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Tacit Knowledge Capture in Thai Design and Consulting Firms

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Abstract: Tacit knowledge in the construction industry is essential in the development and innovation of the operation. It also helps improve the built environment in the communities. The purpose of this research was to develop an effective process to capture tacit knowledge gained from project operations. To understand the complex processes happening within the firms in the Thai construction industry, an action research approach was adopted. Two well-established design and consulting firms participated in the study. After two iterations of action research, the four-stage process of tacit knowledge capture was proposed: (1) develop the firm's strategic knowledge containers, (2) reflect on past project experiences, (3) identify project learning and new knowledge and (4) validate and test new knowledge. It was emphasised that a firm should put significant effort in identifying the strategic knowledge and capabilities required in order to establish the knowledge containers which were clearly understood by all staff. Once the new knowledge had been tested, validated and accumulated in the knowledge containers, it would change the operations in the subsequent projects. The process should be conducted at the end of the project to allow sufficient time required for reflection of knowledge attained during the project operation.

Keywords: Knowledge capture, Tacit knowledge, Project knowledge, Action research, Consulting firms, Construction industry

INTRODUCTION

The construction industry is a project-based industry utilising a variety of professional and specialised services from different organisations. The complex nature of construction projects together with the increasing demand of value for money, speed of delivery and emphasis on environmental concerns of clients and regulators force the industry to become more efficient and innovative in delivering the project. Therefore, the ability of the organisations to manage their knowledge is critical to the success of the construction industry. Two forms of knowledge commonly referred to are tacit knowledge and explicit knowledge. Tacit knowledge is the knowledge which cannot or is not explicated such as skills and know-how (Addis, 2016), unlike explicit knowledge which can be codified in the forms of text such as books or manuals. Collins (2010) has contended that explicit knowledge is not valuable without associated tacit knowledge. Therefore, the two types of knowledge are significant and are complementary. However, many studies have found that most of the valuable knowledge deployed in the construction industry is experienced-based and tacit by nature (Rezgui, 2001; Sheehan et al., 2005; Chen and Mohamed, 2010). This experience-based knowledge of professionals in the industry is often

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created, exchanged and shared during problem-solving of complex projects. However, heavy reliance on a substantial amount of tacit knowledge accumulated by individuals makes organisations vulnerable. People-based approaches alone cannot mitigate the risk of losing tacit knowledge embedded in the staff, nor can they cope with a firm's continual development.

The organisational performance is positively affected by knowledge management especially the tacit dimension (Muthuveloo, Shanmugam and Teoh, 2017). However, barriers impeding effective knowledge management, particularly in the construction industry, have discouraged the development of such a process. The major barrier that inhibits effective knowledge capture in the construction industry found in the United States, United Kingdom and China is a time-pressure environment (Egbu, 2006; Hari, Egbu and Kumar, 2005). Due to the unique requirements of each project together with the lack of standard work processes, key personnel usually spend most of their time solving immediate problems arising on-site. There is no time to stop and reflect on their decisions and operations. Another significant barrier is the lack of trust to share knowledge among participants for fear of losing value to the firm (Carrillo and Chinowsky, 2006; Senaratne and Sexton, 2009). Hari, Egbu and Kumar (2005) and Newell et al. (2006) also identified the lack of awareness of the benefits of capturing and transforming tacit knowledge into explicit knowledge as part of the barrier.

Studies have pointed out the necessity of providing a linkage between project and organisation in managing knowledge of the project-based organisation and models have been proposed (Gann and Salter, 2000; Eriksson, 2013). In the construction industry, valuable experience and important lessons learned are developed at project-level but there is no mechanism to capture this project learning and embed it in the organisation for future uses. The lack of a mechanism to capture this valuable knowledge and experience often leads to repeated mistakes which are costly and sometimes to the detriment of the project. For example, one designer may learn from the roof failure from his past project that in designing cantilever rooftop with the top of the rim beam higher than the roof slab, he must consider the issue of water confined on the roof slab if the roof drain is blocked. The minimum reinforcement required by the design code is not sufficient to carry the load of the water retained on the slab, the reinforcement needs to be doubled in this particular roof design. If this experience is not transferred to others, this mistake can lead to casualties of the passersby. Lack of clear understanding and process to capture and reuse tacit knowledge in the industry has forced the industry to continue to manage knowledge through people-based strategies and an informal network of relationships (Egbu, Hari and Renukappa, 2005; Kamara, Augenbroe and Carrillo, 2002).

