TOWARDS A FRAMEWORK FOR INTEGRATING KNOWLEDGE MANAGEMENT PROCESSES INTO SITE MANAGEMENT PRACTICES

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There has been a growing awareness of the importance of knowledge management in construction over the last few years. However, knowledge management is still under-utilised within construction organisations. More specifically, there is much scope for making construction organisations more competitive through better knowledge management practices. One of the most promising, but also very challenging aspects is the integration of KM processes into site management practices. Managing know-how, know-what and know why is unlike managing materials, labour or construction plant, yet intellectual capital investments need to be treated with every bit of care. This paper reviews current site management issues and problems and presents a summary of knowledge management processes, with a view to identifying the most applicable knowledge management processes for improving site management practices. The outline features of a new framework to support the integration of site management practices with relevant knowledge management processes then presented.

Keywords: construction, knowledge management, processes, site management practices.

INTRODUCTION

The primary objective of site management practices is to produce a building of the highest possible quality within the constraints of cost and time (Gray 1992). An awareness of the importance of quality site management has been growing in the construction industry over the last few decades. The greatest challenge facing construction managers today is to find most efficient way of managing construction site. An improvement of managing construction site can be achieved by implementing management forms which emphasize co-operation, delegation, continuous learning and the use of information technology. Knowledge management (KM) is central to this management forms as it facilitates continuous improvement through project learning and innovation (Robinson et al. 2001). One of the aspects investigated in this paper is the management of intellectual capital and an attempt to integrate knowledge management processes into site management practices, undertaken by means of a combination of methods including intensive literature review of site management practices and synthesizing the main knowledge management processes

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This paper review a process of developing framework to support the integration of site management practices with applicable knowledge management processes. This paper starts with reviewing current site management practices problems and which aspects need to be improved. Knowledge management in construction and its development strategy are discussed. This paper review well known knowledge management process includes Nonaka and Takeuchi (1995), Wheterill et al. (2002) Robinson et al. (2002), KPMG Report (1998) and etc. with a view to identifying knowledge types that relevant to construction site. Classifications of knowledge, types of knowledge relevant to site management and relevant relationships between knowledge management processes and site management practices also discussed. The paper concludes with a discussion of the findings showing outline features of a new framework and how knowledge management processes can be integrated into site management practises.

SITE MANAGEMENT

Site management is a combination of activities which turns basic resources into a finished product. This can range from organization of the materials, labour and other resources on the site activities which control the flows of information and finance (Construct IT 1996). The construction site is, therefore, seen as a key area where money is made or lost and where there is considerable scope for improving efficiency, productivity and quality performance. In order to achieve the quality of site that is needed, site management must concentrate on understanding the whole system of construction and ensuring that it is focused on the production aims of the site operations (Gray 1992). Illingworth (2000) views the construction process on the construction site is a combination of two fundamental activities:

- Handling of materials and equipment and
- The skill of the workforce in the positioning of the materials and equipment (assembly) to produce the desired completed whole.

To accomplish these two fundamental activities, Construct IT (1996) has divided site management practices into the seven sub-processes:

- *Policies, procedures and site arrangements*: for the management techniques and systems of managing construction site processes.
- *Management, supervision and administration of sites*: including correspondence, minutes, RFIs, labour allocations, payroll, progress reporting, notices/claims, instruction, drawing register and technical information.
- *Commercial management*: this covers estimating, valuations, sub-contractor, payment, variations, dayworks, cost-value reconciliation, final accounts and cash flow.
- *Legal, health and safety*: management of legal, health and safety requirements on sites. This considers safety policy; COSHH and CDM regulations, insurance, building regulations, British Standards and Codes of Practices.
- *Planning, monitoring and control*: this covers all activities associated with project planning and scheduling, typically the production of Gantt-chart, network analyses, method statements, resource levelling, progress report and exception report.

- *Delivery and materials' handling*: the activities associated with the management of deliveries and the subsequent handling of materials on site are covered including requisitions, purchase orders, material call of, GRNs and plant returns.
- *Production on-site and off-site*: this considers activities supporting production for instance QA plans and report, contract terms drawings, specifications, setting-out and measurements.

