Knowledge Management Practices on Large-Scale Construction Projects in an Australian Company: An Ethnographic Study

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ABSTRACT:

A three and a half year ethnographic study of knowledge management practices on Australian large-scale projects observed professionals at work in the design and construction within one company over one such project. This study shows how knowledge is captured, exchanged and transmitted on fast-paced construction projects, supported by interviews, descriptions and document analysis. It also discusses factors that impede and support knowledge management, and also takes into account issues of technology, cultural differences in valuing knowledge management, and the codifying of knowledge and relationships. This study concludes with a discussion of results and implications for both knowledge management in construction industries, and for undertaking ethnographic research.

Keywords: *Ethnography, Knowledge Management Practices, Construction Industry, Knowledge Management Systems*

Introduction

This paper reports insights about Knowledge Management (KM) practices on large-scale Australian construction projects over a three and a half year period in one Australian international construction company. The study discusses results from an ethnographic three year field-based research project which focused on the design phase of several projects. Additionally, this paper will contribute and build on much research into the crucial area of managing knowledge on such projects to help create value for the company when bidding for future construction projects.

Two claims, with supporting evidence from the study, will be made. First, that before construction, during and after, knowledge is managed and added to the minds of the project staff and sometimes captured in various technologies through more thorough than informal everyday channels of conversation. Framed by Iske and Boersma (2005), knowledge in this context means the experience, skills, ideas and attitudes of people in a context which fosters value to be added. Construction projects are environments where adding value is prized as a company and its practitioners struggle to balance time, cost and quality issues for their clients.

The second claim that emerged from this study are the differing cultural attitudes project practitioners had towards using technologies of any kind to capture and store knowledge. Many large-scale projects hire professionals from many countries who are trained with differing attitudes towards using technology on projects. Capturing and transmitting knowledge from the design and construction teams to the site is crucial to accuracy. Technologies such as document management systems, 4 Dimensional Computer Aided Drawing (4D CAD), knowledge databases and increasingly Web 2.0 platforms such as virtual communities and social network sites play a major part in this process. However, the study observed differences between projects and teams in using such technologies for capturing and disseminating knowledge.

This paper will take a case study ethnographic approach using Yin's (1994) well-founded approach and ethnographic methods from Brewer (2000), LeCompte and Schensul (1999a), Atkin and Hammersley (1995). Such research methods have become commonplace in construction research in order to understand many issues. These include understanding workplace socialities, the crucial qualities of the social relationships that develop on construction projects learning about forms, uses and communication of knowledge on construction sites and, importantly, turning these into meaningful recommendations (Pink et al, 2010). With such an emphasis on KM in construction projects, research that goes beyond pure economic and statistical data, important as this still is to construction companies, is important in order to improve KM practices on large-scale projects.

Literature Review: The Problem of Managing Knowledge in the Construction Industry

It is well documented that the construction industry is under pressure to deliver quality, and sustainable structures that solve society's issues with reduced costs and shorter completion rates. However, governments, special interest lobby groups and environmentalists, amongst many, have demanded that more attention be paid to caring for the environment and reducing the amount of resources. In particular, the design and construction process, once an adversarial part of large-scale projects, needed to become a collaborative effort (Puddicombe, 1997 Law 2004). Since the late 1990s, part of this increasing working arrangement has seen the increased sharing of information between previously competitive construction firms: in joint venturers and amongst engineers, designers and many other project staff from various locations on to one project.

The potential of gaining KM knowledge from information that a diversity of personnel can bring is advantageous. Knowledge emerges as an outcome of the relationships project personnel form with each other (Stacey, 2001) and can result in economic and social benefits for the company. This can also become, as Daghfous (2003) describes, a core competency of the company as it strives to maintain competitive advantage over other firms by offering unique services to clients. For example, the company may be able to offer not only competitive cost-effective resources to build the project but also a network of skilled professionals who are trustworthy. This can be achieved by capturing knowledge in both human and technological form and transmitting it to others who join the project.

A problem in the construction industry is the importance of making KM a priority in the business, but the difficultly of managing that knowledge. Capturing such knowledge is possible but the fast pace of projects and demands of daily responsibilities often mean knowledge is not captured correctly. Information technology generally can capture and codify knowledge, but also create effective human networks of experts who can be turned to for their knowledge of past project success or failure (Bloodgood & Salisbury, 2001; Hansen et al, 1999). However, resistance to technology still exists. Many information management systems form the backbone of potentially captured knowledge. Yet as Craig and Sommerville (2006) in their investigation of United Kingdom large-scale construction projects found, the upkeep of such repositories is often seen as the responsibility of support staff, not project personnel.