The Thai government has continually boosted the Thai economy through large infrastructure project investments such as the Eastern Economic Corridor (EEC), dual-track railway, Phase II Suvarnabhumi International Airport, as well as the ongoing urban mass rapid transit system in Bangkok. These projects require high technological capabilities, resources, knowledge and skills from international engineering and construction firms. The ability of Thai consultant engineers, architects and contractors to develop required knowledge and capabilities from these upcoming opportunities is critical in the emerging market in the region. The objective of this study is to explore the current practice of knowledge management and propose an effective means to capture tacit knowledge gained from project learning and embed it in the organisational knowledge. Since the practice of

knowledge management is currently conducted informally through complex interactions of firm's staffs through work routines and various business processes, action research strategy is selected to investigate the issues in selected firms. Although action research requires strong collaboration from the firm understudy, it can increase understanding of such complex processes happening in the firm and allow the theory to be applied simultaneously in order to improve the practice (Azhar, Ahmed and Sein, 2010). The target groups of this study were the design and consulting firms, as they were knowledge-intensive in nature and because they were more willing to collaborate in this issue than did the contractors.

Knowledge Management in the Organisation

The knowledge-creating process (SECI) model proposed by Nonaka and Takeuchi (1995: 62–73) is a continual process involving four steps: socialisation, externalisation, combination and internalisation. According to Nonaka and Takeuchi, knowledge is process-related and can only be created in the actual practice in which individuals share and create tacit knowledge through direct experience of work. Then, they have to externalise their tacit knowledge into an explicit form through dialogue and reflection. This can be achieved by reviewing one's tacit knowledge by standing back from the task and review what has been done and experienced (Kolb, 1984). This reflection is significant in experiential learning. It helps to prevent the staff from repeating the same mistake (Schon, 1983). The third step, combination, is to gather and systematise the shared explicit knowledge. Then, the knowledge is internalised once more by a larger number of individuals through action and reflection during the application of this new knowledge in their practice. And the new, richer, subjective knowledge internalised into individuals will become the basis for starting another cycle of knowledge creation. The enablers of the SECI process consist of knowledge vision, driving objectives, dialogue and practice, *Ba* (space and time), knowledge assets and environment (Nonaka, Toyama and Hirata, 2008: 26–47).

Snowden (2002) has suggested that knowledge management has moved from the first generation of focusing on information technology, to the second generation of emphasising on the conversion of tacit knowledge to explicit knowledge led by Nonaka and now to the third generation which expands beyond content to the context surrounding the organisational knowledge management. Grant and Grant (2008) has compared models proposed by various researchers and found that McElroy's model fits most with the third generation knowledge management. McElroy's model has made a clear distinction between knowledge management and knowledge processing. Knowledge management is a management discipline that seeks to have an impact on knowledge processing. From the Knowledge Life Cycle (KLC) developed by the Knowledge Management Consortium International in 2008, knowledge processing consists of two major processes: knowledge production and knowledge integration. Individual and group learning, including problem-solving, site meetings or community of practice, is considered to be part of knowledge production which results in knowledge claim, the knowledge that has not been validated or tested. Whereas knowledge integration refers to activities like sharing, broadcasting, searching or disseminate the knowledge produced by groups and individuals. After the knowledge claim has been circulated among staff and validated, it is then is stored in an organisational knowledge container. Then the knowledge will be implemented into a regular business process and its feedback will be the

input to a new cycle of knowledge production. Figure 1 shows the concept of KLC superimposed with Nonaka and Takeuchi's knowledge creation process to exemplify the concordance of these two models.

