A comparison between knowledge management in Construction and Software and Computing Services firms

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There has, in the past, been concern about firms' capacity to engage with the external business environment. A 'back-to-basics' approach asks, "*Where* do firms look for knowledge and information and *how* do they access knowledge?" In this pilot study, the construction industry is compared and contrasted with the software and computing services (SCS) sector to highlight the ways in which knowledge is managed by firms. Amongst other things, it was found that, whilst the SCS firms accessed relatively large numbers of sources of knowledge beyond the firm boundary, Construction firms accessed relatively few. SCS were adept at using the internet to search for knowledge and information and regularly scan beyond the firm boundary to keep abreast of latest developments. In contrast, Construction firms referred to product information and trade magazines, predominantly for the identification of new business. Of far greater importance to Construction practitioners was the experiential knowledge of colleagues and the knowledge of members of the project team within the supply chain of the project upon which they are working at that time. This has the advantage of generating local, applied learning, but limits the capacity to absorb new ideas or create or apply innovations.

Key Words: Knowledge Management

Introduction

Knowledge management in the Construction context

The emergence of 'the knowledge economy' has led to a growing awareness amongst construction companies of the terminology, tools and techniques of Knowledge Management. Within the knowledge economy, business success is predicated upon managing 'intellectual capital' in order to 'add value' to products and services. For construction, this translates into delivering projects faster, better meeting clients' requirements, creating less waste, managing costs, generating profit and offering quality in the built environment, amongst other things. However, research amongst some large UK national and international construction companies has revealed that their utilisation of knowledge management is not yet mature (Robinson, Carillo, Anumba and Al-Ghassani, 2005).

One reason for the difficulty of managing knowledge within the industry may be the nature of organization of the construction activity. Teerajetgul & Charoenngam (2006, 586) write,

> Construction projects are independent and defined as temporary organizations with specific objectives, detailed tasks, restricted time, and budgets to deliver a one-of-a-kind-product such as buildings (Oglesby et al., 1989; Carrillo, 2004)...
> Once a project is completed, project team members disperse from the

construction project either for other employment opportunities or get re-appointed for other subsequent projects.

As such, knowledge – which is contextualized on one project – must be recontexualised on following projects to make it meaningful and useful and this is an investment that not all personnel may be prepared, or able, to make. Consequently, post-project review for knowledge capture is a common focus for KM activity (Boyd et al., 2004; Maqsood et al., 2006).

Kamara et al claim (2002) that, "The various studies on KM… indicate that the practice of KM in the AEC [architecture, engineering and construction] industry has more to do with (and is influenced by) 'contextual' factors (such as organizational factors, diversified markets, supply chain management, etc.) rather than 'content' issues (with respect to rapid change of knowledge)." Accordingly, there has been considerable interest in organizational learning within the supply chain (Bessant and Kaplinsky, 2003; Orange et al, 1999; Barlow and Jashapara, 1998; Barlow, 2000). Similarly, 'contextual' factors feature in research on KM strategies, resources and barriers in Construction, highlighting an absence of standard work processes, lack of time and organizational culture (a 'top down' management of 'silos') as obstructing knowledge management (Carrillo et al., 2004).

Recent research has investigated knowledge creation among construction managers (Teerajetgul & Charoenngam, 2006). This reveals that Construction Managers regard knowledge creation as being most heavily influenced by individual competency (persuasion and drive), incentives (increased salaries, bonuses and rapid advancement) and IT support for collaboration, communication, searching and accessing, simulation and intuition and systematic storing.

However, there is a general lack of research into how, indeed, knowledge is managed within Construction – the 'content' issues referred to by Kamara et al (ibid). This might be because work in Construction is perceived as a kind of 'dark art' – a combination of the individual competency noted by the Construction Managers in Teerajetgul & Charoenngam's study (op cit) and industry experience, or 'having mud on your boots': "site managers and project managers solve complex problems in their day-to-day work by using their experience and intuition" (Hari, Egbu & Kumar, 2005). The pilot study described in this paper begins to compensate for this deficit by exploring the day-to-day activities of those within the industry.

Firms and their environments

For some time, the Innovation literature has recognized the concept of "absortive capacity" (Cohen and Levinthal, 1990) as critical to understanding how organizations become aware of new knowledge, make associations with their in-house knowledge, assimilate the new with their existing knowledge and then apply it (Trott et al.,1995). Research into SME has shown that where the information available to the firm is poor, innovation is stifled (Dou & Dou Jr., 1999; Julien, 1995; Ifan et al, 2003). Where small firms engage in business networks, they are shown to be learning organisations with a flexible, proactive business response capability (Chaston and Mangles, 2000).