Yet as well as technology which aids KM capturing and dissemination, relationships and the knowledge that is generated from constant interactions between professionals and project support staff generates knowledge for future projects. Resting KM on the definition that it is a systematic and organisation-wide process of acquiring, documenting and transferring

people's experiences so that something of value can be used effectively in the future (Alavi & Leidner, 1999), is crucial as a construction company moves to new projects. Again the fast pace of projects and bidding for projects may prevent the needed post product reflective practices that companies need to share knowledge and lessons gained on projects for use on future projects.

As well, the culture of the organisation impacts on attitudes towards having affective KM capturing, documentation and dissemination. For this project, defining 'culture' is from Kroeber and Kluckhohn's (1963) definition. These are the explicit and implicit patterns of behaviour acquired and transmitted by symbols and embodied in artefacts. The concept also refers to the beliefs and values of those in the company, but importantly their habits, as human habits, give clues to what is occurring in the situation. Artefacts in construction companies are many, but the design drawing and 4D CAD drawings are vital sources of information and later historical knowledge to be codified. Much of KM is relationship based on embodying trust and willingness to disclose something to another. As Mushtaq and Bokhair (2011) argue in their study of KM leadership, there is a strong link between culture and its components, such as values and beliefs, as well as trust, goodwill and reciprocity as stated by Yli-Renko et al. (2001 and Keenan (2002). Managing knowledge on large-scale projects is vital. Capturing, reporting on, analysing and codifying that knowledge, particularly for an outsider researcher, is a challenge that this paper addresses.

Research Question and Rationale for Study

The overarching question which guided this research is: what are the ways project staff capture, exchange and transmit knowledge on large-scale projects and what factors either facilitate or impede this process? Being a general research question, this allowed flexibility to uncover what is happening in the company with their KM practices. However, using ethnographic methods allows the question to go beyond just reporting and assist in interpreting the possible reasons why KM may or may not work. Understanding reasons for KM practice, using ethnographic field work, goes beyond mere description of KM practices. Rather they assist in finding out what power structures, vested interests and limited resources to meet project goals (Klein & Myers, 1999) contribute to finding out how KM is practiced on large-scale projects. The results section will provide examples to clarify these points.

The Ethnographic Study Design and Company Research Site

This study uses an ethnographic research design using mixed methodologies of collecting and analysing data. Brewer (2000) describes ethnography as studying people in naturally occurring settings and capturing their social meanings and ordinary activities. An important part of this is to be a participant in the setting; that is, shadowing and even doing some form of knowledge work amongst the people the researcher observes. In this study performing tasks for the project staff gave access to documents in their various KM electronic systems and proved useful for data collection.

Field note writing of observations was the main data collection instrument. These were written regularly both at the time of the occurrence and at a later date in order to build a picture of what was occurring (Emerson, et al, 1995). Places, actions of those observed and comments made during the projects were recorded. These were written according to a thick description, where the event was richly recorded, but also the context where the event took place was also recorded (Geertz, 1973).

Through the second data collection method, open ended semi-structured interviews were conducted with project staff to gain in-depth insights from individuals on KM related practices. They were asked questions about their activities and also their attitudes towards issues such as knowledge sharing and use of technology in their daily activities. A third data collection technique, consulting document and archival records was used as examples to see how KM practices were codified. Patterns of human action can be revealed in the documents (Anderson, 2010; Hammersley & Atkinson, 2007), providing clues to the way project staff uses them as KM instruments. These included design documents, meeting minutes, photographs and online documentation. However, their content functioned merely as supportive data to the observations and interviews.

Analysis of data used a thematic approach, where data was organised and used to reveal emergent findings. Though focused on KM issues specifically, it did allow a flexible approach where what emerged was driven by the behaviours of those being observed and interviewed, and the knowledge artefacts in the documents. Data is grouped according to the repeated descriptions of speech, events, observed activities and behaviours as well as researcher comments (LeCompte and Schensul, 1999b). Codes were allocated to the data in order to develop a set of themes. As undertaken by Burford and Ferguson (2011) in their KM study of the Australian Government Sector, the main benefit of thematic analysis is to provide, without pre-existing expectations or existing coding frames, a level of theoretical freedom to approach vast amounts of data to reveal patterns and insights.

Although the study has ethical clearance, large-scale projects are subject to much confidential information. The data examples presented in the results have had informant details heavily masked to protect the company and informants, though the projects in this paper have been completed.