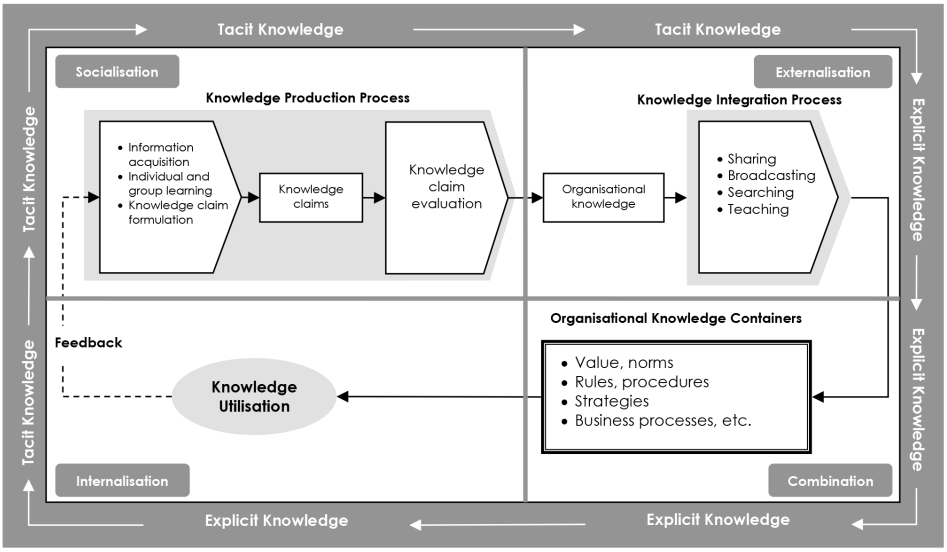

Figure 1. The Concordance of Nonaka and Takeuchi's Knowledge Creation Process and the Knowledge Management Consortium International's KLC

KLC indicates that organisational knowledge should be clearly expressed and documented in a knowledge container in explicit form, which can be organisational value, norm, set of rules, procedures as well as business processes. Once the organisation clearly understands the knowledge they possess, then the double-loop learning which is the concept developed earlier by Argyris and Schon (1978) can continue to revisit these knowledge containers as they progress on their spiral learning.

Knowledge Capturing Tools in Construction Industry

Many studies have proposed methods to share and capture valuable tacit knowledge such as debriefing process by Schindler and Eppler (2003), which is a post-project review to document the lessons learned. They suggested that debriefing should be regularly captured with an external moderator and enforced by integrating learning and knowledge goals into project goals. Boyd et al. (2004) have proposed a quite simple form of gathering information of problem-solving events on-site for a monthly debriefing session by using an audio diary. There were 55 debriefing sessions held during the six months of the study. The quality of the audio diary became better after the engineers saw the value of the knowledge gained from the debriefing session.

Lately, more tools utilising information technology are developed to facilitate knowledge management while capturing the tacit knowledge at the same time,

including dynamic knowledge map by Woo et al. (2004), activity-based knowledge management system by Tserng and Lin (2004) and practice-based knowledge management system by Lin and Lee (2012). Eken et al. (2015) presents a lessons learned database which is divided into simple subject areas such as delay, claim, dispute, cost change, budget change, construction technology, construction experience and so on. Collaborative model to manage design changes aimed to capture and reuse the past lessons learned and add value to the future project is proposed by Yap, Abdul-Rahman and Chen (2017). At the same time, a collaborative system designed to facilitate knowledge capture, retrieval and reuse are proposed and demonstrated through a case study (Peng et al., 2017). However, these systems require the engineers to edit their experience and knowledge, which they are often too busy to do so. The use of Building Information Modelling (BIM) as a visual knowledge management platform to help project participants share and reuse tacit and explicit knowledge is proposed and tested in Taiwan by Lin (2014). BIM-Knowledge framework aimed to integrate knowledge capture and reuse along the knowledge management life cycle is also proposed by Abiodun and Egbu (2018). The information technology system aims to enhance the socialisation and connect the experts while capturing all the discussion more efficiently. But without developing the organisational knowledge containers as shown in Figure 1, the discussion captured are not systematically reviewed and combined. The results can hardly be reused in the following project.

RESEARCH APPROACH

The study requires collaboration between a firm's staff and research team to construct the current knowledge management process, as well as to investigate its efficiency and its effectiveness through direct observation of the firm. The action research approach deemed an appropriate method used to improve current practice while increasing theoretical understanding, is employed (Kemmis and McTaggart, 1988; Coghlan and Brannick, 2001; Ragsdell, 2009). The process consists of five phases: (1) diagnosing, (2) action planning, (3) action taking, (4) evaluating and (5) specifying learning (Susman, 1983; Baskerville, 1997; Azhar, Ahmed and Sein, 2010). The five-stage process is repeated for as much iteration as required to achieve the research objectives.

