Project Control Body of Strategic Knowledge for Complex Construction Projects

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Abstract
To enhance project control in the construction industry of complex projects, it is important to embed knowledge management practice in it. The research question is: The knowledge management serves in improving the management of large and complex construction projects. The objective of this paper is to identify the strategic knowledge which lies underneath the project control workflow. The exploration of the strategic knowledge, will allow focusing on the strategic areas of project control workflow and effectively changing the mechanism ensuring project success. Based on literature review and the objective of this paper, the proposition is, "Scope (value added), quality and budget are the strategic dimensions that can be mapped out in the project control process ensuring that project controllers will focus on those areas, so the project control success can be achieved." Due to the nature of this research, the scientific ideal implemented is critical realism. This research is conducted based on qualitative method of secondary data analysis on organizational documents. The research strategy is archival research since the author analyzed manuals from two organizations. Based on the empirical data and analysis, the author accepts that strategic knowledge can be depicted in a diagram. The specific areas in the project control workflow are indentified: cost control, planning and scheduling, internal reporting, client reporting and variations/claims. It was found that knowledge management constitutes a basis for the development and management of large and complex construction projects.

Keywords
Knowledge management, Project control, Project success, Complex construction projects

1. Introduction

Many researchers and writers argue that we are entering an era when traditional economic power means such as capital, earth, raw material and technology, are not the critical success factors for a business or an organization. On the contrary, the future and the success of enterprises are now determined by their ability to exploit the most strategic resource: business knowledge. Obtaining, structuring, and allocating project knowledge is essential for organizations to achieve their objectives through the utilization of knowledge (Gasik, 2011, p. 40). Creating, managing, and transferring knowledge is essential and challenging. In that context, it is imperative for construction companies to perform knowledge management in order to sustain themselves in the competitive business environment, because "managing knowledge effectively gives companies several advantages in improving business performance and increasing productivity, and finally in becoming a learning organization" (Kivrak et al., 2008, p. 94).

Effective knowledge management enables organizations to explore opportunities and avoid problems through adapting to the competitive environment (Rozenes et al., 2006). As a part of project management,

project control knowledge is derived from testing of actual performance against the planned objectives and requirements, because successful project control is necessary to deliver project success (Rozenes et al., 2006, p. 6).

Knowledge Management aims to cover all the required knowledge for the development of a project due to the complexity, the size and time that make them difficult to be implemented (Antill and Woodhead, 2000, p. 29). This paper refers to the connection of the management of knowledge through the development of projects, seeking a meaningful connection in relation to the development steps from the beginning to the end (Antill, and Woodhead, 2000, p. 25).

According to Desouza and Evaristo (2007, p. 417) typology, project management offices functions can be classified to two knowledge-archetypes: administrative and knowledge-intensive. Administrative support functions provide project managers with administrative support and knowledge-intensive functions have an active role in developing and applying knowledge to improve performance. Project control is the only function at the boundaries of these dimensions. It requires the provision of information to project management and initiatives from the project management office (Desouza & Evaristo, 2007, p.418-421). Julian (2008, p.52) divides the knowledge from the learning function of the project management office to retrospective learning (status reporting and governance, lessons learned practices, personal experience) and prospective learning (project methodologies, knowledge sharing forums, formal training, personnel selection). Project control (Julian, 2008, p. 51-56) produces retrospective learning. If Julian's framework moved one step ahead, the knowledge can be stored for future use. Pemsel and Wiewiora (2012, p. 40-41) claim that alignment between project management office's knowledge sharing functions and project managers' knowledge sharing behaviors is critical for successful control and quality assurance.

Based on the above it becomes understood that all the studies carried out until today didn't try to associate management of knowledge and the wider management of new technologies, measures and instruments with the development and the management of a project. Knowledge is power and the integration of this power in the project management will be a strong advantage.

2. Theoretical Methodology

The objective of this study is to map and highlight the strategic knowledge embedded in the project control workflow functions so that project controllers can focus or make changes on those areas ensuring effective project control that will contribute to project success. Due to the nature of the research, the author will investigate the subject using iterative approach. Theory and a proposition on knowledge management in project control in complex construction project will be introduced which will be verified or rejected by the findings. This deductive approach will be cross-fertilized with inductive elements since some findings will be generalized. The approach taken by the author indicates a "weaving back and forth between data and theory" (Bryman & Bell, 2007, p. 14). The objective of the research is exploratory since it is not fully known the extent of the findings and what will be finally mapped and described (David & Sutton, 2011, p. 11). The author seeks to explore the strategic knowledge embedded in the project control workflow of complex construction projects.

