THE EFFICACY OF USING APPROPRIATE TECHNIQUES AND TECHNOLOGIES FOR KNOWLEDGE CAPTURE IN SMALL AND MEDIUM ENTERPRISES IN ARCHITECTURE, ENGINEERING AND CONSTRUCTION

Subashini Hari, Charles Egbu and Bimal Kumar

School of the Built and Natural Environment, Glasgow Caledonian University,
Glasgow G4 0BA, Scotland, UK

Email: s.hari@gcal.ac.uk

Abstract: Knowledge capture techniques and technologies are important for any knowledge management strategy. Organisations that have implemented knowledge management (KM) strategies seem to have realised that if techniques and technologies are not carefully selected, the likelihood of success is very limited. This requires careful selection of techniques and technologies based on the organisations’ needs and the functions that these can perform. There seems to be very few empirical and construction related studies on knowledge capture geared towards small and medium enterprises (< 250 employees). This paper investigates the efficacy of current techniques (informal and/or paper based) and technologies for capturing knowledge (including knowledge of individuals) within organisations in small and medium enterprises (SMEs). The paper is based on an-ongoing PhD research study which adopts, inter alia, a grounded theory approach as a systematic means of investigating knowledge capture in SMEs. Forty one architects, engineers and contractors from the UK were interviewed as part of the study. The paper documents and discusses the main challenges which SMEs face with regard to the capture of employees’ knowledge through the use of current and existing techniques and technologies. Attempts were also made to establish which techniques and technologies the participants felt would be helpful to capture knowledge for the future (next five years). The paper concludes that capturing knowledge in SMEs is not easy. It is an integrated and complex social process, which has culture, people, technology, communication, leadership and organisational structures at its core. Similarly, face to face discussion is the most effective technique to capture tacit knowledge and project database is the most effective technology to capture explicit knowledge. It is suggested that a qualitative research has been adopted in this research study is necessary to uncover many of the complex and intricate issues associated with knowledge capture in SMEs.

Keywords: grounded theory, knowledge capture, knowledge capture techniques and technologies, small and medium enterprises.

1. INTRODUCTION

The UK construction industry has changed significantly over the last 50 years, placing considerable pressure on its organisations to respond to their business environment (Holt et al., 2000). Demands for industry-wide improvement led to a series of government commissioned reports examining the industry’s structure, culture and operation (Latham, 1994 and Egan, 1998). The important role of improving people-management practices within the construction industry has also been recognised by
reports such as the Rethinking Construction report on respect for people (Rethinking Construction, 2003). Knowledge management (KM) can also promote innovation and business entrepreneurship, help manage change, and emancipate and empower employees (Nonaka and Takeuchi, 1995). This view is supported by the UK Government in its White Paper focusing on KM (Department of Trade and Industry, 2000). It is argued that the main drivers behind the increased interest in KM amongst organisations operating in the UK construction industry are the Government’s prerequisite to achieve industry-wide improvements and the desire of individual organisations to seek competitive advantage. The industry has begun to recognise that knowledge is an asset, just like the physical assets of an organisation (Wiig, 2000).

The question regarding the nature of knowledge is extremely challenging. Although philosophers have been discussing the issue for several hundred years, the search for a formal definition continues (Emery, 1999). The definitions appearing in the literature range from studying knowledge from a broader perspective to more sophisticated definitions. For the purpose of this research, knowledge is viewed as a complex concept which consists of information and skills acquired through experience; truth and belief, perspective and judgements, expectations and methodologies. Knowledge exists in individuals, groups and in organisations, in various forms. Knowledge can be tacit and explicit (Nonaka, 1994). Tacit knowledge is personal, context-specific, subjective and experience-based knowledge and therefore, hard to formalise. Explicit knowledge, on the other hand, is formalised, coded in a natural language (French, English, etc.) or artificial language (Unified Markup Language, mathematics, etc.) which could be transmitted. It is objective and rational knowledge that can be expressed in words, sentences, numbers or formulas. It includes theoretical approaches, problem solving, manuals and knowledge base.