Action research is a research strategy that requires rigorous participation from the organisation and its employees. However, most firms in the Thai construction industry do not give importance to organisational learning, continuous development or innovation (Wethyavivorn, Chareonngam and Teerajetgul, 2009). Therefore, the two leading Thai engineering consulting firms with details shown in Table 1 were selected for this study due to their willingness to collaborate in the study. Before entering the firms, the study process was explained and the existing knowledge management practices were reviewed. It was found that both firms had conducted lessons learned reports for most projects to merely fulfil the International Organization for Standardization (ISO) or client's requirement. For the most part, it was just the excerpt from the final report to the client which was about the cost and time increase without any detailed reasons or actual lesson learned in the report.

Due to the time and disruption involved during the research investigation, it was decided to begin the first iteration in one consulting firm to clearly understand the current practice of knowledge management and identify problems. Then in the

second iteration, would be applied the process developed from learning gathered in the first iteration to the other firm.

Table 1. Two Leading Thai Construction Firms which were Preliminary Investigated to Identify Current Practices of Knowledge Capture

Firm	Type of Service	Age (Years)	Characteristics of the Project Involved
A	Project management consulting	27	Stadiums, concert halls, high-rise buildings, hotels and resorts
B	Structural design and construction management consulting	32	High-rise commercial and residential buildings, manufacturing facilities

RESULTS

The details of two iterations of action research to identify the effective tacit knowledge capturing process in consulting firms in the construction industry are summarised in Table 2.

Table 2. Two Iterations of Action Research to Achieve Effective Knowledge Capturing Process

	First Iteration	Second Iteration
Problem Diagnosing	Lessons learned reports are found to record only problems and the solutions taken. Tacit knowledge is not captured and reused effectively in the Thai construction industry.	The learning specified from the first iteration. Individuals need time to reflect on their experiences to identify the lessons learned. Knowledge containers must be established first.
Action Planning	H1: Tacit knowledge is exchanged, transferred and can be effectively captured during project meetings.	H2: Tacit knowledge can be captured effectively in a meeting with the prime objective to identify the learning that is valuable to the firm and among a project team who trust each other.
Action Taking	Observe the project weekly site meeting for three months.	Conduct focus group session among the project team. Conduct a focus group session with experts who are not involved directly with the project. Confirm learning captured with the firm's executives and suggest changes in knowledge containers.

(*continued on next page*)

Table 2. (*continued*)

	First Iteration	Second Iteration
Evaluating	Problems are often solved outside the meeting. Only information is exchanged during the meeting.	During the first focus group, the project team feels negatively towards the owners and the fast-track project. During the second focus group, analysis of the problems is more systematic and theoretical.
Specify Learning	Actual tacit knowledge exchange is happening outside weekly meetings, only solutions are given. The objective of site meetings is solely to control the time, cost and quality of the project not to identify learning. Lack of trust among participants from various organisations in site meeting.	Effective tacit knowledge capturing process consists of four stages. Organisational knowledge containers must be established and known to all staff.

First Iteration

Step 1: Problem diagnosis

A preliminary investigation was undertaken to investigate how organisations in the Thai construction industry currently manage their knowledge. It was found that both firms had conducted lessons-learned sessions after each project's completion. Most of the problems found in the lessons-learned reports had similar nature. They recorded the problems and solutions without comparison with other possible alternatives and the rationale leading to the solution implemented. Therefore, the lessons could not easily be applied to future projects when conditions differed or when technological development provided a more innovative alternative. The user could not compare prospective alternatives since the justification had not been explicitly articulated in the report. Therefore, the value of knowledge provides by these reports was quite limited. However, the tacit knowledge gained was still embedded among the project participants. They normally used their network to discover knowledge and experience to solve problems directly from the key personnel through personal contacts.

Step 2: Action planning

In the construction industry, the knowledge and experience of experts are often exchanged and transferred through face-to-face project meetings (Koskinen, Pihlanto and Vanharanta, 2003; Fong and Lo, 2005; Teerajetgul and Chareonngam, 2008). The results of the case studies together with previous studies lead to the establishment of the initial action hypothesis thus:

H1: Tacit knowledge is exchanged, transferred and can be effectively captured during project meetings.

In the hypothesis, the project appropriate for the study should not be too long but should have enough complexity so that the knowledge and experience of key personnel will be shared to solve issues during the site meetings. Firm A's refurbishment project, which had just started and would end in six months was selected for the study.