The company's four divisions, building, civil, process and mining, all have large-scale projects. These include a liquid nitrogen tank, dams, office buildings, apartment complexes and transport projects. Research took place both in the head office and on sites. Knowledge Management policies are in place and the company does value practices which add value to current and future projects, particularly the lessons learned on projects to improve future ones. Much of the data comes from observations and interviews with high-level project staff who shared knowledge with each other and electronically. The company's management has knowledge sharing as a key goal in their overall business strategy. During the second year, a new Management Information System was created which aimed to capture knowledge from project staff and have it codified for future reference.

Findings about Knowledge Management: Relationships and Technology Use

The two main themes that emerge from the analysis about KM practices on large-scale construction projects gives insights into answering the research question. First, relationships between project staff, the clients of that project and external stakeholders such as those affected by the project's construction or the government, produce much knowledge during and after the design and construction stages. Exchanging and transmitting knowledge occurs frequently through informal conversations, often called corridor exchanges as they happen often during routines in many situations such as mentioning something in passing to another person. However, capturing that knowledge and in the future codifying it is done less as the fast-paced activities and time pressures do not allow this to occur. That is the main

impediment, though the company encourages its entire staff to share things in written form that may become codified knowledge at a later date.

The second theme is that of the company's use of electronic technology and information systems to attempt to codify knowledge, store and retrieve it in order to aid future projects. In this study, this company used document management systems, Auto Cad, particularly 4D CAD drawings, management information systems and construction project management software. A common view of technology in construction projects is that their introduction and forced use creates resistance to change in new procedures and working arrangements (Mitropoulos & Tatum, 2000). Whilst this is a common experience in many industries, in the Australian KM practice context, when the company employed overseas labour and worked with overseas companies who had used advanced electronic KM technologies, the view from some was that the company lagged behind in capturing knowledge. This will be discussed in further observation and interview data examples.

Yin's (1994) advice is to present data as a story, which ethnographic writing does to illustrate what is going on in the observed culture and is a rich way of showing what does and does not work on large-scale construction projects. To show KM practices on their large-scale projects in this company, this study answers the question about relationship and electronic technology use, by presenting two main themes.

Theme 1: Relationships between Project Members in Knowledge Management Generation

A key observation is that the project manager on the large-scale construction projects can be described as being the controller of knowledge flows. That person has vast amounts of knowledge to draw on, hence a major factor in their being chosen to lead, and has the ability to create new knowledge about the two most important things on projects. These are processes, the technical knowledge to manage the structure such as construction and design, and relationships between many stakeholders.

Although having this knowledge is useful for meeting time, cost and quality performance, it is mostly tacit knowledge. Codifying knowledge is difficult during the construction phases. Much knowledge is captured after the project is finished at post-construction meetings. But the notes at these meetings are rarely put into any management systems for future reference. Yet the project managers want to pass on their knowledge about both relationships and processes. This desire is noted in interviews, represented by this comment:

Interview Extract 1:

> I've gained that knowledge over the six years, ten year period that I've been involved with it, and how the process works. Will it be around again the next time? I don't know. I would like to be able, that is probably where I see my future is in imparting that knowledge and process on to the next generation that come through as builders and constructors.

What is observed continually is the desire for the company to re-engage the same people on larger projects because the clients and company management trusted them based on reputation. They did this on the basis that the design and construction experts have technical and relationship knowledge to maintain cost, quality and time key performance indicators. In

interviews, the relationships between project staff are a key part of KM performance. This is because knowledge is managed by sharing experiences. This extract is illustrative of the attitudes that were expressed by the project managers:

Interview Extract 2:

> If, say, previous experience with S Company, very good client. I have very good relationship with them, The Hague, that main engineering office group. I have more than twenty years' relationship. Apart from the project, sometimes, you know, contacts, and exchange technical opinions and information easier. It's certainly different from engineering company.

A high value is placed on tacit knowledge held by project professionals. If their knowledge was vast they were sought for projects and offered appropriate rewards. Therefore KM skills were part of the selection criteria. The problem arose in management's desire to turn such tacit knowledge into codified knowledge, even though it is well known in KM literature that this is difficult. Project staff had previously worked together; therefore, the project manager would trust them to share knowledge, particularly when issues arose that required significant drawing on many types of knowledge.

Another reason the informants disclose is a large amount of knowledge in the form of notes, drawing information, photos and other documents placed into KM systems at the end of projects. Close-out meetings with clients and others presented opportunities to disclose and record knowledge; however, this was impeded by the need to start tendering on new projects at a time in Australia's economy when infrastructure projects were abundant.

