational behavioral model. Behavioral processes influence the form, content and nature of work processes as a set of behavioral norms. Behavioral processes are different from corporate culture since they also reflect aspects other than the corporate values and beliefs. A behavioral process is a sequence of events creating the cognitive and personal nature of the given work. This process can be divided into segments including decision making, communicational and organizational learning (Garvin, 1998). This implies a comprehensive view of what makes an organization more or less effective. Members of the organization should understand how goals are set, the motivation behind the chosen measures and their consequences. In fact, business managers' entire way of managing an operation should be known (Schein, 1988).

The application used in this study brings openness to communication while keeping anonymity at the same time. Personification of problems may cause friction, which in turn gives rise to resistance to change. Argyris and Schön (1978) refer to an organizational defense mechanism, where overcoming resistance to changing the values steering the organization should be based on relevant information, freely made choices to which all are committed and the monitoring of implementation thereof (Argyris and Schön, 1978). However, members of an organization seldom act in line with the aforementioned values. Instead, individuals are likely to base their

actions on personal in-built features: one-sided control, self-defense, reasoning. This, in turn, undermines active information gathering and coping with uncertainty.

Resistance to change can be reduced by adopting a so-called constructive approach. The basic assumption in this approach is that people do not act based on objective reality but, rather, their behavior is guided by their personal notion of reality, their image of the world (cf. proactive vision). People develop 'theories' of their own by means of which they explain phenomena and construct their own image of the world. The power of these theories is significant as they can potentially suppress a person's unbiased information gathering. Should people take the view that their notion of the world is just a theory or a hypothesis of reality, it would naturally be open to testing. When acting in line with the constructive model, an individual compares his or her own notion of reality (world view) with that of others (Friedman, 2002). The learning model presented allows the comparison of views of different individuals concerning the difference between current and desired states.

Currently, organizational learning is commonly recognized as a major factor contributing to an organization's capability of producing added value and maintaining a competitive position in the market. The creation of new information is based on shared views and mental models within the organization. In the organizational process of learning, four primary processes can be discerned: knowledge acquisition (gathering), interpretation, dissemination, and retention (storage) of information (Garvin, 1998). These four constituent areas are closely linked to the communication and behavioral processes discussed above.

Change processes are rooted in strategic management expressed by the current catchword 'management of change'. Change processes reflect how individuals, groups and organizations enter into new things, develop and grow. Unlike the relatively static work and behavioral processes, change processes are temporary and dynamic by nature. The project organization's lifecycle provides an example of the change process. The project is started under certain initial conditions and has a clearly specified end, between which there is a series of functional changes. The process of change can also be seen in terms of co-evolutionary development from the

current state into the desired vision (cf. proactive vision) (Garvin, 1998, p. 40; Van den Ven, 1990, p. 213; Kantola and Vanharanta, 2004).

Change processes can be managed autonomously or in a goal-directed manner. Autonomy refers to processes that have been triggered by circumstance. For instance, organizations must change – adopt a new way of operating – whenever the prevalent technology in the market changes. On the other hand, in a decentralized organization a managed and controlled change can be identified, for instance, by the ability of timing the introduction of a new policy, a new way of operating or a new information system adequately (Garvin, 1998). The process of change can involve a slow incremental development or the fluctuation between a state of balance and a radical transformation (Garvin, 1998). An increase in individual experience can be considered as a slow accumulation of tacit knowledge, whereas dynamic fluctuation in the project organization can be seen as a radical change. Change processes and learning processes are clearly connected. Any change necessitates the adoption and acceptance of new information; there can be no change without learning (Hilden, 2004).

A project organization is a complex social institution with complicated *management processes*. For this reason, management of an organization is obviously anything but one-dimensional decision making. The system integrator faces the challenge of steering the organization towards a common goal, fostering co-operation and, on the other hand, supporting bright individuals. In other words, the challenge here is how to reconcile various group interests and common objectives. Management is a social process, a series of actions that guides a group of individuals to work together towards the shared objective. According to Garvin, organizations are ultimately political units. In a complex organization, the manager has to cope with the conflict of pressures arising from partial optimization and adopt the role of a true mediator (Garvin, 1998). Garvin divides the management processes into three component areas: guiding, negotiation and sales processes, as well as supervision and monitoring processes.

Specifying directions takes place through strategic planning and the setting of goals. At best, strategies serve as guidelines, not as detailed procedures. A market-driven

strategy is an integrated selection model allowing the steering of an operation in a turbulent market environment (Day, 1990). Lampel refers to this also with his opportunity-driven strategy (Lampel, 2001, p. 478). The planning process of a market-driven strategy is an iterative and adaptive continuous sequence of events where the strategy is compared to the changes taking place in the surrounding environment. The development process of a strategy consists of four stages: assessment of situation and strategy, strategic thinking, decision making, and implementation (Day, 1999). Strategic thinking described by Day is the continuous generation of creative alternatives. The model gives an excellent description of the process nature of strategic planning. A developmental continuum is involved. The strategy will never be complete because of the changes taking place in the surrounding market.

The chosen strategy can also be based on resources like the *focusing strategy* presented by Lampel. The strategic planning process based on resources consists of an analysis of the current situation, the selection and creation of a strategy and its implementation (Thompson, 1997). The strategy based on resources starts with the existing resources that are available in the market.

Strategic planning is actually included in the negotiation and sales process of the management process described by Garvin. Creating a strategy requires these social processes. Implementing the planned strategy within the entire organization requires vertical and horizontal promotion efforts, which pose a particular challenge for a network-driven decentralized organization. Supervision and monitoring are essential in obtaining feedback from the field. A functioning communication between all organizational levels is central for the learning of the project organization (Aramo-Immonen, 2004).

The *knowledge management process* is a complex combination of organizational subsystems and informal organizations (Carlucci et al., 2004; Bredillet, 2008; Koskinen and Aramo-Immonen, 2008; Jashapara, 2004; Little et al., 2002). Researchers divide the knowledge management of a company into the following four components (Soo et al., 2002); (1) The *database subsystem* serves as a shared source of information; (2) The *organizational language subsystem* enables understanding

contents of verbal and non-verbal communication between people; (3) The *networking subsystem* works both officially and informally providing a channel for procurement transfer of information and knowledge between people. Networking is a process that takes place within an organization and between the organization and its external stakeholder groups; (4) In the *transfer subsystem* the systematic knowledge is either passed between individuals or is combined in a unique manner in another person's experience, thus creating new information. In many respects, this is the most important subsystem. A combination of the above system consisting of all four components will, at best, produce more innovations in the form of improved products, services and better operative performance. From the viewpoint of a fragmented project organization, all four elements create a highly challenging equation for the system integrator (Soo et al., 2002). Coordinating a mega-project means managing a decentralized and network-driven project organization which consists of expert organizations of different fields. This involves controlling the knowledge management process in the most demanding circumstances.

Hofstede (1991) makes a comparison between the processes and goal orientation of an organization. The processes focus on the meaningful content, whereas the result thinking is directed towards the goal. According to Hofstede, in a process-centered work culture, people perform only what is necessary and avoid anything that could be seen as excessive. In contrast, the result-oriented culture creates a setting characterized by competition, where maximum input is expected of the employee (Hofstede, 1991, p. 189). Primarily, this view focuses on criticizing the work processes and ignoring the behavioral, change, management, and knowledge management processes discussed above. When examining a project organization, the significance of these processes culminates in ensuring the continuation of the operation. The processes provide a preliminary survey, planning, implementation, maintenance, and control, while the systemic view provides a framework for management (Aramo-Immonen and Vanharanta, 2009; Faulconbridge, 2003; Kerzner, 2003). In order to be able to integrate project learning into the processes, it is essential for managers to be able to recognize the processes.

3.9 Summary

The chapter delineating the theoretical framework firstly discussed organizational learning theories, knowledge management, activity theory and expansive learning related to the project learning model introduced in this research. Secondly, generally accepted project management knowledge and practice and theories related to the project management ontology created were examined. These sections were based on project risk management, project process management and decision-making processes. Finally, communication processes and the utilization of metaphors in communication were analyzed. This was seen as an essential part in creating a shared understanding in a mega-project organization.