When researchers have examined *how* people draw knowledge into firms, it has been shown that personal contacts are used to access information on the market and competition (Shaw, 2006) and it is often up to the owner/manager of small firms to balance the acquisition of knowledge from external sources with internal, operational activities and to share their knowledge with employees (Zhang, MacPherson and Jones, 2006). These lessons for innovative small firm behaviour highlight the need to understand the processes by which all firms acquire and assimilate knowledge and it is these processes that this research sought to understand. *Where* do firms look for knowledge and *how* do they access it?

Knowledge Management definitions & processes

Knowledge management has been defined as "the process of systematically and actively managing and leveraging the stores of knowledge in an organisation" (Laudon and Laudon, 2001; 357). Some writers prefer to distinguish between the management of knowledge via technology-based mechanisms and the management of knowledge via person-based mechanisms. To this end, Al-Ghassani et al (2004) use the term 'tools' to describe the former and 'techniques' to describe the latter. Similarly, Robinson et al. (2005) refer to codification and personalisation strategies respectively.

In an attempt to understand the nature of knowledge management, whether it be deliberate or accidental, operationalised through tool or technique, this research explored a series of knowledge management processes: creating knowledge (Alavi & Leidner, 2001); communicating or sharing knowledge (Laudon and Laudon, 2000); searching or sourcing knowledge (cf Jackson (1998) uses 'gather'); synthesising knowledge (Jackson, 1998) and applying and re-using knowledge (Alavi & Leidner, 2001; Shin, Holden and Schmidt, 2001).

Research Method

This pilot study involved 17 interviews with a sample of eight firms from the SCS and construction industries. There are some similarities between the SCS and Construction industries that render them amendable to comparison. Points of comparison include the difficulty of capturing client requirements, the difficulty of capturing user needs, and the structure of the design processes. Also striking are the project-type organisation of their activities. It can be argued that the industries share the difficulties of operating on the client's site, of project team formation and of re-absorbing learning from the project to the originating organisation. The sample is not claimed to be a structured, representative sample of each sector. However, it identifies some interesting issues which are worth reporting and could be the focus of future investigation.

Interviews were conducted using a semi-structured approach. The need to address deliberate knowledge management and informal, unstructured knowledge processing behaviour precluded any initial focus on 'Knowledge Management' *per se*. Instead, interviewees were asked about actual activities and work processes, such as the sources of knowledge and information used for

problem-solving and creative work and the way in which the sources are accessed and used. The knowledge processes highlighted above were an heuristic to inform the interview questions.

The companies interviewed reflected a range of the businesses operating in the Software & Computing Services sector. One was the UK subsidiary of a major player in global markets with revenue in 2002 of $81,186 million and employees numbering 300,000. Globally, it produces and provides computer software, computer hardware and computer services,

Another was a small business, operating a successful national operation with 9 staff. It offers Project Management Services, System Design Services, Software Development Services, System and Middleware Software Provision and Licensing, Systems Integration and Data Migration Services, Training Services and Managed Services.

A further two businesses were self-employed IT consultants. One consultant specialised in writing software, for example databases to sit behind websites. Another provided workstation support (applications, peripherals, trouble-shooting) and advice and technical expertise for the deployment of PCs, networks and other IT systems. He also created bespoke systems. As a designer of print and web-based media, he designed user-interface of websites.

The firms interviewed in the construction sector included a large company with 7500 employees worldwide, offering Construction Management, Programme and Project Management, Design Management, Engineering and Procurement Management; a small regional civil engineering company employing 95 people, a main contractor with 1000 employees, and a small roofing contractor offering design and installation, monitoring and roof management, with 40 staff .

Findings

The findings show two types of activity in both industries – formal and informal knowledge management (Hutchinson & Quintas, in print). The formal KM is easily identified. The largest construction contractor had some strong formal knowledge management initiatives in place (including Communities of Practice, a knowledge-sharing tool and a proposals library). For example, the firm's knowledge-sharing initiative was inspired by the proposition that the company is a knowledge-driven, service company. They do not make anything; all manual activities are subcontracted out. In effect, the only thing they sell is their knowledge. Because they don't make anything, they must demonstrate to clients that they add value in other ways, for example, that they're not repeating mistakes, they innovate, they achieve on time, cost and quality, and so on. To be able to add value, the company wants to be able to access the knowledge that its employees have. They don't want their projects to "re-invent the wheel". If someone in the company has already solved a problem, or found a good way of doing something, then others should be able to take advantage of that. Knowledge-sharing is enabled by a facilitator that anyone within the company can contact with a question – a request for knowledge (RFK). The facilitator logs the RFK in simple IT system and finds a knowledge sharer (or number of sharers) who might be able to help. Sharers are even sought within the supply chain. The seeker or sharer does not interface with the knowledge management IT at all. The facilitator

contacts the sharer to establish whether they can help. Then they contact the seeker and put the two in touch with one another.