Step 3: Action taking

The project selected for the study was the refurbishment of a 5,000 sq. m basketball gymnasium into a 10,000 sq. m lecture hall at a university in the vicinity of Bangkok. The project duration was 210 days, starting from November 2009 and scheduled to be completed in May 2010. The project site meeting was conducted every Thursday from 10:00 a.m. to 12:00 p.m. The participants included the owner's representatives, designers, a construction management team and contractors. The research team accompanied the project manager from Firm A to observe the project site meeting. All project participants allowed all meetings to be voice-recorded for further transcription and analysis.

Step 4: Evaluating

Only data and information was exchanged during the meeting. The objective of the site meeting was to control the time, cost and quality of the project which was the traditional purpose of project site meetings. Since the contract was a lump sum, the cost was fixed. Therefore, project participants spent most of their time discussing problems that posed a risk of delays such as a lack of as-built drawings, differing site conditions or change of a major subcontractor. Most of the time, the decision was made by higher up or more experienced participants outside the meeting. So the meeting was used only to announce the decisions formally and to further identified arising obstacles that could prevent contractors to complete their contract on time.

Step 5: Specifying learning

Tacit knowledge could not be captured during site meetings due to three major factors. First, the actual tacit knowledge exchange and the transfer took place outside the weekly site meeting. This could be due to the fact that the project was small. The participants attending the meeting were limited in numbers and authority. Thus, the decision was often deliberated and made outside of the meeting among authorised personnel. Second, the objective of the site meeting was to control time, cost and quality not to identify learning, especially when there is no established structure of knowledge required to develop identified by the firm. And third, participants representing various firms in the meeting might not have the trust and respect in relationships identified in Brookes et al. (2006) as necessary elements for effective knowledge and experience sharing.

Second Iteration

Step 1: Problem diagnosis

According to the learning specified in the first iteration, it was found that knowledge should be captured through a special session dedicated to identifying project learning among the project teams that had been working together for a long time and had a high degree of trust in each other. We also observed that individuals in the project team needed time to reflect on tacit knowledge gained. This was also found in previous studies (Egbu, 2006; Senaratne and Sexton, 2009). The session should not be conducted too often, but at major milestones (Schindler and Eppler, 2003). Moreover, the knowledge containers suggested by McElroy (2003) was necessary to provide a structure of knowledge as a starting point. It made the project team more focused on harvesting the learning and experiences related to the firm's strategic knowledge and capabilities.

Firm B did not have any containers clearly written except the design codes, technical specifications and project management manual. Interviews with executives regarding the firm's existing operations, target market and future expansion plan to identify the competencies and knowledge required to be competitive in existing and future markets were conducted to establish a loose structure of the firm's knowledge containers as shown in Figure 2.

Firm's B approximately USD100 million brewery facility project, which had just finished a month prior to our study had been chosen, so the memories of the project team were still fresh. The brewery facility project consisted of 78,260 sq. m of a reinforced concrete structure with steel roof. The fast-track construction with overlapping design and construction phases was chosen for the procurement of the facility. The brewing equipment was all designed and furnished by a German manufacturer without a permanent office in Thailand. The project duration was 18 months and completed on time, but the cost increased to USD165 million due to changes in design and construction. Firm B provided structural design as well as construction management services for the project.

Step 2: Action planning

The action hypothesis for the second iteration of the study was reiterated as follows:

H2: Tacit knowledge can be captured effectively in a meeting with the prime objective to identify the learning that is valuable to the firm and among project team members who trust each other.