From the project management view, one might ask why such important issues as e.g. scope management, time management, integration management, and supply chain management are missing from this discussion. These management disciplines exist in the project management ontology and there is a wide range of research literature available concerning these subjects (e.g. PMI, 2000; Turner, 1999; Remington and Pollack, 2007; Lock, 1996; Levine, 2005; Kerzner, 2003; Aramo-Immonen, 2004). In this thesis, however, the researcher chose to refresh the discussion by introducing some novel angles to project management such as activity theory and expansive learning.

The next chapter presents a range of standards and knowledge areas studied for the project management ontology. These are introduced as a result of the literature study in Chapter 4 in order to make a clear distinction between theories and standards (PMI, 2000; Global Alliance for Project Performance Standards, 2009; Association of Project Management, 2009; International Project Management Association, 2009; ISO 2003; Commonwealth of Australia, Department of Defence, 2006).

4 RESULTS OF THE THEORETICAL STUDY

Answers to the research question ‘How can qualitative project management features be prioritized to focus on the development of project processes?’ are introduced in the next chapters. In order to prioritize the qualitative features, a project management ontology and analysis method is introduced. The integration of organizational learning into project processes is factored into the project learning model by utilizing a project management ontology.

4.1 The project management ontology

The conceptual outcome of this research is a project management ontology. In this context, the ontology is a classification of qualitative project management knowledge areas (Shanks et al., 2003; Gomez-Perez, 2004). In this domain the concept of an ontology has to be distinguished from its philosophical meaning in existentialism. An ontology is a formal representation of a set of concepts within a domain and the relationships between those concepts. It is used to reason the properties of that domain and may be used to define the domain. According to Gruber (1993), an ontology is a “formal, explicit specification of a shared conceptualization” (Gruber 1993, p. 199). An ontology provides a shared vocabulary which can be used to model a domain – that is, the type of objects and/or concepts that exist, and their properties and relations (Arvidsson and Flycht-Eriksson, 2008). In this study the ontology models the domain of mega-project management.

An ontology is a list of attributes that describe the meta-data (features affecting project management). Each attribute has its instance in a real life project. These instantiations vary depending on the project’s characteristics (e.g. in shipbuilding or offshore domains). At the heart of the learning model (introduced in Chapter 4.1.2) is a selection of commonly agreed and accepted project knowledge areas – the project management ontology. Need for such a classification was indicated while studying project management memory aids (Koskinen and Aramo-Immonen, 2007; Koskinen and Aramo-Immonen, 2008). Motivation to share knowledge in a project organization was established, but a lack of vehicles for knowledge sharing and incomplete understanding of all parties was also found. The ontology introduced assists knowledge transfer in project management processes.

The ontology (Table 8) is structured by three management discipline categories: (1) generally accepted project management knowledge and practices (integration, scope and time management, c.f. Flyvbjerg, et al. 2003; Görög and Smith 1999; Turner 1999; Kertzner 2003; Levine 2005), (2) general management knowledge and practices and management theories (process, cost, human resource and communication management c.f. Porter 1985; Prahalad and Hamel, 1990; Mintzberg, 1994; Day, 1990; Child, 2005), and (3) application area knowledge and practices (such as knowledge of market, product integration, environment and partners from various contemporary sources depending on the project in question). This division was introduced in the Project Management Body of Knowledge (PMI, 2000). These three categories partially overlap and are equally important elements of project success. The disciplines needed to manage projects are partially unique to project management. However general management disciplines provide fundamental supporting disciplines, such as strategic planning, accounting, logistics and human resource management (PMI, 2000; Turner, 1999). As there is no such thing as a project management theory, the generally accepted knowledge areas introduced in the ontology are collected from project management standards and project guidelines widely used (Appendix 2). Table 8 presents the content of the ontology.

Limitations of the ontology created for project performance evaluations are the size of the ontology (40 features), its generalizability, and practicality. The concept of ‘feature’ has been chosen to present management disciplines and/or variables in the ontology. As the ontology is utilized in the analysis tool, there are management ‘features’ to be analyzed for project managers. The content of the ontology was chosen at the very beginning of the research and this was kept in its original form in order to provide repeatability and comparability of research results. In order to be able to conduct the evaluation in case companies, the amount of features chosen was limited to 40. To keep the ontology at a general level, some application-specific information was lost. Therefore it is important to include the use of the ontology with interactive workshop sessions. This ensures sharing of the knowledge specific to the project context, e.g. the offshore industry (see the learning model in Chapter 4.2).

4.1.1 Knowledge areas

The first project management discipline category in the ontology is based on generally accepted project management knowledge and practices taken from standards and guidelines supporting global project management development. Although the national and international project management associations and institutes as well as standardization agencies provide project management classifications, there does not seem to be one general rule. Appendix 2 lists the content of six classifications:

- PMBOK, Project Management Body of Knowledge. Description of the knowledge of the project management profession by the Project Management Institute (PMI) based on internationally accepted standards (ANSI, IEEE). This represents the United States' project management association's view of project management (PMI 2000).
- GAPPS, Global Alliance for Project Performance Standards, performance criteria. A global standardization organization (Global Alliance for Project performance Standars, 2009)
- APM BOK, Association of Project Management Body of Knowledge. By APM, a European association, UK member of IPMA (Association of Project Management, 2009).
- IPMA, International Project Management Association's competence baseline. By a European project management association (International Project Management Association, 2009).
- ISO 10006:2003 standard. Quality management systems – guidelines for quality management in projects. By the International Organization of Standardization.
- DMO, Competency Standard for Complex Project Managers (2006). Very large and holistic competency standard from the Australian Department of Defence (Commonwealth of Australia, Department of Defence, 2006)

As artifacts in this selection have a different angle on project management in terms of knowledge areas and competences, quality and management of complex projects,

they have been chosen as a base for the ontology generated in this study (Table 8). The appropriate features for the ontology created have then been selected from this literature (Aramo-Immonen et al., 2005; Aramo-Immonen, 2004).

The second project management discipline category, i.e. general management knowledge and practice and management theories such as process management (Garvin, 1998; Davenport, 1993; Harrington, 1991; Galbreight et al., 1986), knowledge management (Nonaka et al., 2000; Argyris, 1982; Soo et al., 2002), and risk management (Miller and Lessard, 2001; Ward and Chapman, 2001; Flygbjerg et al., 2003; Lampel, 2001; Turner, 1999), as discussed in the conceptual part of this introduction, are also applicable to project businesses. This forms the base of the general management disciplines in the ontology.

The third project management discipline category, application area knowledge and practice such as knowledge of markets, product integration and environmental impacts, depends on the specific circumstances of project execution. This part of the ontology was created based upon the literature study (e.g. Turner, 1999; Levine, 2005; Flyvbjerg, 2003; Artto and Wikström, 2005; Görög and Smith, 1999; Remington and Pollack, 2007; Faulconbridge, 2003; Miller and Lessard, 2001; Lock, 1996; Lock, 1994) and on interviews with project managers in the case companies.

4.1.2 The ontology and the learning process

The learning model is designed for project management and mega-project coordinators especially. For the content of the ontology, the focus has been on the features typical of large, diversified and fragmented projects. The user of the application evaluates 150 statements describing 40 qualitative features affecting decision making in the domain of mega-projects (Table 8). Statements are linguistic variables presented on a web-based graphical user interface (Aramo-Immonen et al., 2005; Aramo-Immonen and Vanharanta, 2006).

Features affecting decision making are grouped into 11 main categories (Table 8). It is difficult to classify the importance of the features for all projects generally. Therefore the amount of proactive vision that results from the evaluation gives a guideline for the weight of each feature. Proactive vision, as shown in the result

report (Aramo-Immonen, 2008), illustrates the amount of development potential for each feature in question. The results are unique to each project. The definitions of the features chosen by the researcher are explained below.

