MANAGING CONSTRUCTION PROJECT CHANGE IN THE KNOWLEDGE AGE: A CASE STUDY

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Changes in construction projects are common and can lead to disruptive effects such as project delays, cost overruns and quality deviations. The rework due to unplanned changes can cost 10-15% of contract value. By managing these changes more effectively, these disruptive effects can be minimised or avoided. Previous work has approached this research problem from an information-processing view with the introduction of hard IT based solutions. In this knowledge age, this study argues that effective change management can be brought about by understanding the significant role of knowledge during shared activities such as change problem-solving. In managing change the construction team members bring their tacit and explicit knowledge into the problem situation and it is this knowledge that is captured, converted and shared between the parties during the change process. As such, the study aims to explore the role of knowledge during managing project change in collaborative team settings. The case study method has been selected as the research approach for theory building and testing. The interim findings of the first case study revealed that the different forms of knowledge are created during shared problem-solving activities during construction change events. However, this knowledge remains largely tacit and does not disseminate to the wider organisation due to ineffective codification and learning mechanisms.

Keywords: Case Study, Knowledge Conversion, Project Change, Shared problem-solving.

INTRODUCTION OF THE PAPER

The aim of this paper is to present the findings of the case study of a research study on managing construction project change in the knowledge age. The paper begins with presenting the background to the research study. Secondly, the findings of a detailed literature review are given. Thirdly, the research problem statement in terms of the research questions and the conceptual model are established. Fourthly, the paper sets the methodology of the study. The fifth section presents the interim findings of a case study. Finally, conclusions and future research priorities are presented.

BACKGROUND STUDY

Construction projects often undergo project delays, cost overruns and non-conformance to quality, leading to poor performance and dissatisfied parties (for example see Latham, 1994 and Egan, 1998). An understanding of the driving forces behind such problems is a necessity if the performance of the industry is to be improved.

Change can be a major contributor to above raised problems in construction. Unexpected change which occurs throughout the design and construction phase hinder project success to a significant extent (CII-Construction Industry Institute 1994;

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CIRIA 2001). Changes can lead to time overruns, cost overruns and quality deviations. The major cost due to change is by the cost of rework and this can amount to 10-15% of contract value (Love & Li 2000). Indirect effects of change are also considerable. Examples of indirect effects are loss of productivity, interruption to workflows and cash flows and may also lead to lower moral, claims and disputes between the parties (Bower, 2000). These disruptive direct and indirect consequences of project changes demand effective ways of managing them.
The appropriate management of change is thus essential to the minimisation of the disruptive effects of change in construction projects. The next section develops this research problem further through a review of the relevant literature (for a full discussion, see Senaratne et al, 2004).

LITERATURE SYNTHESIS

Project change management: A review of the construction literature

CIRIA (2001 p10) views construction project change as "an alteration or a modification to the pre-existing conditions, assumptions or requirements". These project changes are the *additions, deletions or revisions* within the scope of a project contract that causes an adjustment to contract price or contract time (CII 1994) or the quality. As affirmed in the introduction, to overcome problems faced within construction projects, these project changes need to be effectively managed.
Effective change management allows change to take place in a controlled way so that viable alternatives are identified, developed and the impact is defined before implementation. Change management in construction is central to the project management process. Since construction problem-solving takes place in a team setting, effective project change management does not rely solely on the role of a project manager; rather, it requires appropriate input of all relevant team players. As Cornick & Mather (1999) stress, teamworking in construction has a direct impact on project performance.
Previous approaches to construction project change management adopt a variety of different perspectives. CII (1994) and CIRIA (2001) provide best practice guidelines on project change management. These guidelines are based on five principles: anticipate change; recognise change; evaluate change; resolve change; and, learn from change. These principles aim to mitigate the disruptive effects of changes by suggesting a framework established from the start of the project to deal with change.
Love et al (1999) contribute to construction project change literature through a series of research activities addressing the rework effects of project change. Their work confirms the complexity and the interdependence of project changes, with the identification of various causes and effects of project changes. Other studies have approached project change from a process management perspective. Kagioglou et al (2000), for example introduce a separate change management process within the generic design and construction process protocol.
Drawing from this previous construction project change literature it is evident that the change problem-solving has been viewed essentially as an information-processing activity rather than a knowledge intensive activity. The information-processing perspective on organisational processes originates from the work of Simon (1957) and leading to Galbraith (1974). Recently, an alternative theory of the firm has been proposed which recognises 'knowledge as the key asset' or 'knowing as a key process', in delivering organisations' competitive advantage. This knowledge-based view of the firm (Grant 1996; Spender 1996; Empson 2001), we argue, opens new avenues to approach effective project change management in construction.

