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Managing construction project change: a knowledge management perspective

SEPANI SENARATNE[1]* and MARTIN SEXTON[2]

[1] *Department of Building Economics, University of Moratuwa, Sri Lanka*
[2] *Research Institute for the Built and Human Environment, University of Salford, Salford, UK*

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In the information age, organization theories have addressed problem-solving as an information-processing activity. However, in this era, with the realization of knowledge-based views of the organization, shared problem-solving is increasingly recognized as a knowledge creation trigger. During shared problem-solving, stakeholders bring different types of knowledge into the problem situation and it is captured, created and shared by the team members. In construction projects, shared problem-solving often takes place through pragmatic problem-solving on site, in particular, through managing project changes. However, this significant role of knowledge in managing project change is not well appreciated in the extant literature. Accordingly, to explore how knowledge is created during project changes in construction a case study approach was adopted using two change events in two collaborative settings within the UK construction industry. The case study findings revealed that different forms of knowledge are created during the project change process within construction projects. However, this knowledge remains largely tacit and does not disseminate to the wider organization due to imbalanced codification and personalization strategies existing in such settings. A knowledge management perspective is introduced to manage project change so that construction project teams can successfully resolve and learn from change events.

Keywords: Shared problem-solving, managing project change, construction projects, knowledge management.

Introduction

In construction, problem-solving often takes place in a team environment (Anumba *et al.*, 2001). Recent studies have focused largely on information technology (IT)-enabled collaboration systems to support problem-solving in construction projects (for example, see Kamara *et al.*, 2000). However, with the complexity and messiness arising from construction project environments, the capability of these hard methods to capture soft issues and the applicability of these research studies in practice (Barrett and Barrett, 2003) are major concerns. In fact, several studies have identified that IT-enabled collaborative environments alone are insufficient for problem-solving (for example, see Lurey and Raisinghani, 2001; Ingirige, 2004). Li and Love (1998, p. 721) confirm this:

> current research in construction problem-solving has been focused heavily on developing decision aids, innovative techniques and methods for construction professionals to formulate and solve problems. There is very little research that has been done in understanding construction problem-solving as a cognitive process.

The importance of addressing soft issues in problem situations, which arise especially through construction project changes, is of significant importance (CIRIA, 2001). Project changes of whatever sort that were not expected by any team member involved generally become the basis of a problem within a project (Cornick and Mather, 1999). In fact, Egbu *et al.* (2003) and Tan *et al.* (2004) identify project changes as a key trigger of knowledge production in construction. Similarly, other studies have identified the importance of integrating project experience to the organizational business processes to induce innovation (for example, see Gann and Salter, 2000). However, specific project change literature has failed to deeply understand this

*Author for correspondence. E-mail: sepani@becon.mrt.ac.lk

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role of knowledge during the project change process. The growing knowledge-based views of the firm (Grant, 1996; Spender, 1996; Empson, 2001) open new avenues to approach this problem.

Evolution of knowledge-based views of the firm

Up to the 1980s organization theory was dominated by information-processing views, which are rooted in the works of Simon (1957) and followed by researchers such as Galbraith (1974). The assumption underpinning the information-processing perspective is that organizations should match their information-processing activities to their information needs (for example, see Daft and Lengal, 1986). However, empirical research has found that information-processing across organization boundaries presents significant barriers to effectiveness. Tushman (1978), for example, emphasizes that some project members often will not have appropriate knowledge within their group and they need to absorb knowledge from outside the group. This absorption of external knowledge presents a unique challenge in multi-organizational, multi-disciplined project-based environments, as successful project delivery requires the development and application of a wide range of specialist knowledge located in different actors, and different actors 'know' how his or her role fits with each actor 'knowing' their role. This cognitive dimension cannot be overcome by information-processing alone; rather it is the integration of disparate, actor-specific bodies of knowledge across the inter-organizational project context that is the primary task of organizations and determines their performance.

This limitation of the information-processing view has stimulated the development of an alternative theory of the firm (Spender and Grant, 1996) that has blossomed since the mid-1990s, which recognizes that the primary role of an organization should be the integration of knowledge: that is by generating new combinations of existing knowledge (Grant, 1996). Empson (2001) identifies two perspectives of knowledge: 'knowledge as an asset' and 'knowing as a process'. On the 'knowledge as an asset' perspective knowledge is often viewed as an objectively definable commodity, which can be managed and controlled by certain mechanisms. For 'knowing as a process' viewers, knowledge is a social construct, developed, transmitted and maintained in social situations. Dixon (2000, p. 159) provides interesting metaphors to explain these two perspectives of knowledge,

> if the warehouse is a metaphor for the stable view of knowledge, then a metaphor for dynamic view of knowledge may be water flowing across … The warehouse image has about it a feeling of control … the flowing water image seems less controllable, but also powerful.