Table 8. The ontology of project management knowledge areas

Knowledge Areas of The Project Management Ontology			
	Feature Affecting Decision Making	Management Discipline	Management Discipline Category
1	Project Management Project Complexity Resource Planning (ERP)	Project Integration Management	Generally Accepted Project Management Knowledge and Practice
2	Contract Pricing Local Content Demands Segmentation	Project Scope Management	
3	Capacity Timing Time Scheduling	Project Time Management	
4	Management Processes Change Processes Behavioral Processes Work Processes	Process Management	General Management Knowledge and Practice
5	Cost Calculations Risk Analysis Lifecycle Costs	Cost and Uncertainty Management	
6	Human Resources Management Capabilities Work Atmosphere	Human Resource Management	
7	Understanding of Cultural Diversity Language skills Information Technology	Communication Management	
8	Customers Strategic Fit Competitors Branch of Industry Market Opportunities Economic Trends	Market	Application Area Knowledge and Practice
9	Research & Development Technological competencies Thread of Substitution Technologies Documentation Quality Systems Operative Execution	Product Integration	
10	Social Stakeholders Supply Chain Management	Co-operation with Partners	
11	Infrastructure Nature	Environmental Impacts	

Feature 1: Project Integration Management consists of the project management style, such as a centralized or decentralized style, the project complexity measures, and the coverage of information systems, such as enterprise resource planning

systems. The integration of several subsystems and different expert knowledge areas is a typically challenging task for mega-project management.

Feature 2: Project Scope Management consists of the evaluation of pricing and contract scope as well as issues affected by the customer's demand of local work content in the project. Suitability of a company's strategic customer segmentation in the project features in question is also part of the scope management review.

Feature 3: Project Time Management is related to timing, scheduling and the capacity reservation of the project.

Feature 4: Process Management consists of the framework of managerial processes and organizational processes. Process management is composed of diverse interlinked tasks concerning both individual managerial tasks and activities, and the organization as a whole.

Feature 5: Cost and Uncertainty Management concerns questions such as whether ultimate cost accounting or only approximate cost estimations were available, and what kind of risk analysis was carried out for the project. Effects of total project lifecycle costs are also taken into consideration.

Feature 6: Human Resource Management is based on the holistic concept of man. The consciousness, situationality and corporeality of the human being are a part of the project resource review.

Feature 7: Communication Management is an important part of the study of the diversified, fragmented, multidisciplinary mega-project organization, consisting of language, cultural differences, as well as communication infrastructure and differences in professional language.

Feature 8: Market issues consist of customer needs and the company's strategy-based statements, and evaluating the compatibility of these in the turbulent dynamic market environment. Long-term economic trends, such as raw material price development or forecasts of labor costs, affect the value of long lifecycle projects. The market opportunities for any particular industry branch are effective factors in the evaluation of project lucrativeness.

Feature 9: Product Integration focuses on the project organization's capability to utilize and combine technological knowledge and learning. Operation management issues such as quality systems and the capabilities of operative execution are linked to this category.

Feature 10: Co-operation with Partners evaluates the impact of stakeholder networks on mega-project decision making.

Feature 11: Environmental Impacts are the critical limits the nature or infrastructure sets for project performance.

Each of these eleven management disciplines is divided into a more detailed set of features that affect decision making (Table 8). The user of the application evaluates 150 statements altogether describing the instantiations of 40 features in an authentic project. The structure of statements and the linguistic form of the user interface minimizes the erosion of information during the process.

4.1.3 Human, commercial and technological dimensions of the ontology

The evaluation results (Appendix 3-11) introduce three angles: a technology dimension (TD), a human dimension (HD), and a commercial dimension (CD). The division is based upon a metaphor where the company consists of capital, labor and human-centered business factors interacting with one another (Figure 7, Vanharanta, 1995).

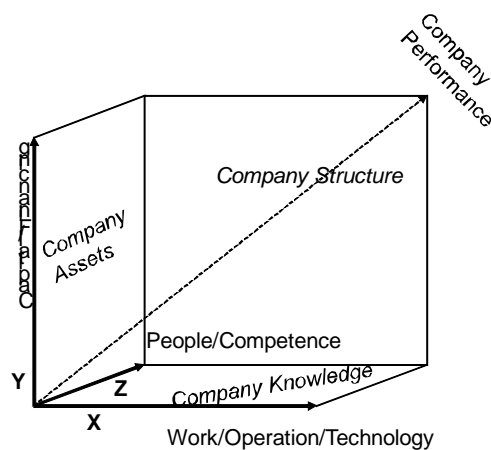


Figure 7. The company world metaphor (Vanharanta, 1995, p. 70)

The statements to be evaluated by project managers were classified accordingly. In practice this assists management in using the results; for example, human resource managers can focus on the human dimension or operations managers on the technological dimension.

4.2 The learning model – integrating learning into project processes

The learning model in Figure 8 systematizes the relation of the qualitative linguistic analysis method to the structured workshop. In this learning process, knowledge (tacit in nature) from the project organization is collected with a software application. The chosen project managers and operative project executors join the evaluation via the Internet. The user interface of the application is linguistic (here a non-numerical scale). Use of visual, linguistic scales instead of numerical scales is important as this minimizes the loss of tacit knowledge. People have a tendency to lose knowledge between conversions from the numerical to linguistic domain. The application utilizes fuzzy logic to make conversions (Zadeh, 1994; Berkan and Trubatch, 1997; Kantola, 1998; Kantola et al., 2005). For a more detailed introduction to the software solution see e.g. Aramo-Immonen et al., 2005, Aramo-Immonen, 2004.

The result of the analyses, the project management discipline priority matrix (Figure 10), is discussed and evaluated in a structured workshop. The more people from the organization who can attend these workshops, the more effective the socialization and combination modes in this knowledge-sharing arena are and the wider diffusion of knowledge within the organization. In a structured workshop knowledge is shared (system critical parameters), new knowledge is created (revised guidance), and finally that knowledge is expanded in activity systems (utilized in actions) (Kuutti, 1995; Bendy and Karwowski, 2004).

In the method developed in this research, soft systems thinking is utilized in the structured workshops by generating a rich dialogue (Flood and Carson, 1988; Checkland and Holwell, 1998). There are workshop roles for each person attending the meeting. The dialogue is guided by one person while the others are given opportunities to generate ideas and discuss them using pictures and words.

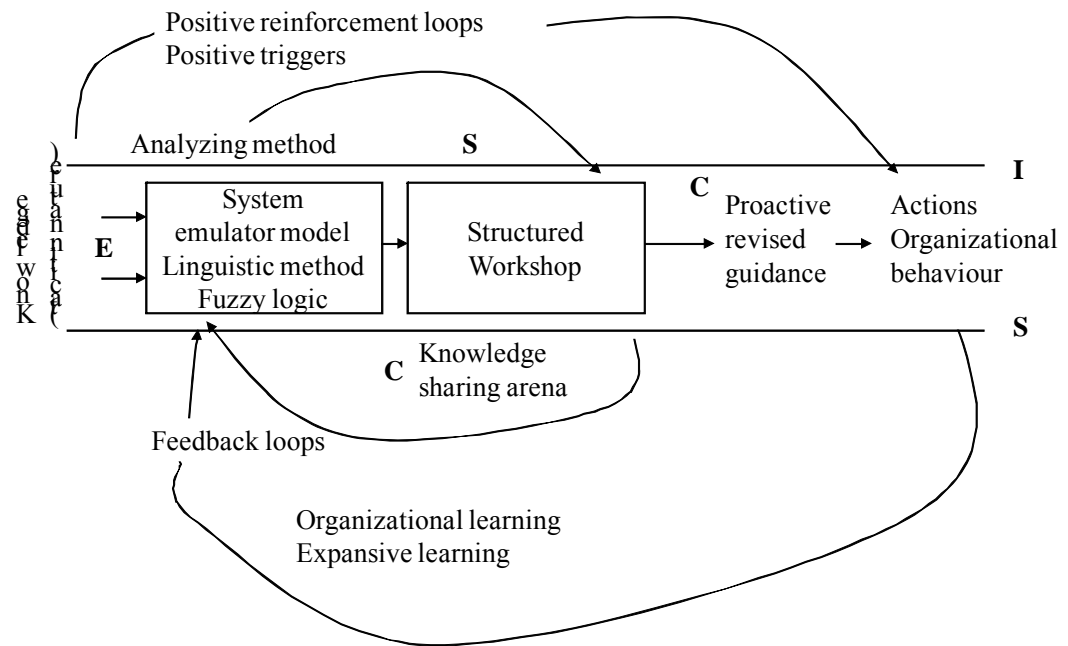


Figure 8. The learning model . Capital letters illustrate the modes of knowledge conversion in the process: (S) Socialization, (E) Externalization, (C) Combination, (I) Internalization.

This method generates development paths which focus on the company strategy. It leads to collective learning, which is defined as the organization's ability to learn from its own processes by means of testing and adopting new ways of operation (Lampel, 2001).