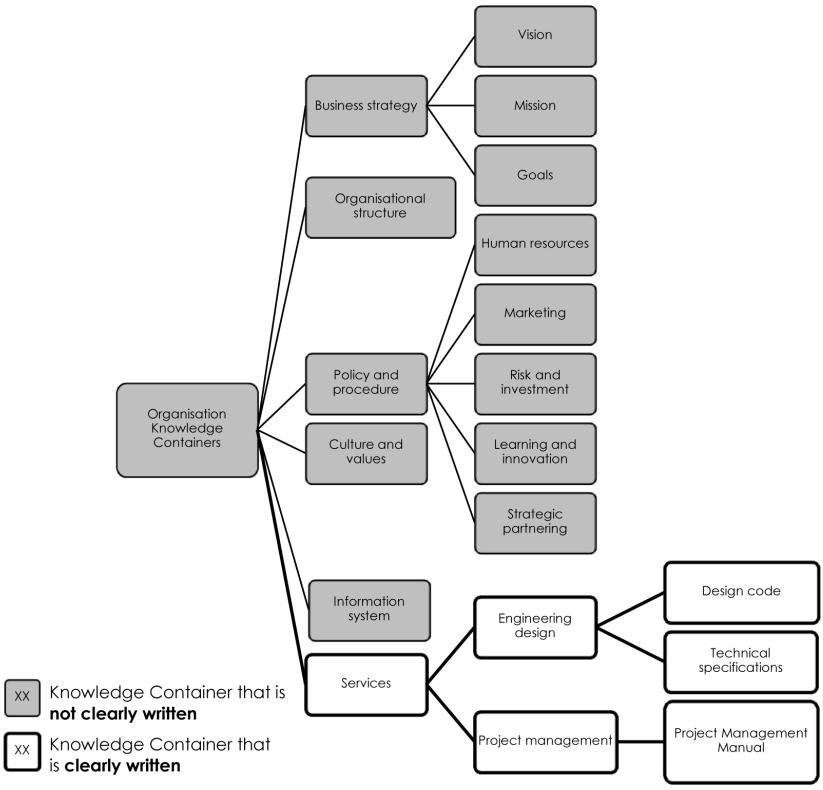

Figure 2. Preliminary Structure of Firm B's Organisational Knowledge Containers

Step 3: Action taking

After reviewing project documents, a focus group discussion among project staff to identify four issues was held. These four questions were adapted from Peter Drucker's personal experience taught by his editor-in-chief while he was a journalist in the 1930s (Drucker, 2008: 508): (1) "What did we do best so that the project could save time, cost or increase in quality or efficiently satisfied the client's needs?", (2) "What did we already try our best but the result was not as good as we expected?", (3) "What did not we try our best and that we should have done better to prevent a loss incurred by the project stakeholders or the loss could have been reduced?" and (4) "What had we done badly that resulted in a loss both to the project and our firm?".

In the first focus group session, five persons, including two structural designers, project manager, project engineer and site engineer, attended the discussion. Executives were not allowed to attend this meeting due to pressure in revealing mistakes of the firm. The session was recorded for future transcription. However, the result did not turn out as expected; only the problems were identified. An effective solution to the problems could not be identified. Therefore, an additional focus group session had to be organised to identify an appropriate solution to the

problems identified by the first focus group. The research team decided to select three experienced academics and professionals in the Thai construction industry who did not work with Firm B or with the project under investigation to attend the focus group, so their judgment would be tingled by the direct involvement and direct responsibilities as mentioned in Schindler and Eppler (2003). The three experts selected were proposed and approved by Firm's B executives. After a clear structure of problems was established and effective solutions to the problems were identified through the second focus group sessions, the learning captured was confirmed with executives and changes to organisational knowledge containers were suggested as shown in Table 3.

Step 4: Evaluating

During the first focus group, the project participants felt negative towards the project owners so they blamed the owner for schedule delays and cost overruns. Together with two success stories, they identified five problems (as shown in Table 3), but a rational solution was not proposed. For example, they proposed that the firm should not undertake fast-track projects or the firm should not work with a specific client again. This might be due to at least three main causes. First, the staff attending the meeting became emotionally involved in various arguments and situations during the duration of the project and had developed attitudes toward the project owners that hindered them from seeing the problems clearly. Second, the staff might not clearly understand the purpose of the meeting and did not believe there would be any fruitful learning to come out of it similar to the study of Boyd et al. (2004). And third, the staffs were not familiar with the knowledge containers that the research team and the executives had recently developed. During the second focus group, since the experienced professionals and academics did not have direct involvement and responsibilities with the project, the analysis of problems was systematic and unbiased.

Step 5: Specifying learning

First, it was found that the tacit knowledge capturing process should begin with establishing the strategic knowledge containers. Thus should be clearly understood by all staff so they could focus their learning and development of tacit knowledge during project operations in the right direction. As a result, insights gained through focus group sessions conducted at the end of the project could be more valuable. Secondly, there should be two separate focus group sessions, for the internal project team and external experts selected by the firm's executives. So, the knowledge could be discussed in all aspects to ensure collective evaluation and analysis of experiences as suggested by Schindler and Eppler (2003). It was important to separate the first group who had direct responsibility to the project from the second group who was not involved with the project which might have functional conflict found in Sackmann and Friesl (2007). From this study, it was found that a process that could effectively capture tacit knowledge gained from a project should consist of four key stages, as shown in Figure 3. The final stage emphasised that new knowledge must be validated and tested through implementation in a pilot project and appropriate adjustments made prior to actual embedding in the firm's knowledge containers for wider application.