Construction literature that address knowledge management, learning and innovation studies, show a trend towards identifying construction problem-solving as a knowledge intensive activity. For example, Winch (2002) explains that knowledge and learning are generated in solving problems that involve team discussions and dialogues during the construction process. For such problem-solving to become true innovation the solutions reached for particular problems, should be learned, codified and applied in future projects (Sexton & Barrett 2003). Similarly, other learning and innovation literature in construction identifies the importance of integrating project experience to the organisational business processes, to generate learning and innovation (see for example Barlow & Jashapara 1998; Gann & Salter 2000). However, the extant knowledge-based construction literature is arguably limited in providing an in-depth understanding on the role of knowledge during construction problem-solving and especially during managing change context.

To this end, general knowledge management literature aids in understanding the fuller role of knowledge during problem situations that is facilitated by team interactions. Accordingly, during shared activities such as problem solving, individuals bring various forms of knowledge that could be shared and converted into new knowledge (Nonaka & Takeuchi 1995; Leonard & Sensiper 1998). As such, this study draws extensively on the general knowledge management literature in order to understand the role of knowledge during managing change events in construction. The next section will summarise the findings of this review.

Insights from general knowledge management literature

Most literature identifies two types of knowledge: tacit and explicit. Polanyi (1966) explains the tacit knowing by saying that we can know more than we can tell. Tacit knowledge is highly personalised and hard to formalise, making it difficult to share with others. On the other hand, explicit knowledge is codified knowledge, which is transmittable in formal systematic language, often found in rules, policies, procedures, specifications and documents. Spender (1996) places knowledge types in a matrix by adding a second dimension to the tacit-explicit dimension. This is the individual-collective dimension. Thus these different types of knowledge especially collective-tacit knowledge that is embedded in shared problem solving brings useful insights into team knowledge during managing construction project change.

In looking into team knowledge during change events, the theory of knowledge creation (Nonaka & Takeuchi 1995) shows how a team can advance knowledge and learning through team interactions. By exchange of tacit and explicit knowledge four modes of knowledge conversion takes place: socialisation, externalisation, combination and internalisation. As Nonaka (1994) explains, each of these four modes can create new knowledge independently. New knowledge created in the internalisation and externalisation modes, in particular, is more valuable as it can be shared beyond the context, that it was created. However, according to Nonaka & Takeuchi (1995), substantial knowledge creation happens when forming a continual cycle through the dynamic interaction between the four modes, which further advances when it flows from individual to collective level. Thus, it creates a spiral effect of knowledge accumulation and growth leading to organisation knowledge creation.

In bringing this understanding of knowledge creation into construction project change situations, it is useful to explore to what extent this tacit and explicit knowledge interacts and create new knowledge that lead to team learning. Inter-project learning can emerge when team knowledge is stored for re-use in future projects. However, team knowledge transfer to organization level can be constrained by internal

stickiness (Szulanski 2000). Hence, as Huber (1996) explains, inter-team knowledge transfer is affected by factors such as team's absorptive capacity, casual ambiguity and arduousness of the relationships. Bresnen et al (2002) states that apart from this internal stickiness, the problems of capturing and diffusing knowledge generated at project level comes from the very nature of the project-based work. Hence, this study captures the context variables related to a construction project change process in terms of process specific characteristics, group characteristics, organisational characteristics and wider environmental characteristics.

In summary, the literature review of this study identifies the problem of construction projects with disruptive effects due to unplanned changes. Previous approaches to managing project change adopt an information processing view, without appreciating the significant role of knowledge in managing change. This led to the exploration of the role of knowledge during team interaction as explained in the knowledge management literature. From this knowledge-based perspective of managing project change, the research problem is articulated below.