4.3 Summary

The results of the theoretical study were discussed in this chapter. The conceptual analysis result, the *project management ontology*, and the designed construction, the *project learning model*, were introduced. The concept of an ontology and the three-dimensional approach to project management were explained. The learning model in Figure 8 systematized the relation between the qualitative linguistic analysis method and the structured workshop.

The project management ontology was utilized in the empirical analysis in the case companies. Furthermore, the project learning model including workshop sessions was tested in each case company. In Chapter 5 the empirical case results are presented.

5 RESULTS OF THE EMPIRICAL STUDY

5.1 Empirical research setting

This research represents the applied sciences, therefore the questions imply an immediate problem in the research domain in the mega-project management environment. In this research, multiple methods are applicable. To gain a holistic understanding of a complex research area, such as the mega-project management system, a multimethodological research strategy is relevant (Nunamaker et al., 1990). The research domain of industrial management represents an economic science; the research approach is qualitative. The empirical methods utilized are discussed below.

Figure 10 systematizes the relation between the method of the qualitative linguistic analysis and the structured workshop. In this process, knowledge from a project organization is collected with a software application. The chosen 54 project managers and operative project executors from 9 project-based companies joined the evaluation via the Internet. The user interface of the application is linguistic (a non-numerical scale). Visual, linguistic scales are preferred to numerical scales as the loss of tacit knowledge is minimized.

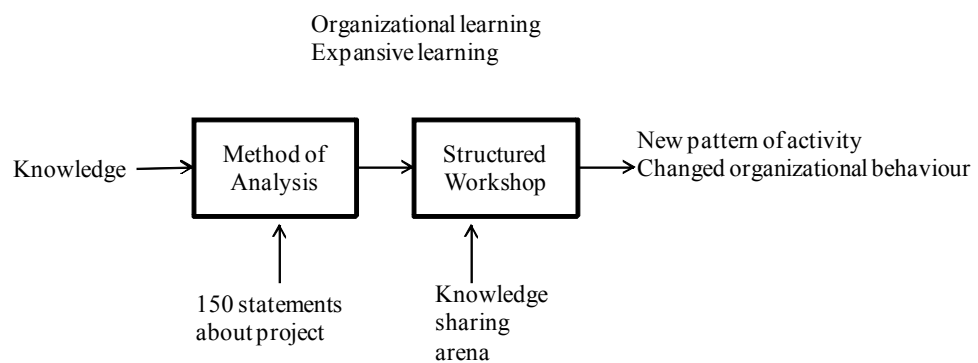


Figure 9. Relation between analysis and workshop. In this method, data representing tacit knowledge is collected from the project organization. The results of the analysis are discussed in the workshop. Afterwards the results are transformed into actions in the organization.

The difficulty of tacit knowledge is that it is not directly measurable and explicable. In this research, the data regarded as knowledge, tacit in nature, was taken from the linguistic statements. These statements present propositions regarding the

relationships within the company and its departments, between the company and its stakeholders, and within project execution. Respondents had to evaluate the current state of the statement, how things are at that moment in their organization. Also the desired target state, how they wanted the situation to be in the future, was evaluated. Along the statements two-part linguistic scale values were utilized. The scale varied according to the statements, but was typically of the following form: “not at all–completely”. The respondents provided their answers, both to current and desirable (target) states, by clicking on two bars beside the scale. With this method, the respondent was able to choose from over 100 different values for each statement since the graphic bar offered a continuous scale of values. The advantage compared to, for example, the bi-polar Likert Scale (Blalock and Hubert, 1968) of five different values is the better accuracy of answers. Responses to each statement were then transformed into a numerical form, a real value between 0 and 1 (see Figure 11, vertical axis). Both current and target values were stored in a database.

5.1.1 Method of analysis

Senge (1990) has discussed the concept of creative tension, which is a motivating factor. He states that a person’s motivation to improve a competence is the tension (difference) between the value of the current state and the value of the desired (target) state. In the project context this can be interpreted as a proactive vision. The difference between current and target states constitutes the vision of a company goal. For analysis purposes, a value for a proactive vision is also calculated. This value represents the motivation and development potential of respondents.

In the analysis, the data were treated like data in the qualitative research since no numerical methods (sums, averages, etc.) were utilized. The data were in their natural form; in the form the respondent had provided. However, the data were also treated as in the quantitative research, when a large amount of data was analyzed in one graph. This was achieved by drawing a trend line from a single statement, where each respondent’s answer was a single plot. These single values were sorted in ascending order, thus the lines were always ascendant. When all the lines were drawn in the same graph, their differences were immediately visible. It should be clarified that the values provided by one single respondent are not traceable in the graph, since each trend line was sorted. The respondent who provided the smallest value for one

statement did not necessarily provide the smallest value for other statements. The graphs representing the current value, target value, and proactive vision were then produced (see Figure 11, graph of current values).

5.1.2 Structured workshops

The results of the analysis were discussed and evaluated in the structured workshops. The more people from the organization that can attend these workshops, the more effective the diffusion of knowledge in this knowledge-sharing arena. It was demonstrated that the requisite variety and mixed structure of working groups is fruitful for workshop idea generation (Suominen et al., 2008). In the structured workshop knowledge is shared, new knowledge created, and finally knowledge is utilized in actions (or activity) (Bendy and Karwowski, 2004; Kuutti, 1995) affecting organizational behavior.

In the method there are workshop roles for each person attending the meeting. The dialogue was guided by one person, while others were given opportunities to generate ideas and discuss them with visual aids. This method generates development paths which focus on the company strategy and customer demands. It leads to collective expansive learning, which is also defined as the organization's ability to learn from its own processes by means of testing and adopting new ways of operation (Lampel, 2001; Engeström, 2001). Moreover, the people working for project-based companies do not necessarily have time to reflect, being bombarded by urgent problems and pressing deadlines (Jashapara, 2004). Therefore, project-based companies should find ways of preserving the asset of knowledge they have to consider within the practices of everyday teamwork (Koskinen and Aramo-Immonen, 2008).

5.1.3 Case settings

The research material based on the cases should be chosen carefully in order to help the understanding of the research problem. A single case connotes a project observed in research (here two mega-projects); the multiple-case (Eisenhard and Graebner, 2007) or cross-case (Gerring, 2007) study focuses on ten project organizations participating in two mega-projects.

Empirical information from two large and relatively complex projects was collected for this research. Project case one was a multinational oil drilling rig project and project case two a large cruise shipbuilding project. Altogether ten organizations were chosen for the research and fifty-four project management members were involved. The empirical data collection contained a pattern of 150 statements to be evaluated (e.g. Aramo-Immonen and Vanharanta, 2006).

According to Olkkonen (1993), cases should be chosen by applying the following principles:

- (1) Cases that can be justifiably considered typical with regard to the basic set (1st-tier partners, 6 companies, Figure 1).
- (2) Cases that represent examples of different types, in their typical form, in accordance with the preceding conceptual analysis and typeset (2nd-tier partner, 3 companies, Figure 1).
- (3) Special cases, where it can be assumed that they reveal interesting and useful factors with regard to the research (two different departments of one 1st-tier case company, Figure 1).

Case companies in case projects were chosen from the 1st- and 2nd-tier partners, because typically these ‘system suppliers’ have their own project management and project execution processes. Lower level network partners were not chosen as they are typically sub-suppliers that do not carry out project management disciplines.

The empirical data were collected during 2006-2008 and a database containing 16,200 data inputs was compiled. Examples of the result graphs and statistical calculations are given in the following chapters. Only the tip of the iceberg of the data collected is examined in this thesis, therefore leaving considerable potential for further research.

5.2 Single company results - Example of one company’s analysis

The features affecting project management decision making are grouped into 11 main categories (Garvin, 1998; Turner, 1999; PMI, 2000; Kerzner, 2003; Levine, 2005). It is difficult to classify the importance of the features for all projects

generally. Therefore the amount of proactive vision that results from the evaluation is a guideline for the weight of each feature's potentiality (shown in the result report, Figure 10). The proactive vision illustrates the amount of development potential of each feature in question. The results are unique to each case project and case company.