A significant problem of these relationships which senior company management wanted solved is management's belief in capturing any type of knowledge. For this they turn to using technology with mixed outcomes, because the habits and beliefs of project members provided a very different perspective on KM practices that needed codifying to those using tacit KM practices.

Theme 2: The Difficulty of Codifying Project Knowledge with Technology

The principle findings in this theme are that KM capturing is a spoken-about priority but capturing and codifying is difficult. Despite much literature concluding KM does allow competitive advantage in knowledge economies, the solution of using technology to do so, even if vast expenditure is made on it, does not translate into daily practice. The problems lie in the resistance to use, and because many KM systems are treated as repositories and are often ignored by project staff.

Yet these acknowledgements to manage records, drawings and vast amounts of project data so they can be drawn on during the current project, and on future ones, is repeated by the informants. A design manager in Extract 1 explained how managing documents and the knowledge they contain was vital, even though the pace of projects with deadlines was a significant pressure:

Interview Extract 3:

> You know, like, I mentioned document control – it's often considered to be the bottom of the heap in terms of looking after things, but you can end up with a job with a few thousand drawings on it, if you don't have any control over your documents, see how you go construction wise!

At a meeting one manager agreed that managing documents where knowledge may reside was vital. Yet his view was that the information in the major KM system was too large and that a different type of document that was easier to retrieve and less wordy would be ideal to using that system more often:

Field Note 1:

> There is good stuff in the Management System but can't find things. People could not find the Design Management Plan. Lotus Notes in another company's system had only 3 or 4 pages so people would read them. After 40 pages people switch off reading documents. Who will read large documents? Road Map type document seem to be disappearing and they are often better to read and understand.

Clearly this shows an example of a technical impediment to capturing knowledge; being codified in huge documents that were of little use during fast construction stages was not effective for the company.

At the daily project level knowledge was only marginally codified in the design drawings. These drawings not only contained knowledge to build the structure but also facilitated discussions between project members. Often during these observed interchanges, remarks on people or processes not previously considered were mentioned in conversations with each other. If this contributed to any time or cost savings, or in the case of relationships, solved conflicts, it is considered valuable to record that experience of how it was done for future reference.

Repeatedly, a disparity emerged between project staff from other counties and Australian staff. Generally, the observations and interviews suggested that being trained in engineering, construction and design is significantly different in Australia as against overseas. The evidence for this emerged through observing the attitudes of the project staff towards technology use, and the attitudes towards sharing knowledge on many electronic systems.

First, many projects were alliances between construction and other companies, or also government departments such as roads and health. The alliance presents a challenge for KM practices, particularly those that need to share knowledge across new relationships and different KM systems. As Inkpen and Dinur (1998) describe what was observed in this study, the creation of knowledge is fast and dynamic, involving interactions between expanding communities of individuals. The company's project staff struggled as other firms had new technologies in place, and expressed frustration that they were not compatible with the technologies used by the company. Documents from other firms needed rewriting and reconfiguring so they could be placed in the company's KM systems, which was time consuming and not a priority for project staff.

The second finding was the observation that project staff trained overseas had attitudes towards KM and other technologies such that they valued the need to have currency in KM systems. This study does not assert that the country where the project member did their

training for using KM systems is causal; rather, the observations and interviews yields results where the comments said and actions undertaken shows KM practices to be valued more by these staff.

It is important to standardise as efficiently as possible KM systems which document the project's progress. This is a goal the company wanted to achieve, being prepared to work with their former competitors to share knowledge amongst the team. A chief way to achieve this was the convenient use of Microsoft Excel Spreadsheets for this purpose. But the problem arising from the frequent use of spreadsheets was that the knowledge contained in them was spread around on individuals' computers. These spreadsheets for a variety of purposes were routinely used by many on the projects, as this interview extract was typical of comments made:

Interview Extract 4:

> When I use the Internet to some degree to research some aspects of design of cryogenic structures, and I found some useful information there. Apart from that just the normal Word Processing. I mean, of course Excel Spreadsheets are extensively used but that's pretty standard stuff.

It was acknowledged that widely dispersed spreadsheets that held knowledge on anything, from materials costs to contractor payments, were valuable for future reference. But again management had difficulty at that time convincing the project teams to put such information into KM systems. This 'spreadsheet culture' was acknowledged as problematic and also suggests that knowledge on large-scale projects can be fractured and under-utilised.