Polanyi (1962) and Ryle (1949) suggest that the distinction between tacit and explicit knowledge is critical to understanding how people deal with the world in a purposive manner. Sheehan et al (2005) argued that an appropriate balance of ‘explicit’ versus ‘tacit’ approaches depends on each organisation’s strategy and the particular case in point. An organisation is bound to require elements of both approaches and must integrate the two effectively. Hence, the focus of the study presented in this paper, is to consider both tacit and explicit knowledge. The operational definition for knowledge capture adopted in this research is defined as a process, through which knowledge is recognised from its source, examined and in accordance with the organisation’s strategy. Appropriate techniques and technologies are implemented to retain the knowledge, which is filtered, banked, disseminated and updated. The process is iterative (Hari et al, 2004).

A thorough review of literature identified the following KM tools: storytelling, knowledge maps, ontologies, organisational memory information system, expertise directory, e-learning and performance tracking system, virtual collaborations, content management, specialised web-oriented search, categorisation tools, data mining system and information repositories (e.g. documents, databases, electronic document management system to name a few. Egbu and Botterill (2002) have conducted an empirical study on construction, manufacturing, aerospace and the utilities organisations in the UK to investigate the information technologies for KM. Egbu et al (2003) in one of their interim report for “Knowledge Management for Sustainable Construction Competitiveness” project cited that a survey of 170 UK construction organisations
carried out by Loughborough University by Carrillo et al (2002) showed that Communities of Practice (CoPs) is the most widely used technique for knowledge management particularly in large organisations. Large construction organisations with a range of specialist skills tend to have the need and resources to set up communities of practice and to benefit significantly from them. Other techniques that are used include brainstorming, job observation and rotation systems, research collaboration, conferences and seminars. However, there is a lack of empirical study in small and medium enterprises (SMEs < 250 employees) in architecture, engineering and construction (AEC) organisations in UK.

Levy (2003); Frey (2002); McAdam and Reid, (2001) and Sparrow (2001); have considered KM in SMEs in other sectors such as the business sector, manufacturing and hospitality. Capture and re-use of project knowledge in construction a research is in progress (CAPRIKON, 2003). Another research investigated the use of audio diary to capture knowledge events in a project environment in SMEs in construction industry (Boyd et al 2004). Few papers based on this research are discussed in Egbu et al (2005), Hari et al (2004, 2003) to mention a few. However, there seems to be paucity of empirical evidence for knowledge capture tools (techniques and technologies) in SMEs in the AEC industry from an organisational perspective.

This paper investigates the efficacy of current techniques (informal and/or paper based) and technologies for capturing knowledge (including knowledge of individuals) within organisations in SMEs. The paper is based on an-ongoing PhD research study which adopts, inter alia, a grounded theory approach as a systematic means of investigating knowledge capture in SMEs. The paper documents and discusses the main challenges which SMEs face with regard to the capture of employees’ knowledge through the use of current and existing techniques and technologies. Attempts were also made to establish the future (next five years) techniques and technologies the participants felt would be helpful to capture knowledge.

2. RESEARCH METHODOLOGY

In this study, qualitative research approach which includes grounded theory has been adopted to uncover many of the complex and intricate issues associated with knowledge capture in SMEs. Glaser and Strauss, (1967) first described the method of grounded theory in 1967 as a means of enabling the ‘systematic discovery of theory from the data of social research’. Since then two different approaches have emerged; the Straussian and the Glaserian. It should also be noted that a number of other adaptations have developed as identified by Heath and Cowley (2004). Backman and Kyngas (1999) suggest that the researcher should follow one particular author i.e. Glaser or Strauss and then develop their own method using one of these as a foundation for analysing data. If the researcher was to apply a combination of applications of grounded theory from different texts this would undoubtedly result in confusion and the resulting findings would be lacking in substance. Hence this study chooses the Strauss and Corbin methodology for analysis of data.