In fact, away from the project team, the firm had also successfully codified knowledge in order to make the bidding process more efficient: a member of Marketing Support was employed to design and maintain a 'Proposals Library' which contained all the information required for pre-qualification documents, tender documents and expressions of interest. It included formal information such as company statistics, as well as formalized knowledge on, say, the company's skills, behaviour towards the environment, regional capabilities, benchmarks and quality management. Clearly non-project-specific, 'back office' tasks are more amenable to standardization, serving to emphasise the difficulty of managing knowledge within and between transitional project-based tasks.

For other interviewees from the Construction industry, knowledge management was located within existing activities such as training, mentoring, de-briefing and the maintenance of conventional documents, such as a Standard Project Procedures Manual. When asked how knowledge is managed, the Managing Director of a small roofing company emphasised the importance the company placed upon training. Skills training needs analysis had been done in collaboration with Scottish Enterprise and this had led to in-house training installation for labourers and out-sourced training in CAD. Some training was leading to the Scottish Vocational Qualification in Waterproofing; many staff had been trained in health and safety. The Construction Industry Training Board had profiled the company's IT needs and this had led to training in IT skills. Not all training was formal: the MD encouraged staff to learn from their mistakes and mentor others.

In fact, for those attempting formal KM in Construction, some problems had arisen. In the firm specialising in civil engineering, information capture was formalised in facts and figures on past projects kept on a database, and on project de-briefing forms, designed to capture 'lessons learnt'. However, the interviewee described these as being, "*not accessible to new people because they'd not know where to look.*" Another interviewee in the same company described how project de-briefing meetings had been introduced for Quality Audits to capture project knowledge. These meetings had lost their importance over time and representation at the meetings varied between departments and had generally declined. However, this employee, who had studied KM as part of an MBA, felt that these meetings were essential to knowledge sharing within the company. Another interviewee noted: "*Reports in electronic format can be difficult to share with operatives.*"

Formal knowledge management tools and techniques were also evident within the SCS sector. For knowledge capture, one IT consultant, who was mainly writing software such as databases, documented information on clients, software and objects. Client files included information on who he was working for and why. Project files recorded what the project was, why he's doing it, what he's done, progress to date, thoughts and ideas for the future, potential clients, bugs and problems to solve. Object files were files about particular technologies such as internet server configuration.

The software consultancy employing 9 staff used more sophisticated software, specifically designed to track the technical development of products (such as a description of the original problem, how the source code was designed, how the code solves the problem) and all aspects of the business (for example, policies, procedures, company contacts, communications with clients and links to documents, letters and e-mails and concerns and improvements, that is, new business opportunities, potential problems arising, suggestions for improvements and so on).

In summary, formal KM existed in both sectors, but not necessarily employing bespoke KM tools and techniques. However, when asked about activities and work processes, such as the sources of knowledge and information used for problem-solving and creative work and the way in which the sources are accessed and used, some differences between the sectors began to emerge.

In Construction, when asked about sources of knowledge for problem-solving, an interviewee cited personal experience and the experience of colleagues as a source:

> "*You solve a lot of the problems by going back to the work you have previously done. Therefore, the knowledge you use is based on your life experiences. Some of this knowledge would be in your brain. Some of it would be on bits of paper. You refer to these. Or, you refer to your colleagues who you know solved that problem.*"

Another said, "*90% of it is communication*: *We discuss it with everyone associated with the contract… Innovative ideas emerge through informal communication.*" (An interesting point of note here is the specific reference to those bound by commercial agreement: "*everyone associated with the contract*".)