Snowden (2002) argues that knowledge can be seen paradoxically, as both a 'thing' and a 'flow' requiring diverse management approaches. To Hansen *et al.* (1999) these diverse management approaches are either codification or personalized strategies. When knowledge is seen as a 'thing', codification strategies, which especially disseminate explicit knowledge through person-to-document approaches, are considered. When knowledge is seen as a 'flow', personalized strategies, which especially disseminate tacit knowledge through person-to-person approaches, are considered.

In construction projects, where pragmatic problem-solving on site is a common occurrence, these knowledge-based perspectives have not yet been fully realized. In the construction context, 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 and Barrett, 2003). However, the extant construction literature is arguably limited in providing an in-depth understanding bringing in knowledge management perspectives to the project change process.

Project change process: knowledge management perspective

In construction projects, when project teams manage change situations, knowledge plays a key role. When various project team members bring their tacit and explicit knowledge to such a situation, this knowledge can be converted to form new knowledge through various interactions, as explained by Nonaka and Takeuchi (1995) in their knowledge conversion theory.

Nonaka and Takeuchi (1995) argue that during shared activities, four modes of knowledge conversion can take place by the exchange of tacit and explicit knowledge leading to a spiral effect of knowledge creation. They are named as socialization, externalization, combination and internalization modes (see Figure 1). The socialization mode emerges from tacit to tacit conversion. In this mode, tacit knowledge is shared directly between individuals in joint activities through observation, imitation and practice. Knowledge conversion from tacit to explicit is described by the externalization mode. This takes place

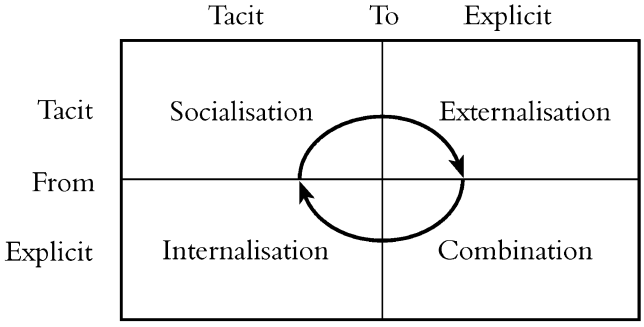

Figure 1 Knowledge conversion modes (Nonaka and Takeuchi, 1995, p. 62)

in a team environment through techniques such as metaphors, analogies and models. Combination mode emerges from explicit to explicit knowledge conversion. In this mode, different bodies of explicit knowledge are combined and documented through meetings, conversations and networks. The knowledge conversion from explicit to tacit knowledge is described by the internalization mode. This happens when individuals re-experience others' experiences that is available in explicit forms.

Different viewpoints exist in literature regarding the importance placed by Nonaka and Takeuchi (1995) on the externalization stage. They necessarily take an asset view of knowledge, by emphasizing that the key to knowledge creation lies in the conversion of tacit knowledge to explicit forms. Supporting Nonaka and Takeuchi's (1995) argument, Davenport and Prusak (1998) state that, difficult as it is to codify tacit knowledge, its substantial value makes it worth the effort. Having access to tacit knowledge is insufficient, as when the person who possesses such knowledge leaves, the firm will lose its knowledge capital. Therefore, making tacit knowledge explicit is important. The opposing argument is that the codification of the rich (highly personalized) tacit knowledge is almost an impossible task. In the event of codifying rich tacit knowledge there will be a knowledge loss. Taking Polanyi's (1966) views, Leonard and Sensiper (1998) explain that some knowledge will always remain tacit due to reasons such as lack of motivation; lack of benefit in converting tacit to explicit; the unconsciousness of tacit knowing; and/or the difficulty in externalization. Balancing the different viewpoints, some authors believe that a selective tacit codification process should exist, in order to share tacit knowledge across time, space and disciplines (for example, see McDermott, 1999).