Table 3. The Knowledge Captured from the Beer Manufacturing Facility Project in Thailand

First Focus Group: Internal Project Team		Second Focus Group: External Experts	
Issues Identified	**Resulting in**	**Issues Clarified**	**Embed in Container**
What Did We Do Best So That the Project Can Save Time, Cost or Increase the Quality or Efficiently Satisfy the Client's Needs?			
An efficient flood protection system.	Save cost, maximise land use, aesthetics.	Technical knowledge and project experience.	Add technical design and value engineering lessons to "design code".
Efficient floor structural system.	Save cost, save time, flexible for alterations.	Technical knowledge and project experiences.	Add technical design and value engineering lessons to "design code".
Where Did We Already Try Our Best But the Result Was Not as Good as We Expected? And Why?			
Fast-track project which requires construction to start with an incomplete design.	Costs incurred and time lost due to delay in design.	These are the nature of fast-track projects and the project team is inexperienced in managing this kind of project.	Add fast-track section to the "project management manual" that the firm as a project manager is required to: 1. Identify schedule of decisions of key project participants. 2. Identify the effect of delays in decisions. 3. Identify a proper mechanism to back-charge the party responsible for delayed decisions.
Coordination with an equipment supplier based in Germany which does not have qualified subcontractors in Thailand.	Costs incurred and time loss due to delay in communication.		
Change in specifications of equipment and piping after structural work has been constructed.	Costs incurred and time loss due to on-site change.		
Lack of authority as well as fragmented nature of the owner's representatives.	Costs incurred and time loss due to delayed decisions.	It is the nature of the client's organisation which the project manager has to deal with.	Add form requesting owners to identify authorised personnel in the "project management manual".
Owner's selected supplier of insulated wall panel provides materials which do not meet specifications.	Low quality of insulated wall constructed.	It is the nature of the industry that the project manager has to deal with.	Add form to identify owners if materials do not meet specifications in the "project management manual".

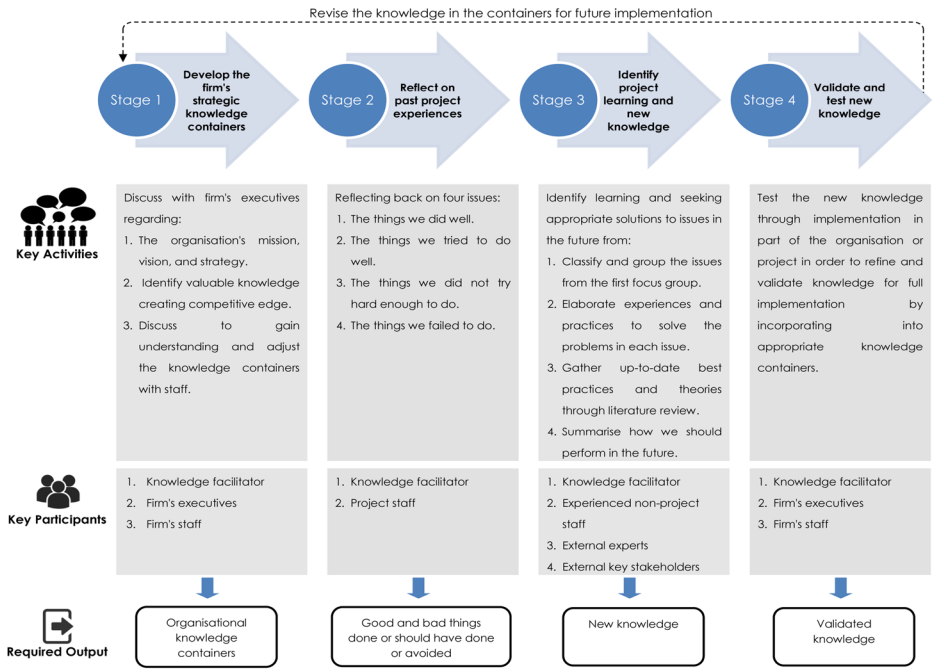

Figure 3. A Four-Stage Process Model of Effective Tacit Knowledge Capture in the Construction Industry

DISCUSSION

Competitive pressures are forcing the construction industry to become more efficient and innovative in delivering projects. Firms in the construction industry cannot afford the risk of losing strategic knowledge and capabilities embedded in key staff in tacit form. The ability to capture and reuse tacit knowledge gained from their project operations with continual accumulation and refinement of the firm's strategic knowledge is the key to achieving sustainable competitive advantage. Through action research in two consulting firms in the Thai construction industry, it was found that tacit knowledge could be captured effectively using a four-stage process: establish knowledge containers, gather project lessons learned from the project team, translate lessons learned into new knowledge by external experts and validate and test new knowledge.