In this study and due to the nature of this research and the research objective, the scientific ideal implemented is critical realism. Critical realism focuses on mechanism and explores its function in order to give explanation, which will lead to deeper understanding (David & Sutton, 2011, p. 76). In contrast with empirical realism it does not merely describes a reality superficially, but identifies structures and mechanisms that enable to understand and introduce changes needed (Bryman & Bell, 2007, p. 18). The objective of this paper work is to identify the strategic knowledge which lies underneath the project control workflow so a change, if necessary, can be implemented.

3. Theoretical Frame of Reference

In order to identify which knowledge is strategic, it is required to define strategy. Academic literature provides different definitions of strategy. According to Wright et al (1992) cited in Mintzberg (1998, p. 9) most of the textbooks try to define strategy as "top management's plans to attain outcomes consistent with the organization's missions and goals". In order to get pave the path toward an overall definition of strategy we have to include the direction, the efforts, the environment and at least the target of the organization itself (Mintzberg et al, 1998, p. 6). Strategy is the long term plan trying to change the status quo situation, by setting the direction to achieve the targets of the organization and focusing on the best results (Mintzeberg et al, 1998, p. 15). In other words, strategy is the long-term optimization plan.

The strategic knowledge is the one required for project success. Project knowledge management is the application of knowledge management in project environments and alignment of the principles of knowledge management and project management (Hanisch et al., 2009, p. 149-151). In order to be successful, the project has to align with the triple constraint (Dobson, 2004, p. 1-18; Byatt et al, 2011). The key element of a successful project is the careful consideration of the triple constraints of projects, which are scope (quality), cost (resources) and schedule (time). Project control is the process of "tracking, reviewing, and reporting the progress to meet the performance objectives defined in the project management plan. The key benefit of this process is that it allows stakeholders to understand the current state of the project, the steps taken, and budget, schedule, and scope forecasts" (PMI, 2013, p. 86).

Combining Hanisch et al. (2009) with Dobson (2004) and Byat et al. (2011) it is concluded that the triple constraints of project are the elements that interact and constrain the project, so they are the element whose knowledge holders should be carefully controlled and managed if the project is to be successful. The link between knowledge management and project control is achieved by aligning knowledge created with these three constraints.

One possible definition for complex project is "Lifecycle delivery of emergent strategic outcomes through projects which: are usually adaptive system of systems; have high uncertainty in scope definition; are distributed; have ongoing environmental and internal turbulence, are implemented through wave planning; and are unable to be decomposed to elements with clearly defined boundaries." (Dombkins, 2007, p. 348). The idea of reductionism, that was first introduced by Descartes in 1637 (Mitchell, 2009, p. ix), is good for analyzing complex projects. Reductionism is the approach of analyzing complex systems by balkanizing them to simpler forms (Hosfstadter, 1979, p. 312) e.g. workflow. According to Descartes (1637/2006, p. 17), the purpose of this scientific method is to "to divide all the difficulties under examination into as many parts as possible and as many as were required to solve them in the best way" and he describes his research method: "to conduct my thoughts in a given order, beginning with the simplest and most easily understood objects, and gradually ascending, to the knowledge of the most Complex".

Project control is important for being able to deal with arising problems and avoid blitzes. Knowledge is the most important asset when it comes to avoiding blitzes. In order to facilitate efficient use of knowledge, project control uses advanced engineering informatics that speed control procedures up.

Project control makes sure that the scope, quality and budget do not deviate from the objectives and requirements set in the planning phase of construction projects. The strategic knowledge created in those three dimensions is comprised within the inputs, outputs and tools and techniques of project control.

In construction project-based organizations, the project management knowledge revolves around project scope, budget, time and achievement of objectives. Measuring project management knowledge is measuring the "ability to manage project scope, ability to control time and budget, and ability to assign

and control team members" (Hahn et al., 2012, p. 32).

Based on literature review and the objective of this paper, the author forms the following proposition. "The project control workflow includes strategic knowledge in its functions. Scope (value added), quality and budget are the strategic dimensions that can be mapped out in the project control process ensuring that project controllers will focus on those areas, so the project control success can be achieved."

4. Practical Methodology

In line with the ontology and epistemology stance, this study adopts a qualitative data collection allowing a depth description and explanation of the knowledge management in project control in construction projects. The qualitative data collection enables understanding of the contextual conditions of knowledge management practices, which hardly would be fulfilled with the rigorous methods linked to quantitative collection (Yin, 2009, p. 135). This research uses a mono-method based on collection and examination of organizational documents and manuals.