RESEARCH PROBLEM STATEMENT

The aim of this research is to explore the role of knowledge during managing project change in construction. Given that the management of construction project change significantly differs at the construction phase from the design phase (CII 1994), this study controls the phase variable by focusing on the reactive changes during the construction phase of the projects. Though unplanned changes at a later stage of a project are costly they are common in construction projects. Therefore, when late changes are unavoidable, the remedy is to manage them reactively, to minimise their disruptive effects.

Based on these aim and objectives the key research questions established for this research are as follow:

1. How does the project team capture different forms of knowledge in managing reactive changes in the construction phase of projects?
2. To what extent does knowledge conversion take place during this change process?
3. What knowledge is created during this change process?
4. How is the knowledge gained from this change process stored for re-use?

The conceptual model (see Figure 1) depicts the role of knowledge during reactive change process in the construction phase of projects. The core of the model represents the *change process* as an input-output model. Knowledge conversion, where the tacit and explicit knowledge is captured, shared and converted to new knowledge, is represented in the transformation stage of this change process. The project-to-project knowledge transfer is represented by arrows that link project to organisation layer through the project team layer. The context of this problem statement is shown in four layers. The characteristics corresponding to each layer is shown along that respective layer. The *change process* in the inner layer is influenced by the *process characteristics.* The second layer represents the *construction project team,* which is influenced by *group characteristics*. The third layer represents *multiple organisations*, which is influenced by *organisational characteristics*. The outer layer shows the *construction environment,* which is, affected by the *wider environmental characteristics*. These contextual factors in terms of the four characteristics are depicted in the model by a triangle to represent the direction of the impact.