There are many problems in managing construction sites and these affect the time, budget and plans, and specifications (Trauner 1993) and often causes defects, disputes and delays (NEDO 1983 and Clarke 1988). In addition, if one were to compare a construction site today with the last few decades, we would see that many procedures and methods have not been changed and the selfsame mistakes are being repeated (Holroyd 1999). For instance, the problems identified on the site management practices were:

- *Poor communication* – top management often did not know what was happening on site (Barber et al. 1999).
- *Poor information* – the information passed on was often wrong or inaccurate (Barber et al. 1999)
- *Inaccurate planning* – wrong assumptions were made as to where the project was in terms of completion , low technological input, unfavourable clients' attitudes towards projects and lack support from top management (Barber et al. 1999).
- *Training/education issue* – the majority of personnel on site where skilled in one very narrow area and the teams had not become truly multi-functional (Barber et al. 1999)
- *Motivation issues* – the bonuses paid were still based on old efficiency-based performance measures rather than team performance (Barber et al. 1999, Ling 1991, Ogunlana and Olomolaiye 1989)
- *Shortage of skilled workers* – affected by the cyclical nature of the UK construction industry (Mackenzie et al. 2000 and Agapiou et al.1995)
- *Plant problems* – maintenance of construction plant and plant management (Ogunlana and Olomolaiye, 1989).

KNOWLEDGE MANAGEMENT IN CONSTRUCTION

Knowledge management could be defined as "the identification, optimisation and active management of intellectual assets to create value, increase productivity, and gain and sustain competitive advantage" (Webb 1998). Knowledge management in construction could be described as a process of acquiring, creating, sharing, utilizing and storing intellectual assets and other stimuli from the internal and external business environments that facilitates an organisation's performance successfully (Kululanga and McCaffer 2001). This includes all the phases of construction including;conceptual design, advance development, detailed design, production, termination and operational (Shtub et al. 1994).

There are four main benefits identified by the UK Department of Trade and Industry (DTI) Intelligent System in Business Programme for a range of industrial sectors resulting from the application of knowledge management and knowledge based techniques (Anumba et al. 1998) :

- *Organisational Memory* – preservation of knowledge when staffs move.
- *Decision Support* – assisting experts by evaluating and suggesting possible options, enabling a wider range of design solutions etc to be considered.
- *Routine Decision Automation* – relieving key staff from trivial but time consuming tasks.
- *Product Improvement* – enabling increased differentiation from competitors' products through the addition of smart features.

Knowledge management consists of five distinct but interrelated processes; discovering and capturing, organisation and storage, distribution and sharing, creation and leverage, retirement and archiving (Robinson et al. 2001). These processes are as follows:

- *Knowledge discovery and capturing*: this process is aimed at finding out where knowledge resides, whether in peoples' heads, processes or products.
- *Knowledge organisation and storage*: it is deals with structuring , cataloguing and indexing knowledge so that retrieval can be done easily.
- *Knowledge distribution and sharing*: this process is about getting the right knowledge, to the right person or part of the organisation at the right time. It requires awareness of the relevant knowledge or best practice.
- *Knowledge creation and leverage*: involves combining or applying knowledge in new ways to extend the overall knowledge of the business, and to exploit the new knowledge to improve business performance.
- *Knowledge archiving and retirement*: it is deals with treatment of knowledge that has already been used but not updated or knowledge that has not been used or is no longer valid.

In addition, there are suggested developments of strategy which construction organisations can undertake to realise the above mentioned benefits of knowledge management (Carrillo et al. 2000 and Yusuf and Samad 2000):

- Develop strategic statement and clear goal of knowledge management intent.
- Map the organisation's business processes to identify one small area that could bring tremendous benefit.
- Establish systematic procedures to capture and transform knowledge components into useful knowledge.
- Allow the sharing and communication of knowledge between individuals within and outside the organisation.
- Implement a process and infrastructure to leverage knowledge, experience and lessons learned to enhance the delivery of strategic planning engagements.
- Implement tools and approaches to leverage and enhance social capital, knowledge content and infrastructure.

- Implement a system for continuous review and improvement of offerings and services.

TAXONOMIES OF KNOWLEDGE

Before exploring the development of a framework to integrate KM processes into site management practices, this section will discuss the different taxonomies of knowledge and an attempt to explicate those that are particular relevance in a site management context. This will include a review of well known knowledge management process frameworks developed by earlier researchers and industrial practitioners including: Nonaka-Takeuchi (1995), Wheterill et al. (2002), Robinson et al. (2001), KPMG Consultant (1998), Ruggles (1997), Heron (1996) and Blacker et al. (1993).

In the construction site environment, KM can incorporate any or all of the following four components: (a) business processes – in written documents such as drawings, minutes of meetings, specifications or embedded in the construction methodology or setting-out procedures. (b) information technologies – IT tools used by site staff such as expert systems, word processing and CAD workstations (c) knowledge repositories – Intranet and groupware linked separated geographical area , and (d) individual behaviours – construction knowledge in the mind of knowledge workers and trade workers. The implementation of KM processes should not completely restructure current site management practices, but should become an integral part of key site management practices. It is therefore important to identify which KM processes and which aspects of site management practices can be integrated.