According to Hill (1993) there is no fixed archival analysis method and the author learns in the process how to extract information. The author decided to implement the process analysis "networks and Cohorts" (Hill, 1993) due to the research nature. Archival data usually helps the researcher to identify the true nature of complex networks and show unrecognized human interactions. This type of analysis uses tables, diagrams of human interactions along with organizational linkages (Hill, 1993, p. 62). The steps for analyzing the manuals are as follows: 1) Reading the manuals, recognizing and highlighting linkages with the research proposition, 2) Creation of diagrams and tables with data needed, 3) Mapping interactions in a Microsoft Excel document, 4) Recognize patterns and describe them thoroughly

5. Empirical Findings and Analysis

Based on the manuals, project control includes the following activities and stakeholders:

Table 1: Activities and Stakeholders

Review Method statements	PCM
Coordination of the End of Project Report	PCM
Evaluation of Site Instructions (SI) and Variation Orders (VO)	QS/PCM
Compilation and maintenance of registers for SI and VO	QS/PCM
Contract Review and Administration	PCM
Preparation of Monthly Invoices	QS/Planner
Preparation of Internal Reporting	
MCWBR	PCM
Contingent Assets & Liabilities	PCM
Monthly Status Report	Planner
Preparation of list of permanent Materials	QS (Quantity surveyor)
Maintenance of cost control system	Cost Control Engineer
Preparation of the Progress Reports to Client	Planner
Filing and Distribution of project and corporate system documents	PCM (Project Control Manager)

The project control manager should distribute the completed chart to appropriate members of the management team. The head of each department is responsible for providing accurate and timely data (in relation to their discipline), to the project control department. They are all responsible for ensuring the work of their groups is properly coordinated and meets the requirements of the contract. Knowledge by department and by operations director in relation to the implementation of the project formed the basis for its development. The starting point of the project control workflow is after the bidding process and the winning the contract. The project control procedure is a multidimensional problem .The project control workflow is a one-dimension algorithm. This algorithm was made using knowledge mapping on the organizational documents, by utilizing the knowledge chain that results from the study of interactions between individuals and/or departments. If every element of this algorithm is broken down, then the multidimensional elements will be made apparent. The main problem with this algorithm is that deferent procedures are meant to be executed by humans. This means that it is very difficult to use this algorithm, as it is, in advanced engineering informatics for developing a computer program, as some of the data cannot be transformed in pure explicit knowledge, understandable by computers or artificial intelligence.

Figure 1: Project control workflow (Kalyviotis, 2014)

The project control workflow is the chain reactions, needed for knowledge mapping. According to Shriven et al. (2008) the basis for the development of a demanding project is the existence of experts who will make the necessary steps, based on a plan and a project control workflow, as in Figure 1, in order to define the development and implementation processes of a project.

Author, after developing a holistic view of how project control interactions with other departments in every procedure, simplified the interactions. Interactions analysis results in a more simplified diagram of the functions is shown below (Figure 2). The instructions provided by a holistic matrix (department/function matrix) allow the successful control of the project from the higher levels of the company. The functions are not exhaustive and the project manager may assign additional functions at his discretion. The project control department has direct involvement in some project control functions. The strategic control processes are identified in project control by the following procedures:

Cost/Time – Cost control Scope/Time – Value added Quality – Quality check

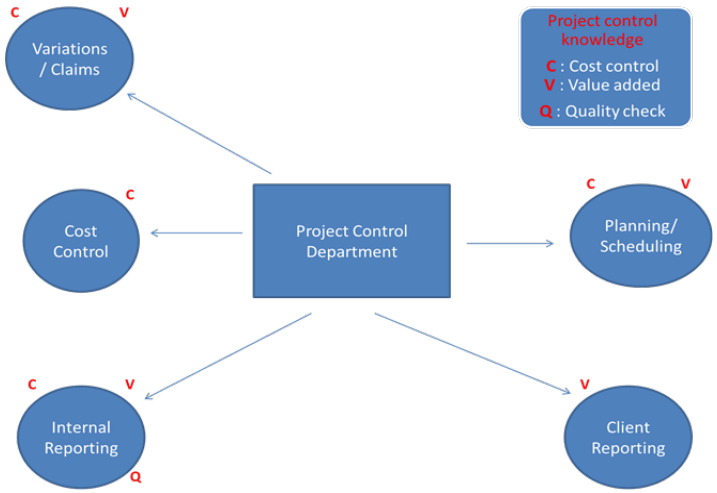

Figure 2: Functions of project control department (Kalyviotis, 2014)

The distinction between cost, value and quality is delicate. Cost control by definition is about cost. Planning and scheduling is about time management and so it adds value to the project for the right price (cost). Variations and claims provide strategic knowledge depending on their nature. They usually sway cost and value, but sometimes they can even sway quality. The internal reporting is a succor procedure used by the project control department (McElroy, 2000, p.62). It effects the project and moreover the organization as a whole in terms of time, cost and scope. Finally, client reporting depends on the context of the project. Delivery method, type of contract, stakeholders' analysis, etc. are typical elements for defining the context of the project. For example, in some context (e.g. incentive contracts) the client may be able to change the quality or the cost of a running project and but fail in another case (e.g. lump-sum payment or turnkey contract). At any case, client reporting adds value.