Other process-viewers of knowledge emphasize the socialization stage rather than the externalization stage. According to them, the key to knowledge creation lies in focusing on informal communities of practice. For example, Snowden (2002) while criticizing Nonaka's knowledge conversion cycle argues that tacit knowledge need not necessarily go through a costly codification process to create new knowledge. Rather, knowledge can be created through a natural flow in informal communities and he has proposed a different model of knowledge creation incorporating this natural flow. However, studying various knowledge creation models, Grant and Grant (2008, p. 577) establish that,

> the importance of Nonaka's work is evidenced by its dominance as, by far, the most referenced material in the KM field and by the number of practitioner projects implementing elements of the model. Further, while a variety of other knowledge classification systems have been proposed, variations on Nonaka's interpretation of Polanyi's original tacit/explicit knowledge concept dominate in the literature—both academic and practitioner.

The extant knowledge-based construction literature suggests that construction is biased towards a process view of knowledge rather than an asset view. For example, Bresnen *et al.* (2003, p. 165) reveal that

> processes of knowledge capture, transfer and learning in project settings rely very heavily upon social patterns, practices and processes in ways which emphasise the value and importance of adopting a community-based approach to managing knowledge.

According to Gann and Salter (2000), tacit knowledge is extremely important within the construction environment. For example, they state that

> although many project-based activities are increasingly organised using IT systems, there is still a need for personal contact. Tacit knowledge of individuals is essential to problem-solving in projects … It involves the individuals in the life of the project (Gann and Salter, 1998, p. 441).

Therefore, learning is centred on individuals within construction projects (Dubois and Gadde, 2002).

Thus, in order to reflect process-based views that exist in construction, this research modifies Nonaka and Takeuchi's (1995) knowledge conversion model while capturing Snowden's (2002) ideas on natural flow of knowledge (see Figure 2). Figure 2 represents a process-based view of knowledge creation that could take place in a construction project setting, in that knowledge mainly flows between socialization and internalization modes (see solid line) while occasionally passing through externalization to combination modes (see broken line).

This research aims to investigate this knowledge creation process during managing project change situations in a construction setting. The next section will describe the research method adopted.

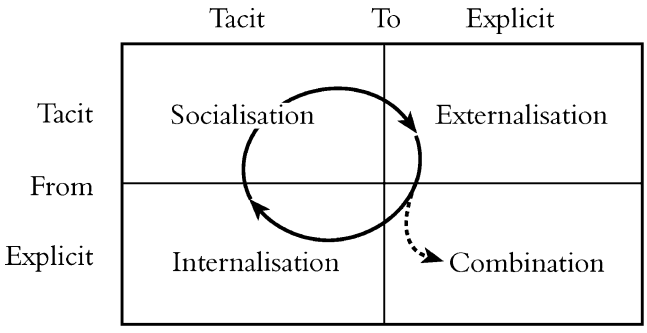

Figure 2 Process-based view of knowledge creation

Research method

This research was identified as being located within the phenomenological paradigm as it deals with a complex phenomenon that is very much context-specific. According to Yin (1994, p. 1), 'case studies are the preferred strategy when "how" or "why" questions are being posed, when the investigator has little control over events and when the focus is on contemporary phenomenon within real-life context.' Thus, a case study research approach was chosen considering its appropriateness in studying such a social setting.

The main unit of analysis in this study was the change event. The study fixed the issue (change event) and the active stakeholders around this issue were interviewed to identify key variables and their interactions with respect to the change event at project team and organizational levels. The interview guidelines, which comprised 60 detailed questions, were designed to capture details with regard to each knowledge conversion stage through the selected change to the higher project team and organization levels.

In the sample selection, the degree to which the case study firms engaged in collaborative arrangements such as partnering and design and build was first considered. Subsequently, active project team members such as contractor, architect, engineer, quantity surveyor and client, around a change event were considered. Change events were selected solely on the basis of project participants' perception of the degree of impact on the construction phase (be it time, quality or cost impacts) which is consistent with the phenomenological paradigm. Accordingly, the study selected two 'change events' within two construction 'project organizations' with the aim of predicting similar results (see Table 1 for the case study details).

The main research technique selected for data collection in this study was in-depth semi-structured interviews and data were analysed using both content analysis and cognitive mapping techniques. The next section offers key case study findings in relation to knowledge conversion stages.