Table 1: Taxonomies of Knowledge

Whetherill et al. (2002)		Robinson et. al (2001)	KPMG (1998)	Ruggles (1997)	Heron (1996)	Nonaka & Takeuchi (1995)	Blacker et al. (1993)
		Process	Methods and processes	Process knowledge	Practical knowledge	Sympathized knowledge	Embedded knowledge
Project	Domain	Product	Customers Company's own markets Competitors Company's own products and services Regulatory environments	Factual knowledge	Propositional knowledge Presentational knowledge	Operational knowledge	Encoded knowledge Embodied knowledge
	Organisational	People	Employee skills	Cultural knowledge	Experiential knowledge Taxonomic knowledge	Systematic knowledge Conceptual knowledge	Encultured knowledge Embrained knowledge
				Catalogue knowledge			

Sources: Compiled from Whetherill et al, (2002), Robinson et al. (2001), KPMG (1998), Ruggles (1997), Nonaka & Takeuchi (1995) and Blacker et al. (1993).

Table 1 shows the variety of classifications of knowledge and the mapping between them. Based on the preliminary synthesis undertaken, several knowledge types are relevant to integrate into site management practices. In general, knowledge in site practices can be found in people, processes and products (Robinson et al. 2001). However, the cognitive (in the form of heuristics and intuitions) and the support processes (such as experiential, cultural and catalogue) are the two most important constructs associated with knowledge management (KPMG 1998, Ruggles 1997, Heron 1996, Nonaka and Takeuchi 1995 and Blacker et al. 1993). Consequently, an effective knowledge management framework should have the ability to manage intellectual assets by leveraging both the cognitive and support processes in site organisation.

It is recognised that there is much "knowledge wastage" and often-considerable difficulty in accessing important information on the construction site. Based on the preliminary synthesis undertaking, several knowledge types are relevant to be integrated into site management practices. The knowledge types relevant to site management practices are summarised in Table 2:

Table 2: Knowledge Types Relevant to Construction Site Management

Knowledge Type & Sub-Type		**Relevance to Construction Site**
Process Knowledge		Collected through best practices and bench marking efforts. Knowledge of construction methods, site lay out, use and maintenance of equipment and plant, concrete technology, estimating and site cost control. *Impact: Optimizing operations & increase efficiency*
	Organisational	This knowledge resides both formally in company records and skilled processes of the firm. It also comprises knowledge about the personal skills, project experience and cross-organizational knowledge. In the site environment, it comprises knowledge of trade workers. *Impact: Improved quality of workmanship and avoiding repeated mistakes.*
	Regulatory	This knowledge is crucial to protect the natural environment and create a healthy and non-toxic environment. It is encapsulated in the site planning and organization, material selection and waste management processes (Khalfan et al., 2002). *Impact: Changes of construction process; from linear processes to cyclic processes.*
Product Knowledge		Collected throughout the life cycle of construction; planning, design, construction and maintenance. Embedded in the procurement process, estimating & tendering process, material management process and construction method process. Key factors to produce knowledge of end product are; type of clients, market characteristics and end product type (standard, traditional and innovative). *Impact: Creative problem solving and suitable to be used to long-term partnering project arrangements.*
	Domain	This knowledge is in principle, available in the company and partly stored in electronic databases. The overall information context which includes administrative information (e.g. zoning regulations, planning permissions), standards, technical rules, product databases etc. (Wethrill et al. 2002) *Impact: Information portal sites that constitute a storefront to the actors (e.g. clients, consultants, suppliers and contractors) in managing site activities.*
	Operational	This knowledge resides in the project management, production process, new product usage and policy implementation of construction site. It is crucial for on-site issues such as labour, material, subcontractors and health and safety management. *Impact: Produce high quality products/services and increase site management efficiency (time, cost and quality).*

People & Employee Skills		Knowledge of mental model and technical tacit skills of workers (Nonaka & Takeuchi, 1995). On the construction site, it resides both formally in knowledge workers (engineer, architect and QS) and trade workers (plasterers, bricklayers, roofers, carpenters, etc.). *Impact: Track the people who involved in a previous project, in a recorded decisions and who understand the context of the making of the decision and its implementation.*
	Project	Created by the interaction between firms. Knowledge for project records (Logs and submittal documents), design documents and schedule. Also unrecorded such as memory of processes, problems and solutions *Impact: Solutions to technical problems and avoiding repeated mistakes.*
	Cultural	Individuals who possess catalogue knowledge know where things are. These people are like directories ox expertise, and while such knowledge can often be codified into a sort of Yellow Pages. *Impact: Assist decision making process when problem arise because the individuals who have valuable knowledge know where to go for the right knowledge.*
	Catalogue	Knowing how things actually get done in an organization, culturally and politically, is an invaluable asset. *Impact: – Preservation of knowledge when staffs move and reduces learning times of new staff to relearn the invisible rules and norms.*