6. Conclusions and Recommendations

Concerning the McElroy (2000) and in combine with the practical part of the project, one can say that Strategic knowledge is not the knowledge created in the strategic level of an organization. It is the knowledge that interests the strategic level (top executives) of the organization (Kalyviotis, 2014). There are three main project control procedures, with strategic planning variables, that are linked with strategic

knowledge creation; cost control, value added and quality check. These procedures control the achievement of the alignment of project objectives with the strategy of the organization (Kalyviotis, 2014). These procedures appear on particular project control functions of construction projects (Table 2).

Table 2: Project control procedures creating strategic knowledge on particular project stages

Project Control Function	Cost control	Value added	Quality check
Cost control	√	-	-
Planning/ Scheduling	√	√	-
Internal reporting	√	√	√
Client reporting	(√)	√	(√)
Variation/ Claims	√	√	(√)

√ Knowledge creation

(√) Knowledge creation depends on the nature and the context of the project

The analysis of project control functions in complex construction project produced the project knowledge flow (Figure 1), which allows mapping the project control procedures over time (Figure 3):

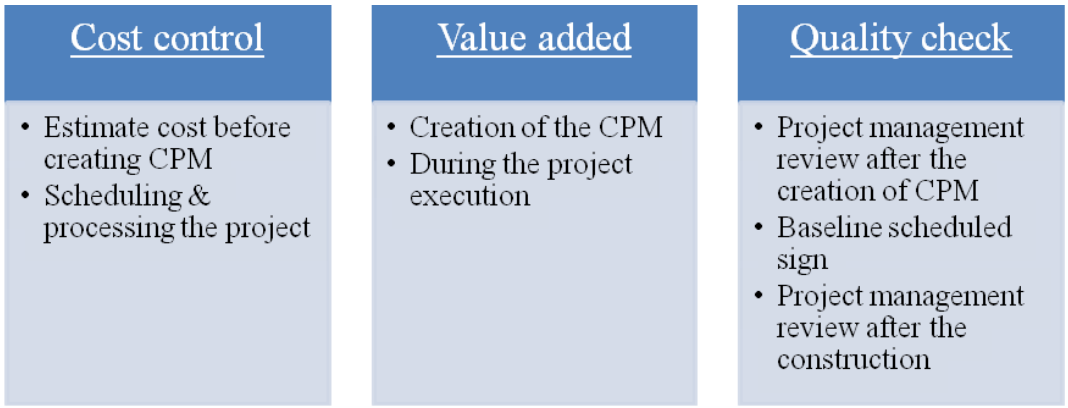

Figure 3: Project control procedures creating strategic knowledge on particular project stages

Project control of projects in progress is the key to success or failure of a project. The goal of the project control knowledge workflow is to achieve business results (value) with on-time delivery of the project (Kalyviotis, 2014). Projects differ and project control methodology must be adapted to environment, type of project and task. The algorithm reveals how the management of strategic knowledge, knowledge mapping and knowledge creation results in successful projects between the three dimensions, scope – budget – quality (Kalyviotis, 2014). Based on the above considerations one key conclusion is that knowledge should be adjusted to the needs of project management in order to provide the right combination of both (Kalyviotis, 2014).

Scope control is tight, as there is not enough time for design and planning cycles. Early design of complex engineering procedures freeze to ensure project success and to allow work of multiple contractors in systematic way. Enough time should be planned for complex coordination of works. Management should be reserved on allowing delays by different stakeholders. Time is required for testing the project control knowledge flow before used. Cost control is based on detailed design, careful planning and previous experience. The cost control is tight, as there should be flexibility in allocating of budget to different stakeholders. The conclusion here relates to the importance of the time and cost relationship for a business and specifically the project management. In particular, when a company manages to complete a project on time and according to the conditions specified by the client, it manages to keep the costs to normal levels and succeeds to realize the budgeted profits, otherwise even if the project is successful, the

time factor and the non-compliance creates problems in a business. Based on the above, it becomes understood that today knowledge is power in managing large and costly complex projects, because companies do not have room for errors and so knowledge reduces the risks. (Kalyviotis, 2014)

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