Key case study findings

Socialization stage

Both case studies indicated that construction team members significantly relied on socialization activities when managing change events. Generally, project changes were discussed at formal progress meetings and specific issues relating to these changes were discussed at separate meetings. For example, in Project A, the architect said, 'mostly at meetings the issues were discussed in detail' and the D&B contractor said, 'decisions were made mainly in these meetings'. In addition, informal discussions such as visiting other members' offices and the project site to discuss issues were evident. Even though between these meetings team members used other communication mediums such as telephones, e-mails and faxes, they preferred face-to-face meetings. The geographical distance

Table 1 Case study details

Project type	Project details	Change case details
A supermarket store extension and refurbishment	The project used a design & build (D&B) procurement path. This was one of a 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 million.	A 'change in the store flooring design'. The original floor design of the store required a shut down of the store. However, the client realized belatedly that it had 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.
A secondary school building	The project used a design & build (D&B) procurement path. The project duration was 15 months and was valued at £8.25 million.	The change events considered were 'change of height in whiteboards'. In the whiteboard change case, the whiteboards in the classrooms were already fixed to the walls by the contractors, when the client party noticed that they were too high for teachers to reach.

between the team members did not seem to have any effect as in these projects the key members were located close enough to meet face to face. Sometimes special meetings were arranged on regular meetings dates so that the travelling time of the members was minimized.

During these face-to-face settings the team members had the opportunity to observe and learn from other team members who were experts in different disciplines. For example, one D&B contractor of Project A mentioned 'hierarchical learning is limited [compared to horizontal learning] as there tends to be similar level people involved'. In addition, in a few situations, seniors accompanied juniors during the problem-solving stage of change processes, giving an opportunity for vertical learning. They also learned from their colleagues who were seated closely to them in their offices and who happened to work on similar types of projects. For example, the D&B contractor of Project B described, '[we met] just going to the next office and sitting down for a cup of coffee. That goes sometimes for three hours or a whole day … It is the best way to do it really.' Hence, seating arrangements within offices had an influence over how members shared their project experiences. There existed other forms of gaining tacit knowledge during change situations; for example, when members visited similar sites and participated in social events.

Externalization stage

The team members showed evidence of externalizing their tacit knowledge in different ways at discussions. According to both case study projects, the most preferable technique was to visualize thoughts through pictures, diagrams or sketches. In addition, project team members, where appropriate, used examples from previous projects. As the D&B contractor of Project A stated, 'there are kind of brainstorming sessions or open meetings that encourage people to come with better solutions.' During discussions the team members generally listened and encouraged each other to express their views. When their thoughts were not clear they were requested to be more specific, repeat or explain further through a diagram.

However, the interviewees mentioned that the use of different techniques is dependent on individual members and their specific roles. For example, architects prefer visualization of their ideas through drawings, which is reflective of their functional role. The quantity surveyors prefer to use language to express ideas whereas the contractors prefer to use examples from previous projects that they have built. Another finding is that how members externalize thoughts depends on the nature of the issues. For example, if the issue has financial implications the externalization stage can suffer as each member tends to be careful when they express ideas.

Combination stage

The externalized ideas and thoughts at discussions do not seem to be effectively codified when managing change processes. Interviewees of both case study projects viewed minutes of meetings as the main record of change processes. However, rather than recording the total change process, the information contained in the minutes was limited to agreed change decisions. One D&B contractor confirmed this point:

> meeting minutes are a way of bringing things that we discussed together. But a drawback is the discussions are not reported in detail at these minutes. We talk for about 40 minutes and include in the minutes what we agreed at last and not the pathway of reaching that decision.

Construction project teams, also, exchange change record forms which provide instructions with details of the finally agreed change option. According to evidence from the case study projects, these forms were not always properly maintained and they contained limited information about the total change process. Another form of change record was revised drawings or as-built drawings. These again provided details of the final change option rather than a detailed account of the change process. Sometimes records of project changes were found in letter correspondence and progress reports, in an ad hoc form. Furthermore, none of the case study projects showed evidence of a project review report that put together lessons learnt.

Internalization stage

In terms of internalizing knowledge created during change, both projects revealed that team members increased their tacit knowledge base by going through the change experience. This learning process was subconscious and difficult to realize. Despite this difficulty, team members were able to identify specific things that they learnt. Accordingly, project teams generally learned technical issues, causes of change, solutions for change and more importantly how to deal with people during the process. The team members built upon their mistakes and became more understanding of change situations. For example an architect professed, 'in addition to learning how to deal with the new technical issues we have become more flexible and understanding of change'. This enabled them to effectively deal with future changes and more importantly to successfully manage a future situation.

However, the data suggested that this internalization process was limited to this immediate learning and was not further strengthened through reflection and experimentation. While managing change they sometimes got opportunities to do quality tests, samples and consider novel solutions if requested by their clients. These limited opportunities were insufficient for deep internalization. Project teams had limited opportunity to carry out experiments not only during change experience but also afterwards due to the time pressure. Project team members moved to the next project immediately after a project and sometimes they worked in parallel projects which gave them very little time to reflect.