There was a slight difference in emphasis for commercial (as opposed to Project) Construction staff. Although people (through processes such as '*networking*' and '*word of mouth*') were sources of knowledge, so too were a number of published sources. When asked about sources of knowledge, one manager in a civil engineering company cited several external sources. His responsibilities were in 'commercial' areas, such as business development, pre-qualification and bid management. He had no line management responsibilities for projects. Business development led him to utilise: "*market intelligence from industry publications*"; "*EU websites*"; "*word of mouth*"; "*national press*"; "*networking*"; "*letters of commendation*"; "*trade & technical press*"; "*publications which track the planning process*"; "*personal network in industry*"; "*internet*"; "*ICE's lending library*". Similar sources were cited by an Area Manager working for a large national contractor whose work also involved business development.

Now for SCS personnel dealing with business/commercial issues, the sources of knowledge are broadly similar (albeit with less reliance on broadcast media and more on local and specialised sources): "*the internet*"; "*Federation of Small Businesses for low-cost services like insurance*"; "*Government [web]sites for information on regulations*"; "*Consultants*"; "*User Groups*"; "*We have internal resources like SAGE, MS Office and a 'Concerns & Improvements system*"; "*Trafford Park Business Forum*"; "*Local universities*".

But when problem-solving technical issues, those in Software & Computing Services used a wide variety of references. These included, "*Technical documents from bookshops'; "Buying books" or "browsing bookshops*"; "*newsgroups*" [internet]; "*discussion groups*" [internet]; "*Trade materials such as CDs with code samples*"; "*Source code from Microsoft site*"; "*Product literature*"; "*Trade associations*"; "*White papers*"; "*Open-source software – Linux*"; "*Groups of advocates (on the internet)*"; "*Gurus who put source code on the internet to prove they're clever*"; "*Microsoft events*"; "*Bullet boards*".

What emerges, therefore, is a picture of two industries which use broadly similar knowledge sources for their commercial/'back of house' operations, albeit that the SCS personnel are perhaps more innovative in their use of specialized knowledge, as illustrated by their reference to *Consultants*, *User Groups* and *Local universities*. However, for technical problem-solving the contrast between the sectors is stark. Where Construction relies upon the experiences of self and others, SCS consult a large number and a wide range of sources, such as *newsgroups, white papers* and *browsing bookshops*. Unsurprisingly, they use the internet to access (eg. by "*lurking*") or interact with, knowledge sources, projecting an image of the industry as far more outwardly engaged than Construction. The outward-orientation of SCS is further exemplified by these comments: When asked where new ideas came from, the Director of Product Realisation in a software consultancy said,

> "*Keeping up to speed on what's possible; from the vendor – technical seminars from Microsoft give you an idea of what kind of technologies might be out there; continuous investment in training – it is often so easy to do something once you know how, that it is easier than figuring something out yourself*"

His Managing Director said,

> '*...efficiency. We can't afford to waste time so we need efficient use of information - fast searches of databases, queries, reports and to act on the information. For example, we need to be able to identify a trend and do a mailshot. We're looking to capture information and re-use it.*'

The image of Construction as somewhat introspective is reinforced when examining responses to the question, "Can you describe your knowledge, skills and expertise?" At one construction company, an interviewee described his knowledge, skills and expertise as, '*Having come from the ranks, being a life-long learner and learning from others.*' Another declared: '*Construction is experience orientated. Experience gained through site work is necessary.*' This can be contrasted with an IT consultant who, when asked the same question, described himself as having, '*intelligence, experience (that provides a base of knowledge), being intuitive with technical things, good at day-to-day information management (for example, setting up processes for stock control), financial management in small businesses, leading teams and risk averse.*' Whilst experience features, it is clearly not everything.

Finally, the research confirmed previous findings that structural characteristics of the U.K. construction industry impede knowledge sharing. In this case, contractually-bound inter-firm relationships and litigious attitudes impede knowledge sharing:

> "*We need to review the number of systems and procedures in place to focus on those that have tangible benefits, rather than following all the procedures in*

order to cover our backs in case there is litigation. We should increase social interaction between employees and keep morale high to improve communication."

This mirrors the comment made earlier : *We discuss it **with everyone associated with the contract…"***

Conclusions

The construction industry is perceived as having some structural features that inhibit the effective and efficient deployment of knowledge. These include the formation of project teams, comprised of personnel from a number of commercially-bound organizations, who design and construct building within tight time and cost constraints and then disperse (Teerajetgul & Charoenngam, 2006). The research confirmed the challenges that arise as a consequence: firms are sometimes preoccupied with avoiding litigation at the expense of managing knowledge.