However, the second technology, 4D CAD, was at that time being implemented with the aim of having this new technology act as future knowledge instruments, particularly in the design process. As Thurk and Fine (2003) strongly argue, Auto CAD supports organisational memory as the design drawings from past projects are returned to at a point when solutions are needed to problems on new projects. In this interview extract, the Technology Development Manager acknowledged that such drawings do support future KM practices:

Interview Extract 5:

> But we hope that - on some projects, not necessarily all of them, but we certainly hope that the programmers, the construction managers, the designers, managers from all walks of life come - can take that model and integrate it, look at it in much more detail to look for issue - potential issues, constructability issues, access issues and hopefully avoid those problems by better planning beforehand or modifying their program. Maybe the 4D model will highlight errors in their program. Often when we get the first program from a site you find a lot of problems just because they've forgotten things - they've forgotten to include things and this happens a lot on jobs where work is cut up into pieces, zoned, and they might remember to build a road up to a certain boundary and then forget about the road from the next part of the boundary because they haven't copied and pasted it properly in their program or whatever.

The spreadsheet and 4D CAD examples show the marked difference between what impedes and facilitates KM practices on large-scale projects. Obviously, capturing these observations at that point in time does not mean the company has not addressed these issues as they

compete in a current competitive construction market for new contracts which require them to draw on knowledge from past projects.

Cultural Differences in Capturing Knowledge

As part of the theme of KM systems use, there were noticeable differences on the projects as to attitudes towards using such systems from those overseas staff compared to Australian staff. Ethnography captures instances of behaviour through observation, noting comments and actions. A significant repeated pattern frequently observed was how the overseas trained engineers paid attention to capturing knowledge through drawings, documents and other data. Often they would stay later into the evening to complete comments on drawings.

To illustrate, on a tunnelling project several recently graduated German engineers came to work on support duties midway through the project. One engineer spoke about how it was 'drilled into their thinking' to be complete and thorough with design drawings which would be needed for future knowledge. Another more experienced designer expressed dismay at the lack of currency of the drawings. Even having comments one day behind, she expressed, can mean loss of money and stalling of the project: hence something could go wrong. Observed over two years their zeal for technology was telling. This is not to place a cultural boundary between Australian and overseas project members on the basis of not appreciating KM systems and strategies. Rather, the study observes that those from overseas saw the need to utilise such systems in order that information be complete and current, drawing upon both in the current project and in future projects.

Conclusions and Implications for KM Practice and Systems

This study set out to be exploratory, using ethnographic methods to capture how KM is captured, exchanged and transmitted on large-scale projects. It is suggested that there are cultural divisions in the attitudes towards capturing knowledge in daily project life. Certainly most knowledge is orally communicated and committed to memory as tacit knowledge. Codifying it into the various scattered KM systems is difficult. However, the company was aware of the need to capture knowledge. As Drejer and Vinding (2006) found, the post-project review and systematic evaluation of practices which can be shared is a valuable strategy for capturing and codifying knowledge. The company is aware of this and at the end of this research procedures and policies were developed to make this compulsory practice.

This study explored over three years how knowledge was captured, exchanged and transmitted on projects. KM practices for the company did have successes, though it was noted by senior management that the impediments were great. These impediments are driven by cultural beliefs and attitudes about how to value KM, so it can be codified for future use; and a noticeable difference arose between Australian and overseas project team members with regard to KM practices.

This assertion of cultural divisions needs further research, as this is an unexpected finding. Over the three years the repeated observations were that overseas project staff were trained in KM awareness. There is much devotion of research into the electronic and tacit capturing of knowledge on construction projects. Therefore, perhaps designing a study as to the use of KM, divided by region and educational and career training, may provide more insights.

This study answers its research question with a conclusion that is similar to the qualitative interview-based one undertaken by Styhre and Gluch (2010) on KM practices in Scandinavian construction companies. Their conclusion is that the existence of formal procedures in such companies has been developed well to support knowledge sharing, but the bulk of sharing appears in personal networks and oral communication. The assertion in this research is that another strategy is periodic reflective meetings between project managers. These can be face-to-face or making notes in a journal. These could be sent to a KM team in the organisation familiar with law, company policies and information technology skills. The company did set up such a department after the fieldwork was completed. Nevertheless, the factors to support this process, including attracting high level management support and changing daily behaviours, are challenging to implement.

Finally, this ethnographic study is a challenging one, and there are many examples of both the failure and success of this research approach. It should be noted that to take on such an approach in private competitive companies requires fitting into the culture, and the researcher balancing research and participation in company life. If work is undertaken for the company, it must be within agreements of confidentiality and the understanding that the ethnographer has dual commitments to the company, and the research team and institution. However, the value of such studies is in showing companies operating in economies where time, cost and quality are demanded with fewer resources and greater responsibilities, this type of study can add value to the KM body of literature on construction company practices.

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