The first stage, developing the firm's strategic containers, is probably the most crucial step since it will integrate learning and knowledge goals into project goals as suggested by Schindler and Eppler (2003). This step is somewhat similar to the topic setup phase in the knowledge management system developed by Lin and Lee (2012), but it is directed toward the firm's strategy. The strategy will identify the knowledge the firm needs to gain competitive advantage including the firm's strategy, organisational structure, policy and procedure, culture and value, information system and knowledge necessary to achieve excellence in the services

the firm is providing to its market. Most Thai consulting firms do not have an explicit strategy established since it is usually crafted in the mind of the management and stay in tacit form without discussing with its staff. However, understanding of the firm's strategy and these containers by all staff provides the necessary foundation and direction of continual learning and self-development, the key ingredient to the success of the firm's knowledge management.

The second stage, reflecting on past project experiences among internal project team, aims toward what happened and what is the lesson learned, not who was responsible for what happened to create trust, not embarrassment among project staff. It is important to point out that time for reflection on actions and experiences is required for individuals as well as the team in order to clearly identify what went right and what went wrong in the project as noted by Schon (1983). That is the reason why we fail to capture knowledge during the project's weekly meeting. Not until the result is seen or the project is finished, whether successfully or not, can project participants reflect and summarise their learning effectively. Therefore, to monitor lessons learned too often would only create more work and spoil the development of valuable knowledge.

After the lessons learned are identified by the project staff, identifying project learning and new knowledge aims to gather the impartial insights drawn from external experts who are not directly responsible for the project performance. This will not only eliminate bias which may occur due to emotional involvement with the project but it would expand the socialisation to gain more recent knowledge and different experience from the experts who may be academic or professional outside the firm. These external experts should have significant knowledge and experience of the area under discussion. More importantly, they shall be related to the firm as a long-term partner as well. The firm's major stakeholders, such as repeat clients, major subcontractors, design partners, etc. can also be invited to participate in this session. The definition of internal and external is left for the firm to decide on. Internal is defined by the level of trust, but the external experts must be chosen based on their knowledge and expertise required to translate project lessons learned into new knowledge.

During the last stage of this continual process, any changes and development in organisational knowledge containers must be validated by the company key staff. Once the company staffs appreciate the value of the efforts they have put in, they will contribute more and more toward the learning and sharing of tacit knowledge as observed in Boyd et al. (2004). It is suggested that prior to any change, the new knowledge should be pilot tested in a project or small units for some time and adjustments made before applying it to the whole organisation. The rationale for embedding new knowledge in the container must be clearly stated as a note to change. Therefore if any condition is altered in the future, the path of change in any part of the knowledge container can be tracked and reviewed and accumulation of knowledge can happen systematically to avoid repeating the same mistake.

CONCLUSION

The four-stage process proposed here can effectively capture tacit knowledge and transfer lessons learned into the knowledge container which is then ready to be implemented in subsequent projects. The process would allow double-loop learning and complete the KLC including the knowledge production and knowledge

integration processes. Moreover, it would reinforce individual and team learning as well as employee satisfaction by providing all staff with opportunities to suggest changes or refinements to the firm's strategic knowledge containers, such as design code, project specifications, project management manual, human resource policy or even the firm's strategy.

Information technology, as well as a social network, can be designed to assist a user's participation in the proposed process. Although the process has been developed from the case of Thai design and consulting firms, the process is not contexted specific to the construction industry and should also be applicable in all project-based firms which significantly rely on tacit knowledge of professionals who mostly work with external partners in the project environment. The four-stage process would provide an effective linkage to manage knowledge gained from project-level to the organisation and vice versa. Future research should examine the application of the proposed model in practice to identify the benefits and also the contribution of information technology as well as other related issues.

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