Both the construction and the SCS sectors employed a range of tools and techniques for the purposes of managing knowledge - a knowledge-sharing tool, a proposals library, training and debriefing. However, some construction staff were candid about the problems that the initiatives had encountered – debriefings forms were hard to find, debriefings meetings lost their importance, it was hard to involve site staff - which lends support to Robinsons et al's finding that, the practice of knowledge management is not yet mature in the industry (2005).

Two significant finding relate to the **sources** of knowledge employed by the two sectors and the **means** by which those sources were accessed. The sources of knowledge, such as on-line discussion groups and trade associations, used by the SCS consultants were many and varied, compared to Construction's tendency to rely upon their own or their colleagues' experience. And where the construction industry relied upon the knowledge management process of **sharing** within the project team to generate ideas or solve problems, particularly technical problems, the SCS industry looked beyond those involved with the project. The knowledge processes of **browsing**, **copying, plagarising, reverse engineering, training** and attending **seminars** emerged as ways of drawing new knowledge into the firm, rather than seeking to invent new solutions 'in-house'.

Where the construction industry valued experience, the SCS named a range of personal and professional competencies which were regarded as significant. Indeed, the construction industry's continued reliance on experience has been criticized elsewhere (Hari, Egbu and Kumar, 2005);

> Heron (1985) suggests that people acquire a vested interest in failing to notice the inadequacies in the face of experience,.. Sutton's (1983) belief is that too often experience is the barrier to learning. Boydell (1976) admits that a great deal of weight is often given to experience, but in practice experience becomes synonymous with "age" or "length of service"… Boud and Walker (1990) believe that a manager's greater awareness as to what is happening in, and a more deliberate interaction with, the learning milieu will provide greater opportunities for a more fruitful learning experience.

What this research indicates, albeit from a very small data set and with a need for further investigation, is the continued existence of a mindset in the U.K. construction industry which

- values experience as a source of knowledge and
- sharing as the process of accessing that knowledge and
- the project-specific supply chain as the pool from which that knowledge should be sought.

This research also illuminates an alternative mode of operation, that of the SCS industry which is, in contrast, outward-looking. Clients, competitors and suppliers are seen as sources of knowledge and 'begging, stealing and borrowing' characterizes the processes of accessing that knowledge. Sharing happens (often on-line) in discussion groups, newsgroups, on message boards and, notably, through open-source software, with a (potentially infinite) group of fellow professionals, whether they are colleagues or competitors, known or unknown. These two styles may be characterized as 'inward-' and 'outward-looking'.

Further research is needed to confirm whether these features are wide-spread throughout both industries. If this is the case, a number of other questions are raised: is there something about the nature of the 'product' (ie. something innately different about buildings and databases, web interfaces, creating and maintaining IT networks) that means that they demand different KM approaches? Is there something about the nature of the procurement process that results in different KM approaches being adopted? What are the relative advantages and disadvantages of each mode of operation?

In the UK, there has been a movement away from lowest cost, competitive tendering (e.g. under a traditional JCT Design & Build contract) towards partnering (e.g. under a PPC 2000 or NEC/ECC contract). This often occurs within framework agreements, where (particularly public sector) clients have a small pool of major contractors from whom they select, with the intention of reducing tendering costs, generating better value and enabling continuous improvement through repeat work. Similar agreements exist between some major contractors and second tier suppliers. These new collaborative forms of working are designed to reduce the litigiousness that has for a long time characterized the construction industry. Following the questions raised above, it would be interesting to explore whether there are any indications that construction companies are any less inward-looking in their search for, and assimilation of, new knowledge under collaborative working agreements.

The Innovation literature is quite clear that the capacity to absorb new knowledge relies upon searching for knowledge, making associations with existing knowledge, assimilating new knowledge and then applying it (Cohen and Levinthal, 1990; Trott et al., 1995). The findings presented here suggest that absorptive capacity is substantial within the SCS sector but limited (contingent upon the experience of colleagues and associates) in Construction. Examining the respective benefits of each mode of knowledge management (inward- and outward-orientation) should examine whether these models of absorptive capacity hold true for multi-firm, project-based form of organization and whether they have the effect of limiting innovative problem-solving. Is it possible that this inward-orientation confers other advantages such as the generation

of local, applied learning and knowledge transfer/cross-fertilisation with the (re)formation of new project teams?

This research confirms some previous findings, such as the immaturity of knowledge management in the construction sector and presents some interesting new findings – the introspection of knowledge management within Construction compared to other sectors. Further research, on a larger scale, is needed to confirm these findings and to better determine what factors influence style of knowledge management.

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