According to the case study data, knowledge created through change events mainly remains in the heads of the project participants, and is passed to parallel and future projects through them. The client agent of Project A elaborated on this:

> what seems to happen in projects is there's always a particular problem and the individuals involved go through the experience and learn best solution for the given problem. But this does not pass to other members. This same flooring problem may be experienced at the same time by a colleague, without my knowledge … This is the problem. Unfortunately, it is only the individuals involved who carry this knowledge in their heads.

The architect of Project B confirmed this point, 'you retain that knowledge [change experience] on a personal level and use that in future projects'.

The next section builds on these literature and case study findings to offer theoretical implications of this research.

Knowledge-based project change process: theoretical implications

General knowledge creation models (see Figures 1 and 2) do not fully represent the knowledge flows during a project change process. They do not represent that knowledge creation occurs when members of a project team make social interactions to solve a change event problem which is triggered by a technical issue. Further, they do not capture project-based settings and do not show how new knowledge created during a change event is fed forward to future projects through multiple organizational settings. Through the closer view gained through the findings, this research offers a new model (see Figure 3) to represent the prevalent knowledge flows during a project change process.

In Figure 3, the technical system denotes the practical, procedural and technological aspects in a

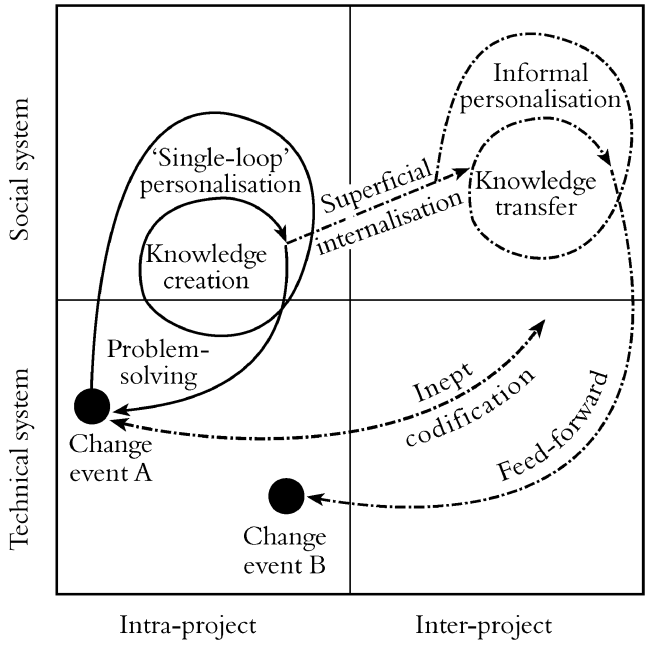

Figure 3 Prevalent project change process

construction setting. The social system denotes the networks of project participants. To represent the project-based nature, two levels are considered in this model: intra-project and inter-project. Intra-project indicates the activities within a project and inter-project indicates activities at the multiple organization level. The terms 'personalization' and 'codification' are drawn from Hansen *et al.* (1999), to explain knowledge dissemination via person-to-person and person-to-document respectively. Two levels of personalization are described in the model, by adopting the 'single-loop' and 'double-loop' concepts of Argyris and Schon (1978). Nonaka and Takuechi's (1995) term 'internalization' is used to describe the experiential learning process.

The research findings revealed that a project change is often triggered by a technical issue. Hence, Change event A (which represents a project change) is located within the technical system in the intra-project level. The research results indicated that knowledge is shared and created when project team members interact, to solve the change problem. Thus, this knowledge creation process takes place in the intra-project social system. The term 'single-loop' personalization is introduced here to explain the knowledge dissemination that occurs immediately between project team members when they *solve* the change problem in the technical system. Most of the knowledge created remains within the heads of individual project participants. This internalization process is described in the model as 'superficial'. This is due to the fact that the new knowledge created through the

change experience is simply absorbed by the team members and not subjected to deep reflection and experimentation afterwards.

The results indicated that these project team members transfer this internalized knowledge to other individuals when they make informal interactions, at the multiple organization level. This knowledge transfer process is, therefore, located within the social system in the inter-project level and referred to as 'informal personalization'. As the research findings revealed, the project documentation that codified the change event generally included details of the final change decisions, but not the details of the whole change experience. Therefore, this codification is depicted in the model as arising from the change event and passing to the technical system in the inter-project level. This codification does not properly reach the knowledge transfer that happens in the social system. Thus, this is referred to as 'inept codification' in the model. Through the informal personalization strategies that occur in the social system at the inter-project level, knowledge is fed forward to future change events (Change event B in the model). The model shows that more emphasis is currently placed on the intra-project technical system.