In terms of obtaining a suitable sample size in grounded theory, the grounded theorist does not decide on the size of the sample population before the study begins. Sample size is deemed to be satisfactory only when the key concepts that have been identified
from the collected data have reached saturation point, in other words, when no new data emerges. However, Morse (2000) cited in Robson (2002) suggests that to reach saturation point, the sample size depends on several factors: the scope of the study, the nature of the topic, quality of the data, study design and research technique. Semi structured interviews were used as research technique for this study. Morse (1994) produced a ‘rule of thumb’ for grounded theory studies recommending approximately thirty to fifty interviews. This research included 41 interviews.

Organisations that participated in the study employed more than 10 people but less than 250 employees. Database for the study was collected from the Small Business Gateway (2003) for the construction industry. The period of study was from 5th April – 27th August 2004, Scotland, UK. The sample consisted of seven small and eight medium enterprises (Table 1). Attempts were made to have a sample across the architecture; engineering and construction organisations.

**Table 1: Organisation distribution in the construction industry that participated in the study**

<table>
<thead>
<tr>
<th></th>
<th>Organisations</th>
<th>Architects</th>
<th>Engineers</th>
<th>Contractors</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4</strong></td>
<td><strong>6</strong></td>
<td><strong>5</strong></td>
<td><strong>15</strong></td>
<td></td>
</tr>
</tbody>
</table>

Twelve (12) interviews from small and 29 interviews from medium enterprises were interviewed (Table 2). This difference clear indicates the characteristics of small firms, where the owner/partner/manager assumes that he/she knows about the organisations and there could not be any important information that the others might contribute to the research.

**Table 2: Distribution of the job role**

<table>
<thead>
<tr>
<th>Hierarchy</th>
<th>Organisations</th>
<th>Partners</th>
<th>Managers</th>
<th>Engineers</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>7</td>
<td>11</td>
<td>11</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
<td><strong>15</strong></td>
<td><strong>14</strong></td>
<td><strong>41</strong></td>
<td></td>
</tr>
</tbody>
</table>

Interviews with personnel across organisational hierarchy allowed some insights at organisational, group and individual levels. Interview in this research spanned between 45 minutes to one hour. Interviews were recorded through a digital dictaphone and later transcribed.

Grounded theory is a repetitive process; the analyst is required to return constantly to data sources, to check aspects of the emerging interpretation and to gather new data where appropriate. Indeed, Smith (1997) refers to grounded theory as a process of constant comparative analysis. The main features of the area of interest are mapped through repeated comparison of the data. In-depth detail regarding grounded theory approach adopted for this research is not presented in this paper, due to space constraints. For more details refer Egbu *et al* (2005).
3. TECHNIQUES AND TECHNOLOGIES FOR KNOWLEDGE CAPTURE WITHIN SMES IN AEC: AN EMPIRICAL FINDING

Ruggles (1997) and Tiwana (2000) state that knowledge management tools are technologies, broadly defined, which enhance and enable knowledge generation, codification and transfer. As with any tools, they are designed to ease the burden of work and to allow resources to be applied efficiently to the tasks for which they are most suited. It is important to note that not all knowledge management tools are computer-based, as paper and pen can certainly be utilised to generate, codify and transfer knowledge. This research adopts Al-Ghassani et al (2002) who refers to KM tools as KM techniques (non-information technology (IT) tools) and KM technology (IT tools) (Table 3).