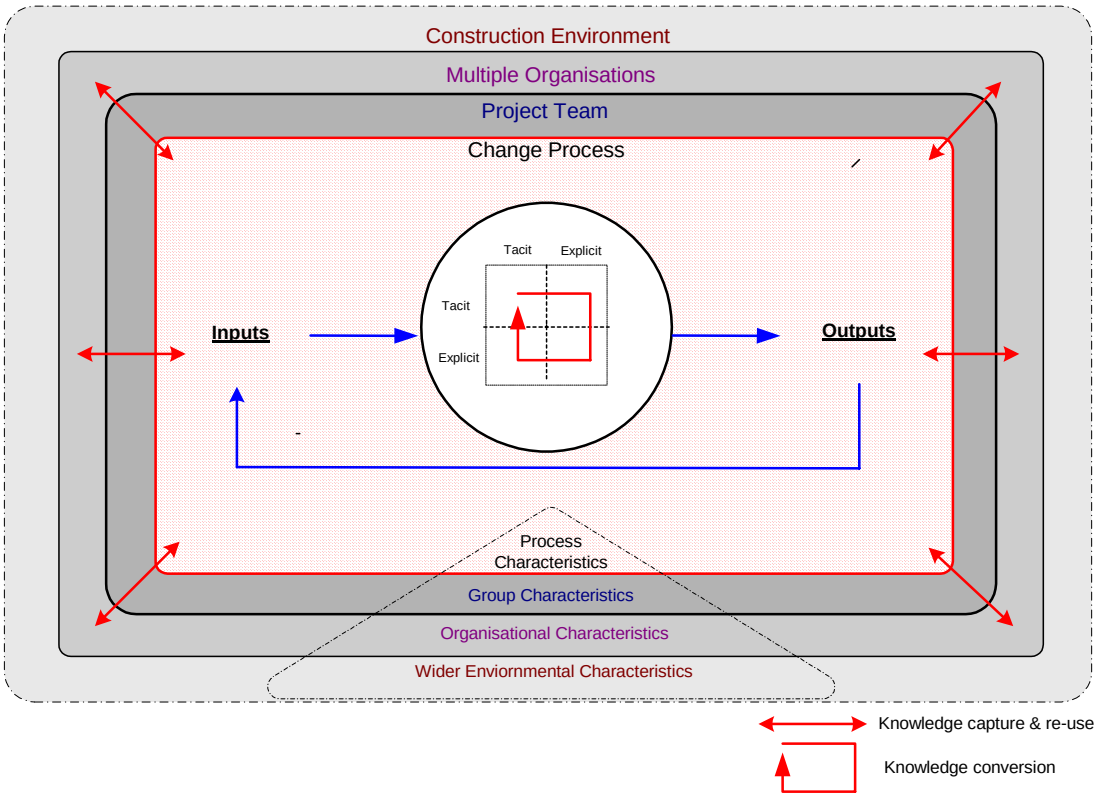

Figure 1: Conceptual Model

The conceptual model along with the hypotheses that are developed to stand for the research questions will be tested through an empirical study. The methodology of this empirical stage is explained in the next section.

RESEARCH METHODOLOGY

The research methodology for this study is selected based on the 'nested' methodology (Kagioglou et al 2000). The Figure 2 shows this nested methodological approach (See Senaratne & Sexton, 2004, for the overall methodological framework developed for this study.)

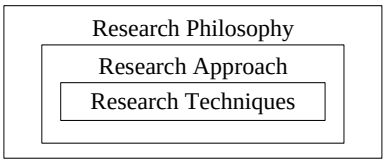

Figure 2: Nested Research Methodology

The selection of the methodology starts from identifying the research philosophy that should explicitly state the assumptions about the ontological, epistemological and axiological foundations (Sexton 2003). This research study as set out in the problem statement, deals with a complex phenomenon which is very much context specific. Thus the study is driven towards the phenomenological paradigm that is more suitable to investigating and understanding social interaction from a variety of actor perspectives.

Once the research philosophy has been identified the next stage is to explore research approaches for theory testing and building. Among the qualitative research approaches, the case study research approach is selected for theory testing and building based on two reasons. First, taking the 'level of analysis' into account: this

study attempts to explore a phenomenon in a team setting and therefore the analysis will be conducted at a sociological level rather than a deeper individual-psychological level. Thus the necessity of employing a pure action research or an ethnographic research approach that demands researcher to be implanted in the problem environment for a longer-term is ruled out. Second, based on the 'reasoning approach': this study starts with a literature review and development of a theoretical understanding prior to the field study. Thus, it has taken a deductive reasoning approach before the inductive theory building process. Therefore a pure grounded theory method that searches for research questions through a field study is also ruled out. According to the theoretical definition of Yin (1994, p13) the case study method is, *"an empirical inquiry that investigates a contemporary phenomenon with its real-life context, especially when the boundaries between phenomenon and context are not clearly evident … the method will rely on multiple sources of evidence and development of prior theoretical propositions."* Thus the case study method is considered suitable for this study and therefore it is chosen against other qualitative research approaches.

The next step of the 'nested' approach is to select appropriate research techniques for data collection and data analysis. The main research technique selected for data collection in this study is in-depth semi-structured interviews. The interview data is triangulated to some extent by analysing documentation and by participating in project team meetings. The research techniques used for data analysis is an integrated method that is aided by computer software. It starts with a content analysis by use of NVivo for data reduction and concept identification. Then the data analysis leads to cognitive mapping by use of DExplorer, for data display and relationship building between the concepts. The data analysis takes a pattern matching approach that matches patterns between the theorised data and the observed data, starting from within case analysis and leading to cross-case analysis. The next section reports the findings that came out of the content analysis of the first case study.

THE CASE STUDY

Case Study Description

The case study project comprised a supermarket store extension and refurbishment. The project was procured under Design & Build path. This was one of the series of projects that the client and the project team contracted, on a partnering arrangement. The project duration was 29 weeks and was valued at £ 7.0 million. A major change event was selected and fixed as the unit of analysis for the case study. The change event considered in the selected project was a 'change in the store flooring design'. The project team members who actively participated in this selected change problem-solving event were interviewed. Accordingly, the interview sample included the D&B Contractor, Architect, Client Agent and the Client. Interviews of 2-hour duration using semi-structured interview guidelines were carried out with each of these team members.