Three limitations in the prevalent project change process are identified to prescribe a knowledge-based approach to effective project change management. First, the 'superficial internalization' needs to be followed by deep reflection and experimentation. Second, 'informal personalization' at the inter-project level needs to be recognized and strengthened to create an effective personalization for wider knowledge dissemination. Third, an appropriate codification that codifies newly created knowledge (such as solutions, lessons learnt), and is transmitted to the social system at inter-project level, should take place. With these implications, Figure 4 represents the 'knowledge-based project change process'.

Figure 4 introduces 'deep internalization' as opposed to 'superficial internalization'; 'double-loop personalization' compared to 'informal personalization'; and, 'apt codification' instead of 'inept codification' for effective project change management. For 'deep internalization', team members need to deeply reflect on their change experience and carry out further experiments where possible. For this to happen, team members need to be given sufficient time and resources, by project clients and top management of individual organizations. To enhance personalization, the management at multiple organization levels need to recognize and strengthen social networks and face-to-face settings. To achieve 'apt codification', knowledge created during project change processes needs to be codified and

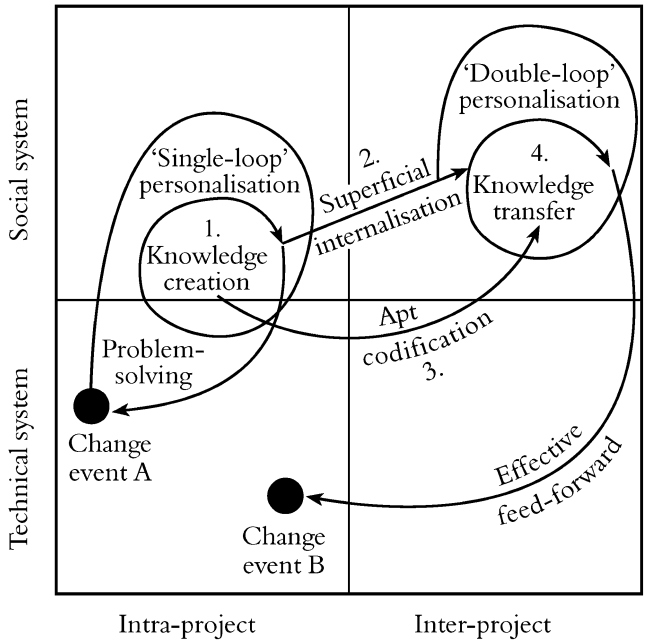

Figure 4 Knowledge-based project change process

transmitted to the social system where knowledge dissemination takes place through personalization. The 'deep internalization', 'apt codification' and strengthened social networks will create the 'double-loop' personalization. This will, in turn, help to effectively feed forward knowledge created from past change events to future events and, thereby, achieve effective project change management. Hence, the key to a knowledge-based project change process lies in shifting the emphasis from the intra-project technical system and placing the emphasis on the inter-project social system.

Conclusions

The existing project-based literature was limited in identifying the important role that knowledge plays during problem-solving activities connected to change events. This gap was identified and filled by providing a richer and deeper understanding of a knowledge management perspective of project change situations.

The study specifically focused on the project change process in a construction project setting. The overall findings indicate that the knowledge flows during project change are very much centred on tacit knowledge and experience of project personnel. This social construction and use of knowledge in change management challenges the prevailing codification of knowledge management solutions based on 'hard' IT approaches, which do not appreciate and accommodate this social phenomenon. Thus, it is argued in this study

that there is a need to balance codification knowledge management strategies with 'soft' personalization strategies to stimulate and support appropriate social interaction between team members and, thereby, enhance the creation, dissemination and shared understanding of tacit project experience. It is through the balance of 'appropriate codification' and 'enhanced personalization' strategies that collaborative project teams can successfully resolve and learn from change events.

Through this deeper understanding, the research provided contributions to theory to enable a knowledge-based project change process. The concepts of intra-project knowledge creation, deep internalization, apt codification and double-loop personalization will enable project teams, top management and project clients to effectively manage change and learn from change events.

The results and conclusions reported here are drawn from a particular case study sample, in construction project settings. Generalizability of these results to other project-based settings should be treated with due caution. Further research is encouraged to develop (or contest) the degree to which these results can be generalized across a variety of different project-based settings.

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