TOWARDS A FRAMEWORK

Construct IT (1996) categorises site management practices into seven sub-processes and its basic purpose is to provide a framework for carrying out work on any construction site. Assessment of the knowledge that resides in these sub-processes is crucial for the efficient performance of site management functions. However, the nature and problems of the construction process, also presents challenges for the integration of knowledge management within the site management context. These problems can be addressed by the development of an effective framework for integrating applicable knowledge management processes into site management practices. There are several aspects to be considered in the integration of KM processes into site management practices. It is important to identify the most significant site problem, KM issue associated with the problem and to develop appropriate KM initiatives, and then establish action plan for implementation. It is also equally important, to ensure the integration of KM processes is not completely resolve current site management problems, but should minimise the number of the problems on the construction site.

Table 3 shows the relationships between site activities, problems, knowledge types, relevant KM processes, and the potential applications that can be integrate site management practices and KM processes. For example, for monitoring and controlling site progress and workmanship of trade workers, the construction organisation can use a recording device that enables the site managers to specify the day-by-day progress achieved in construction activities, allowing the program to link the playback film with the progress observed on the construction site (Dawood et al. 2002). However, it must be remembered that KM initiatives should be problem oriented rather than technology oriented domain. Therefore, it is important to develop problem based framework to facilitate the improvement of construction site management practices.

Table 3: Site Activities, Problems and KM Processes

Site Activity	Problems	Knowledge Types	Relevant KM Processes	Application
Policy, procedures and site arrangement	- Lack of continuity and lack of systematic integration	-Process -Project -Organisational -Catalogue	-Knowledge organisation and storage -Knowledge distribution & sharing	- Used of IT tools such as Groupware and Intranet and job numbering system
Management, supervision and administration	- Poor communication between actors involved and inaccurate planning	-Domain -Product	-Knowledge organisation & storage -Knowledge distribution & sharing -Knowledge leverage	-Knowledge forum and Company Yellow Pages
Commercial management	- Cash flow problems, interim valuations and variation order and final account adjustment	-Product -Operational -Cultural -Catalogue	-Knowledge creation -Knowledge discovery and capturing	- Cross link with other IT system
Legal, health and safety	- Lack of training, supervision and means to carry out task and unfavourable clients' attitudes	-Project -Regulatory	-Knowledge storage -Knowledge leverage	- ISO Implementation and External Auditing
Planning, monitoring and control	- Lack of co-ordination, no relation between activities	-Product -Processes -People -Operational -Cultural	-Knowledge creation -Knowledge sharing	-Use mechanical devices such as Photo-net System
Production on-site and off-site	- Manpower problems, absenteeism and craftsmen's productivity	-People -Catalogue -Cultural	-Knowledge capturing -Knowledge distribution & sharing	- Apprenticeship, mentoring and special interest group

CONCLUSION/SUMMARY

This paper has presented a brief overview of an attempt to integrate knowledge management processes into site management practices. The need to synthesize knowledge management processes was identified and resulted in the identification of types of knowledge relevant to construction site. It is observed that managing construction site offer a wide range of interesting engineering and management problems to be solved. Poor communication, poor information and inaccurate planning were identified as a major problems occur on the construction site environment. These problem is introduced by the many types of project being undertaken, the types of materials and plant, their varied location and the changing nature of the project as it progresses. It is clearly shown that the KM processes can be integrated on the site management contexts. Significant steps of works illustrated in the previous sections are condensing to show the qualitative finding of the results of this study. But, the significant result of findings shows that knowledge capturing, knowledge distribution/sharing and knowledge creation/leverage are provides an interesting avenue to be integrated into site management practices. This paper has

argued for a structured approach involving the development of knowledge taxonomies with a view to identifying most relevant knowledge types need to be manage on the site management practices. A relationship between site activities, problems, knowledge types, relevant KM processes and the potential IT applications are also reviewed as the basis for developing an effective framework to support the integration of site management practices with relevant knowledge management processes. The development of the new framework will be addressed through on-going research project by adapting the selected knowledge management processes in line with the requirements and problems of the current site management practice.

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