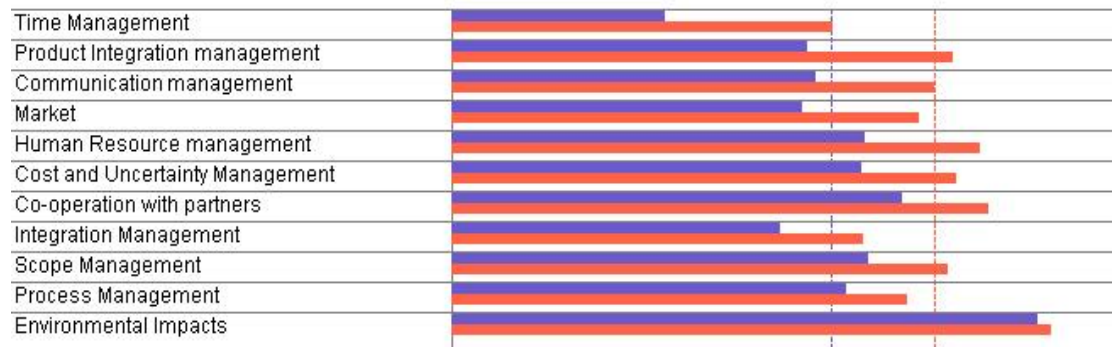


Figure 10. Example of analysis for one case company. Presentation of eleven management disciplines from the project management ontology (Table 8). The upper bar shows the current state, the lower bar shows the latest best estimate of the desired state. The gap between bars reveals the development potential.

These results were discussed at workshops in each case company. Single company results are presented in more detail in the original publications (e.g. Aramo-Immonen and Vanharanta, 2009; Aramo-immonen and Porkka, 2008).

5.3 Multiple-case results - Examples of ten companies' collective result

The selection of multiple-cases is based on theoretical sampling (Eisenhardt and Graebner, 2007). The ten case companies were system suppliers for the mega-project contractor (the customer). Each company had its own project management disciplines. Project managers and project members from each company were professionals capable of sharing their insights into mega-project execution (the object of analysis). Altogether 54 evaluators participated in the research. The analysis consisted of 150 research statements. Next is an example of five statements related to the research question.

The object of analysis was execution of the mega-project. First, the focus was on how well the respondents' organizations functioned in this process (current state in

Figure 11). Second, respondents were asked to estimate their desired, best project performance (target state in Table 9). The project studied was in its final phase of execution.

5.3.1 Result Example I

In order to assess the information flow and mutual understanding between the different stakeholders and the customer, a set of five statements was introduced. The different stakeholders are as follows: the customer corresponds with the project owner (shipyard or contractor), the planning department is equivalent to design engineers in the drawing office or project planning, research and development implies product or process innovation and development, and marketing represents sales and marketing activities in project companies. The research statements were:

1. The customers' needs in the project are (unclear–clear)
2. The planning department understands the ideas of the research and development department (not at all–completely)
3. The planning department understands the needs of the production department (not at all–completely)
4. The marketing department has taken the limitations of the planning department into consideration (not at all–completely)
5. Our design engineers know what the customers want (not at all–completely)

Figure 11 shows the *current state* according to respondents' evaluations. An interesting feature is the gap between Curve 1 and the other curves. Detailed results follow Figure 11 and Table 9.

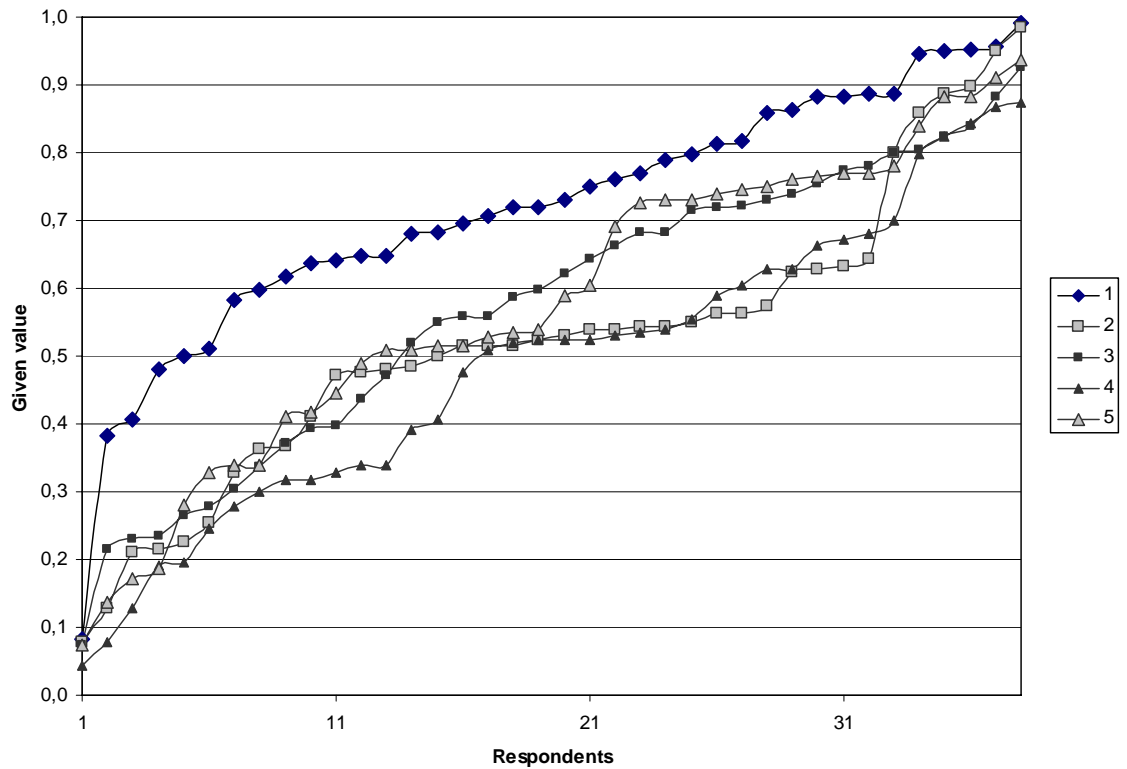


Figure 11. Current state of communication between project stakeholder groups. The vertical axis indicates the qualitative value converted to a numerical scale from 0 to 1. Unclear = 0 and clear = 1 for Statement 1. Not at all = 0 and completely = 1 for Statements 2-5. Values between 0 and 1 are on a continuous sliding scale. The horizontal axis indicates the number of respondents (54). Right, the key for Statements 1-5.

The personal scale of answers between respondents complicates collection of the group data in a single table. The traditional statistics (sums and averages) are statistically not valid. However, it would be interesting to discover how strongly each respondent emphasized the statements' value. It should be noted, however, that the answers are not comparable. Each person has an individual value scale based upon their own cognitive mapping. We suggest that a single respondent's answers are compared to that person's own median of all 150 answers to see whether one answer is above or below the personal median. This value indicates how strongly a respondent weighs a single statement; in other words, how important this statement is to the person. Table 9 demonstrates the percentage values of the 54 respondents' answers above and below their personal medians. Furthermore the values of the target state and proactive vision are presented.

Table 9. Personal median assessment of Statements 1-5.

Target State (future vision)					
Statement no.	1	2	3	4	5
Above median %	86.8	39.5	84.2	44.7	71.1
Below median %	13.2	60.5	15.8	55.3	28.9
Proactive Vision (motivation factor)					
Statement no.	1	2	3	4	5
Above median %	57.9	55.3	73.7	60.5	73.7
Below median %	42.1	44.7	26.3	39.5	26.3

In the Table 9 the target state value above the median (e.g. Statement 1, 86.8%) shows that the importance of the feature this statement indicates is valued by 86.8% of the 54 respondents as a vital success factor in the future. The proactive vision value above the median (e.g. Statement 1, 57.9%) shows that the motivation to improve this feature is high, among 57.9% of the 54 respondents. Consequently values below the personal median indicate that the feature is of low importance and the motivation to improve it is not particularly high (e.g. communication).

Findings from Statement 1: The project managers and project team members stated that the needs of the customer in general are relatively clear. This can be interpreted as a shared vision among the project teams. It is noticeable that the current view of clarity of customer needs is at a much higher level than the mutual understanding between different departments (Graph 1 compared to Graphs 2-5, Figure 11). Most of the project managers regarded this as an important factor; however, 13.2% did not weight this factor as strongly. Even though the clarity of customer needs was recognized, the results also indicated the need for improvement (Table 9). This implies a strong motivation to serve the customer better.