The original floor design of the store required a shut down of the store. However the client realised belatedly that they have not considered the loss of six weeks trading. Therefore the client wanted the D&B contractor to change the original design and consider other floor design options that will minimise the store closure. The floor options evaluation and decision-making went on for about 4 months at the initial stage of the construction works. The change was disruptive and created lot of uncertainty and re-programming.

There was a change order system in place to record and communicate change. The project team discussed the change problem mainly at the progress team meetings, which took place fortnightly. In addition, special meetings were held incorporating the specialist knowledge of the flooring sub-contractor. Other modes of communication were e-mails and telephone conversations. The D&B contractor has led this change event involving the client party, architect and the client agents. The team has prior working relationships, being on a partnering arrangement and this has led to good team working. The team was distributed nationally. However the distance barrier had not affected the team collaboration. The team composition was the same throughout the change.

Case Study Findings

One of the key observations of the empirical study was that team members rely heavily on their previous experience during problem solving. They recall their past experiences and build upon this knowledge and apply this tacit knowledge to the new situations, rather than referring the codified documents that contains past project lessons in the explicit forms. This was clearly evident in the D&B contractor's statement, "*you always have to relate old knowledge with the new condition, to come with a practical solution. We are dealing with an existing floor. So we did not collect various documents and develop the idea, rather used our experience and the existing knowledge to the practical situation*". This finding is consistent with the construction literature, for example Love & Li (1998) recognise that construction problem-solving significantly relies on experiential knowledge.

The second key finding is that the decisions, related to change problem-solving, are mostly considered at team progress meetings, along with e-mail and telephone communication in between these meetings. This finding is confirmed by the Architect's words "*Mostly at meetings issues were discussed in detail*" and the D&B contractor's words "*Decisions were made mainly in the design team meetings where all parties sign up for the final decision*". This reliance on face-to-face settings, despite distance barriers and the availability of virtual collaborative mechanisms, reaffirms that face-to-face settings are the key to team decision-making.

Third, the role of client is a key dependent variable in managing project change. In this change event the client's failure to notice the store closure in the first place caused this major change and secondly the client's lateness in making a decision on the change options further adversely impacted the project. The client representative himself admitted this when he stated that "*We were very slow in deciding, as always and we do so because we can't*". As Architect mentions "*The fact that they are multi-headed client makes the client decision-making process complex*". Thus, the client decision-making process needs to be explicitly established at the start of a project, as it has a major impact on the project change process.

Fourth, it was evident that the collaborative team approaches, in this case the design & build path and especially the partnering arrangement, have created good team working and a long learning curve between the parties. As the D&B contractor states, "*The long term working arrangements that had been developed over the years had allowed the client projects to operate independently"*. However, the D&B contractor further states "*Due to the long learning curve that the team had developed over the years, it is difficult to bring in new members to the projects and those who worked throughout tend to stay*". Thus, confirms Leonard's (1995) views on core capabilities that could lead to core rigidities.

Finally, in terms of knowledge conversion and creation, the formation of knowledge conversion cycle, through project changes, was found to be different to that of Nonaka

& Takeuchi's (1995). The tacit knowledge appears to transfer from socialisation to internalisation while not necessarily passing through the codification stages that involve externalisation and combination modes. Even the limited codification that takes place, such as change record forms and minutes of meetings, lack sufficient detail, to be of use in other similar contexts.

CONCLUSIONS

The key conclusion, which can be drawn from the interim case study investigating the role of knowledge during managing change in construction, is the existence of a process view of knowledge as opposed to an asset view. As Empson (2001) explains in the 'knowledge as an asset' viewpoint, knowledge is often viewed as an objectively definable commodity, which can be managed by mechanisms. For 'knowing as a process' viewers, knowledge is a social construct, developed, transmitted and maintained in social situations. The case study findings such as heavily reliance on tacit knowledge, face-to-face settings and ineffective knowledge codification and dissemination favour this process view of knowledge. However, this process view to knowledge, where knowledge pass from individuals involved through shared activities, limits the transfer and dissemination of knowledge to a wider group. Thus, team members lack the opportunity of learning from others lessons. Therefore, it is very important to create an appropriate balance between asset and process views of knowledge; and decide on the level of codification and dissemination that should be present against the cost of codification and the usability of that knowledge in similar contexts.

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