Findings from Statement 2: The understanding between the planning and research and development departments was at the lowest level (Figure 10). This was seen as a remarkable feature in less than half of responses. However, the motivation to improve this situation was considered important in 55.3% of answers (Table 9).

Findings from Statement 3: The planning department understands the needs of the production department relatively well compared to other communication settings (Figure 10). This was seen as a relatively important feature. Also, the motivation to improve this communication was high (Table 9).

Findings from Statement 4: The marketing department has not completely taken the limitations of the planning department into consideration (Figure 10). The importance of this was seen as relatively low but the motivation to improve this situation was rather high (Table 9).

Findings from Statement 5: Evidence of how well the design engineers know what customers want is at a high level (Figure 10). This aspect was highly valued by 71.7% of respondents and the motivation to improve this communication was also high among 73.7% of them (Table 9). It is noticeable that respondents were even more motivated to improve communication of this type than communication between design engineers and the marketing department (Statement 4).

Based upon observation of the workshops, different communication barriers could be identified. These hindrances to knowledge transfer were, for example, cultural differences, a lack of mutual language, a lack of common, professional vocabulary, and differences in professional roles (e.g. economic versus technical). The insufficient compatibility of computer systems or differences in production processes or in quality systems may have also caused the communication block.

5.3.2 Result Example II

The object of analysis was human resource management in the execution of a mega-project. First, the focus was on how well the respondents' organizations functioned in this process. Second, respondents were asked to estimate their desired, best project performance (target state in Figure 12). The project studied was in its final phase of execution. In order to assess human resources, a set of four statements was introduced. The research statements were:

1. Project personnel are (experienced–inexperienced)
2. The number of project staff is (insufficient–sufficient)

3. The project requires staff training (not at all–very much so)
4. We have the experienced working staff needed to manage the project (not at all–yes we have)

Figure 12 shows the *target state* according to respondents' evaluations. An interesting feature is the gap between Curve 3 and the other curves. Detailed results follow Figure 12.

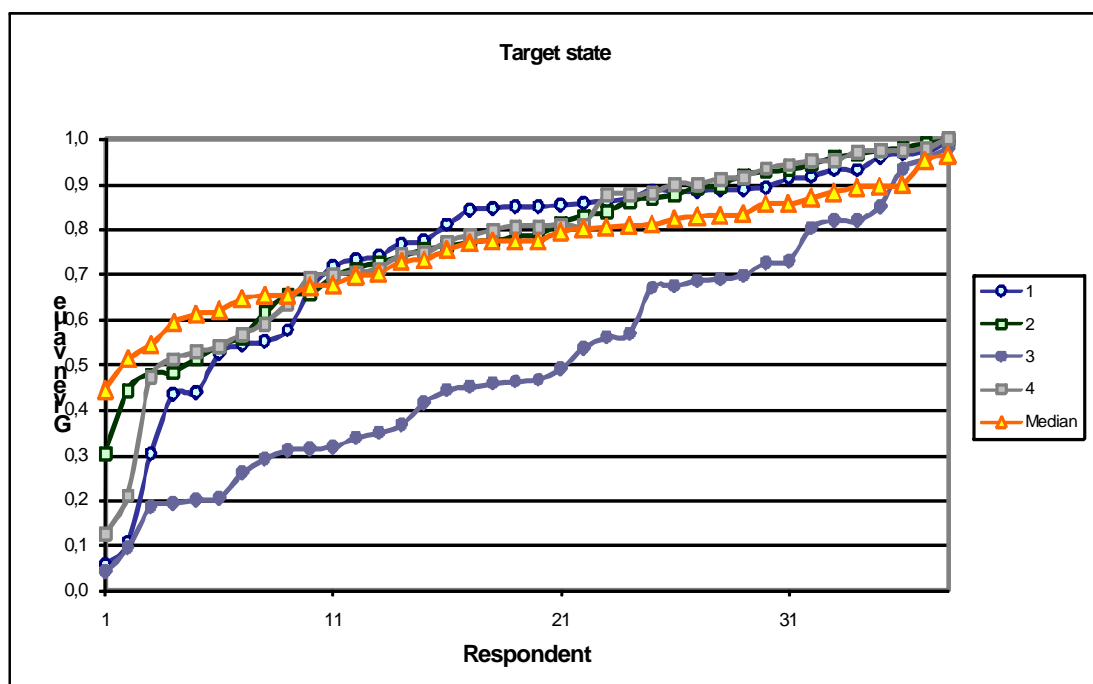


Figure 12. Target state of human resource evaluation. The vertical axis indicates the qualitative value converted to a numerical scale from 0 to 1. Values between 0 and 1 are on a continuous sliding scale. The horizontal axis indicates the number of respondents (54).
Right, the key for Statements 1-4.

This result example focuses on respondents' *target state*. From the results it appears that, across the ten different companies, in the desired state there is a need for more experienced employees in the execution of this kind of project. However it is remarkable that no desire for training the existing personnel was expressed (Figure 12, Curve 3). This raises the question as to why? It is unlikely that a bad experience of a single training course lies behind this phenomenon as the sample of respondents represented several companies. Is it merely relevant to question traditional learning

environments? In workshop sessions the resistance against formal training was experienced as a lack of time, lack of motivation and frustration.

5.3.3 Result Example III

In order to assess vendor management performance in the supply chain of project organizations, five statements were introduced:

1. The suppliers accepted by the customer are for us (new–familiar)
2. Our bargaining power against the supplier is (weak–strong)
3. We have made audits for the suppliers involved in the project (not at all–completely)
4. We have control over the supply chain of the project (to some degree–completely)
5. In this project the use of alternative suppliers is allowed (not at all–completely)

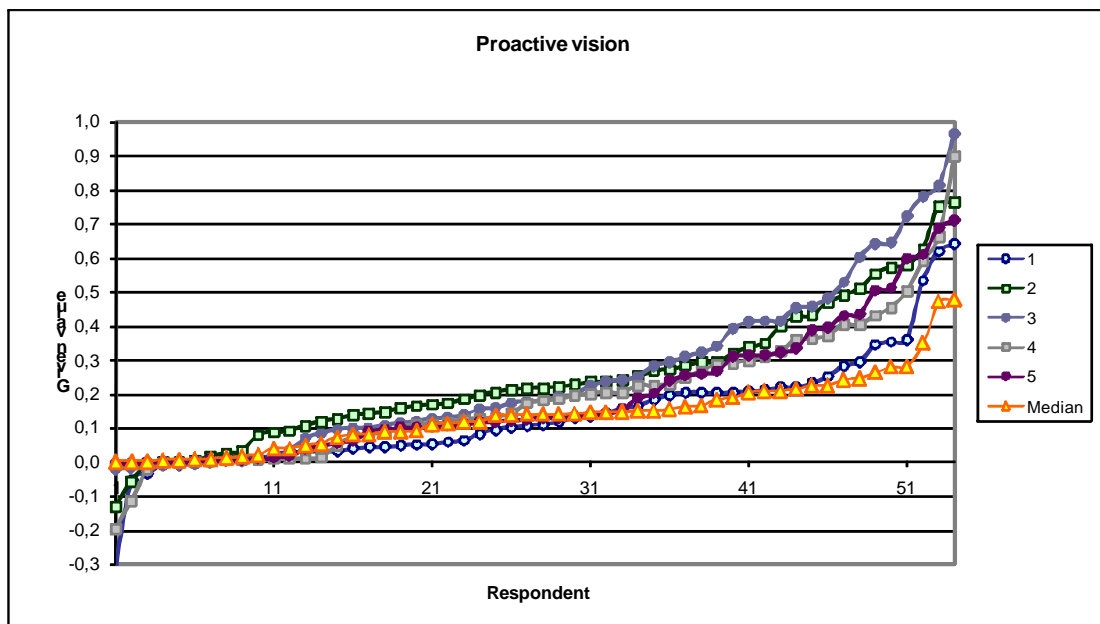


Figure 13. Proactive vision of vendor management performance. The vertical axis indicates the qualitative value converted to a numerical scale from 0 to 1. Values between 0 and 1 are on a continuous sliding scale. The horizontal axis indicates the number of respondents (54). Right, the key for Statements 1-5.

In this example the *proactive vision*, i.e. the tension between the current and target states of respondents, is introduced (Figure 13). These curves illustrate the development potential and motivation to evolve. The median curve is calculated

from each respondent's own answers. In this case the curves are above the median, which shows that the respondents considered this feature as important on their own value scale. There seems to be great deal of motivation and development potential to improve vendor management performance in this kind of project execution.

5.4 Revised guidance proposals

Based upon each particular result (at the company level), guidance proposals can be constructed. For example, Figure 13 indicates that communication inside the project value chain is insufficient when regarding the efficient fulfillment of customer requirements. In general the company respondents had a clear view of their customer needs. Also, the project managers and the project team members appeared to be willing to improve their performance to meet customers' requirements. However, the discussions in the workshops revealed that the vision was somewhat self-evident and at a general level.

When the focus is on communications between the marketing, planning, and research and development departments, the mega-project management environment is problematic. The level of communication between these stakeholder groups was lower than expected, but fortunately the motivation to improve the performance level existed. This raises the question of how well – with the help of the current communication level – customer needs will be fulfilled. In other words, how effectively the organization can add value (knowledge or margin) to the value chain.

The gap between Graph 1 and the other graphs in Figure 12 forms the practical object of project management. How can the gap between understanding customer requirements and communicating within the organization be bridged? How can the capability to add value, especially in the value chain of knowledge-intensive project companies, be improved?

Revised guidance proposal:

Based upon this research, the availability of knowledge-sharing arenas must be emphasized. Also a thorough investigation of the processes and the information flows inside companies is proposed. More in-depth examples of detailed company-

specific revised guidance proposals affecting the mega-project system are explored in the original publications (Aramo-Immonen and Vanharanta, 2009; Aramo-Immonen and Porkka, 2008).

5.5 Single-case results – comparison of two mega-projects

In order to compare the two mega-project cases, the data evaluated have to be treated. Appendices 3-11 show three angles of comparison (HD, TD and CD). Priority matrixes concerning shipbuilding and offshore mega-project cases reveal the differences in valuation of qualitative features affecting project management.

There are many suitable statistical methods for non-numerical data. In our case studies there were several related samples in the data. The most powerful test for several related samples where the number of different treatments is more than six is the Friedman test (Conover, 1999). Statistical calculations were conducted in order to enable the comparison of the different case companies. From the statistical results we can also draw some general conclusions concerning mega-project management and the qualitative features affecting management disciplines.

In this data the applied variables are called treatments (features analyzed). Each person's answers to these variables are gathered in a block. The data can be arranged in a table where columns are treatments and each row gives one person's answers (c.f. Conover uses here concept of block). There are two assumptions the data must fulfill. Firstly, the variables must be mutually independent, that is that the results within one block cannot influence results in another block. Secondly, the observations may be ranked according to some criteria (Conover, 1999).

The Friedman test (Conover, 1999) continues by ranking all treatments within a block. If there are ties, then ranking (priority order) is divided by those with the same values. The Friedman test also has an extra benefit compared to sums; the minimum difference the sums must have, after which they are regarded unequal, can be calculated. With this value the features can be grouped into clusters. This difference may be calculated with different approximate sizes. The approximate alpha value $\alpha=0.05$ has been used here, since it gives the group with the smallest number of

features (Cronbach, 1951, Walpole et al., 2002, Anderson et al., 1996). Other widely used values for the approximate size α are 0.01 and 0.001. To get a tighter (smaller) approximate value, then more features are treated as equal. For example, the values for the minimum difference of proactive vision (development potential of feature), were with different α values are 0.05→57.9, 0.01→71.1 and 0.001→91.2. If the features are divided into fewer clusters, then making conclusions is more difficult; thus more features have been included in the cluster. With the α values chosen the level of significance in the priority order is clearly distinguished (Appendices 3-11).

On the basis of the statistical research results, it can be concluded that the key factors affecting project system steering, in general, were qualitative features such as communication management, the understanding of cultural differences and the diffusion of information within the organization. The results also show that prevailing issues such as the environmental impacts of the project were generally well noticed. However, the management features which were seen as important varied depending at which level of networked project organization the firm was performing. These results brought up the practical knowledge from the project execution managers to the awareness of company project managers and line management. The practical implication was several internal and external project development tasks and knowledge sharing, leading to organizational learning in the participating companies.

5.6 Summary

Chapter 5 presented some examples of the empirical results gained from the research. The empirical research settings were discussed first, followed by examples of single-case and multiple-case results. The chapter then introduced examples of revised guidance proposals for project managers. It finally explored how two mega-projects can be compared with the research results.

The results can be used practically as case results at a company level. However the data collected also gives possibilities for studying mega-projects as a whole from a wider perspective. The next chapter concludes the research process and the results.

6 DISCUSSION AND CONCLUSIONS

6.1 Contribution of the research

In this last chapter of the introductory part of the thesis, the contribution of the research is discussed and the validity, reliability, and generalizability of the results evaluated. Figure 14 illustrates the relation between the research process (section b), the contribution to the academic domain (section a), and the contribution to managerial practice (section c).

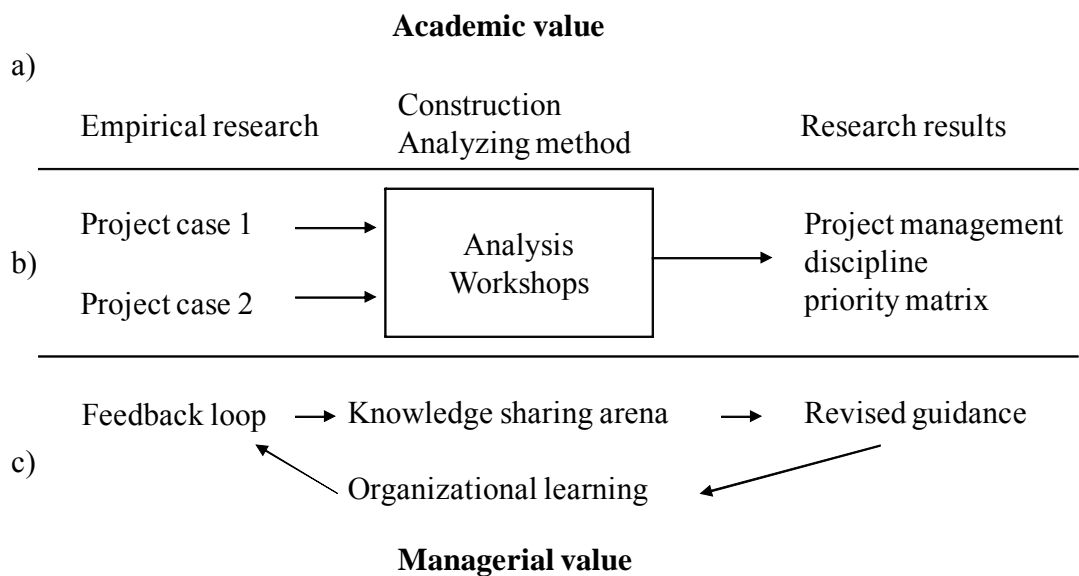


Figure 14. a) Academic value of research, b) research process, c) managerial value of research

As discussed in Chapter 2, the research approach is multimethodological. The solution-oriented applied research provides a variety of angles from which to examine the research domain in light of academic research and managerial practice (Appendix 1).

Two research questions have been stated in this thesis:

- How can qualitative project management features be prioritized to focus on the development of project processes?
- How can project learning be integrated into project processes?

To conclude, the answers to these questions are argued as following:

- In order to prioritize qualitative project management features, the analysis method and the project management ontology focusing on the development of project processes have been introduced.
- In order to integrate project learning into project processes the project learning model has been introduced.
-

6.1.1 Contribution to prior research

The object of this study is to explore project learning from the mega-project partner network view (Figure 1) in order to generate a project management ontology. The focus was on the difficulty in prioritizing project development tasks and on project learning. Many quantitative models for project management have been developed in previous research. In this research a qualitative angle has been introduced. Earlier research has also focused on project learning and project management in general. In this research these two disciplines are seen complementary and closely coupled with each other.

First, this research extends existing research by providing knowledge about the relevancy of the qualitative perspective on project management. The project management ontology that is introduced is a dynamic, new way of assessing and evaluating the project in focus (Aramo-Immonen et al., 2005a; Aramo-Immonen et al., 2005b; Aramo-Immonen, 2004; Aramo-Immonen and Vanharanta, 2006).

Second, this research applies, in practice, a project learning model and an ontology that have been developed during the process. The application of activity theory and expansive learning to the mega-project context gives a new perspective on project learning. From the empirical study, an extensive database of the knowledge of project managers was constructed, consisting of 16,200 data inputs concerning the qualitative features affecting project management. This offers an existing data store for further research (Aramo-Immonen and Vanharanta, 2009).

In addition to previous contributions, this research has shown the differences and similarities in comparison of two types of mega-projects and the pattern of 40 result

sets concerning organizational behavior in the mega-project context. These results contribute to both the theory and practice of project management.

Finally this research has also gained international publicity in the academic domain via several conference presentations around the world and printed publications in Conference Proceedings and Academic Journals. New knowledge and exploration of the research topic resulting from the researcher's contribution are:

Original Publication I: The project organizations' learning model and practical revised guidance proposals.

Original Publication II: Exploration of the idea generation process in mixed groups. Findings that a heterogeneous group in relation to education, age, and professional experience could generate more ideas than a homogeneous expert group.

Original Publication III: A project management ontology and empirical results from action research conducted by the researcher

Original Publication IV: Exploration of organizations' memory aids. Findings that Project managers make personal notes but the sharing and utilization of notes for the benefit of the project success is inadequate. However the motivation to share the knowledge existed.

Original Publication V: The project management ontology constructed by the researcher is introduced.

Original Publication VI: Results from the analysis utilizing the project management ontology is discussed. Findings that project members are not interested in formal learning.

Original Publication VII: Results from the analysis utilizing the project management ontology is discussed. Suggestion that the knowledge-sharing arenas (learning environments) should be integrated into work processes.

In summary, during the research project a project management ontology was designed which was utilized in the analysis of several project organizations. An interrelated study on idea generation (II) and memory aids (IV) was conducted in parallel. The relatively long discussion concerning methodology (Chapter 2) is relevant to emphasize the need for requisite variety of scientific methods, techniques and tools in the process. The mixed methods approach is novel in the academic domain. However it mirrors the research domain, the mega-project environment, from different angles and provides the possibility to explore a holistic understanding of the domain. Therefore the mixed methods approach is relevant to industrial management research.

6.1.2 Contribution to management practice

The overall managerial task is to boost project delivery accuracy, quality and customer satisfaction. The research domain in industrial engineering is the real world. The holistic, heuristic and iterative investigation conducted in the empirical part of this research process was very much “hands on”-type research inside the case companies. The research contributes to managerial practice in many ways.

The results of the analysis first brought up the practical knowledge from the project execution managers to the awareness of company project managers and line management. The practical implication of this was several internal and external project development tasks and knowledge sharing, leading to organizational learning in the participating companies. The main practical implication of the method introduced is the move towards sustainable performance improvement in the mega-project organization. This could be, for example, the prevention of errors and unnecessary changes in the downstream of the supply chain or an improved cost-benefit ratio.

Furthermore, there was a direct and indirect impact on the mega-project organization when utilizing the learning model as a positive trigger for performance development in the participating organizations. The learning model and project management ontology provides a practical managerial tool for project steering.

Thirdly, the change towards a positive proactive attitude of project managers was observed. By choosing the metaphoric language in the workshop sessions carefully the absorptive atmosphere to learn was demonstrated (Nonaka et al., 2000). The linguistic qualitative analysis was utilized in the project context in order to create expansive learning. It is yet to be seen whether this has a sustainable impact on the learning environment in the project organization in the future.

Finally, the project management ontology designed in this research can be further modified for different applications. Here the object was to study marine and offshore mega-projects. The structure of the ontology allows application-oriented solutions. For example, construction and large investment projects could utilize this method in practice.

6.1.3 Relevance of project management research

Recent academic discussion has shown a very postmodern nature. After the eighth conference of the International Research Network of Organizing by Projects (IRNOP VIII), held in Brighton in September 2007, it was questioned whether the discipline of project management was needed any longer (Geraldi et al., 2008, p. 586). This indicates that the topic of project management is at a fruitful moment of revolution of the paradigm. The writer attended this conference (Koskinen and Aramo-Immonen, 2007) and can assure the reader that the study of project management is a topic of current interest.

In general, project management is a prevailing area of management research. There has been a shift from the functional organization to the project-based organization. This shift has been caused by the changing nature of work during the 20th century, from mass production, with essentially stable customer requirements and slowly changing technology, to the situation in which the product supplied may be tailor-made (Turner, 1999; Koskinen and Aramo-Immonen, 2008).

A current observation in Finland is that execution of a multi-national mega-project can run into very serious problems due to a lack of attention to qualitative management features, such as cultural differences. Generally there is a lack of common understanding between stakeholders and a lack of shared language in the

mega-project environment. In other words, the ontology is missing. This could be one reason for the severe delays in nuclear power plant delivery (in Olkiluoto, Finland, delayed by more than one year at the time of writing), or quality risks in shipbuilding (increased amount of outsourcing). The result of this ignorance can be low productivity and a higher risk of poor quality in project execution (Aramo-Immonen and Porkka, 2008).

Therefore, the relevance of project management research is evident. There is a need for academic and professional research of the domain (e.g. Görög and Smith, 1999) as well as from practical managerial executors in the industry. This particular research and its relevancy are evaluated in the following chapter.

6.2 Assessment of the research

The researcher will here assess this research through the validity, reliability and generalizability of the research process and results.

Validity of the research starts from a meaningful research question in the domain explored. This is a challenge. Researchers' understanding of the research domain and the practice are essential (Gummesson, 2000). The preliminary study and supportive research questions are vital (Koskinen and Aramo-Immonen, 2007; Koskinen, Aramo-Immonen, 2008; Suominen et al., 2008). After the relevance of the research problem is established, the research approach and chosen methods should support the validity of the research (Appendix 1). Subject variation (Blalock, 1968), the subject's motivation, and the basis of volunteering and co-operating in an empirical study are essential for validity. The motivation of each respondent in the analysis was compared to his/her own median of answers. Therefore it was possible to evaluate the involvement of a single respondent. In the case study research, the knowledge searched for and gained is not context-free (Denzin and Lincoln, 2003; Denzin and Lincoln, 2000).

Reliability of the research is provided by structuring the methodology (Appendix 1) and reporting the results accordingly. A multiple-case study (also called a collective case study) provides stronger evidence of the domain than a single case study

(Eisenhardt and Graebner, 2007; Denzin, 2000). Cases have been chosen according to scientific rules (Olkkonen, 1993; Eisenhardt and Graebner, 2007). The results also have statistical reliability due to sample size.

Finally, it is worth emphasizing that the data were collected from ten project organizations. The multiple-case method provides rich qualitative evidence that supports the research conclusions. The linearity of the graphs indicates broader generalizability than a single case study. Affecting features, such as the organizational culture, management style or work atmosphere in a single case, can be eliminated from the multiple-case results.

6.3 Suggestions for further research

The project management domain provides a wide range of opportunities for further research. Each of the 40 features evaluated as affecting project management is worth further research. The value of this research is mostly in the model, which provides a tool for prioritizing these features in different project environments.

Based on the results of this research, the following four subjects are suggested for further research: (1) Communication and information flows between organizations in fragmented, decentralized project organizations and the affect of those on competitiveness; Findings from this research showed that communication was seen in most cases as one of the features that most affected project success. (2) Ways to build and organize effective learning environments inside project processes and whether this generates sustainable added value from project processes. Based on the results of this research, there is a potential for further longitudinal research, e.g. observation or action research, following an organization's utilization of the project learning model and adding value with it. (3) Identifying and modeling knowledge value chains in the mega-project context; Here again the empirical data available from this research could be further utilized. (4) Capability to produce and sustain quality via learning processes in a mega-project organization; During the research the question of whether the project organization could sustain learning and the capability to maintain a certain level of quality in a constantly changing organization rose among project performers.

The empirical data were collected during 2006-2008. This has resulted in the formation of a database of 16,200 data inputs from ten project organizations. This thesis was only able to introduce the tip of the iceberg of data collected. The potential for further research based upon the data collected is considerable. The abovementioned research subjects would require longitudinal observation of long-lasting mega-projects during their lifecycle. The analysis method discussed provides possibilities for such an approach in the future.

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