Table 3: KM tools: A comparison between the techniques and technologies (Source: Al-Ghassani, 2002)

<table>
<thead>
<tr>
<th>KM tools</th>
<th>KM Techniques (non-IT)</th>
<th>KM Technologies (IT)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>More focus on tacit knowledge</td>
<td>More focus on Explicit knowledge</td>
</tr>
<tr>
<td></td>
<td>Requires strategies for learning</td>
<td>Requires IT infrastructure</td>
</tr>
<tr>
<td></td>
<td>More involvement of people</td>
<td>Require IT skills</td>
</tr>
<tr>
<td></td>
<td>Affordable to most organisations</td>
<td>Expensive to acquire and maintain</td>
</tr>
<tr>
<td>Examples:</td>
<td>Brainstorming</td>
<td>Examples</td>
</tr>
<tr>
<td></td>
<td>Face to face interaction</td>
<td>Internet/Intranets/Extranets</td>
</tr>
<tr>
<td></td>
<td>Training</td>
<td>Knowledge bases</td>
</tr>
</tbody>
</table>

Knowledge Capture Techniques (Non-IT)

Interviewees discussed various techniques that they use in their job role and in their organisation to capture knowledge (see Figure 1). The first technique that emerged is face to face discussion that occurs at various levels (partner, manager and engineer) which was suggested by 41 interviewees. At partner level they have close contact with client i.e. understanding client priority, informal feedback from client and word of mouth marketing. Partners review financial aspects about the projects. Through this it is evident to the partners/owner-managers which project is delayed and which project is on time. Henceforth, partner’s/owner-manager have knowledge about the projects and well as the clients. At managers level they have meetings with the project teams which included allocating jobs, checking on projects, discussing issues and complaints which engineers have on projects.
Project reviews are held at various stages with experts within the organisations at tender stage, contract stage, design stage and at times crucial stages in construction phase. The knowledge created and captured during this process is in tacit form. There are no documentations of the lessons learnt or best practice at this stage. The experts in two medium organisations have made a document on frequently asked questions. This is an indication of how tacit knowledge been converted to explicit form. In the engineers level informal discussion is by asking their colleagues in the corridor or just shouting the questions if anybody as come across a particular technical aspect or discussing with their immediate line manager. Exit interviews were conducted when an employee leaves the job. Shadowing, send of party and informal discussions were the categories that emerged for exit interviews. Eleven interviewees said that they have shadowing for one week. Send-of-party was revealed by three interviewees where story telling was the main focus. All the interviewees said that the exit interviews were mostly face-to-face discussions with their partners/owners-managers. It is evident that there is no formal capture of knowledge during exit interviews. However, it could be argued that techniques such as shadowing and story telling help to retain some tacit knowledge.

The second knowledge capture technique that emerged from the 41 interviews was paper based folder on projects. This folder contains summary sheet of the project at the start of the folder which includes client details and the contact list of the organisations involved in the project for example list of quantity surveyors, structural engineers, contractors and other services. Summary sheet is followed by project process sheets.
which contains three phases namely pre construction phase, construction phase and post construction phase. The pre construction phase contains building warrant, planning permission, designs, meeting minutes about working drawings, tender documents and appointment of the contractor/engineers/services. Construction phase documents contains site meetings with the project team, time sheets (time needed to complete a particular task) and site instructions. The time sheets are revisited if and only if the project is delayed or if the project is financially over run by partners / owner-managers. It was noted that the best or worst practices identified during the project execution were not formally captured and not widely disseminated in the organisation. During the post construction phase depending on the size of the project and depending on the clients, post project review was prepared. Formal procedures of project handover were evident in three interviews. While others followed informal procedures which involved discussion with clients regarding their satisfaction with respect to quality, time and cost to name a few. It was evident that most of the knowledge gained during projects remained tacit in nature with those employees involved in the project.

Other techniques that emerged were trade journals (41 interviewees) followed by annual review which was revealed by 28 interviewees. It was mainly to review the training requirements of the employees. Technical folder was suggested by 28 interviewees. This folder contained technical guideline documents, templates for checklists at various stage in the project and templates for letter and faxes. Communities of Practice which included: technical group, project feedback procedure group and marketing group were evident in 14 interviewees. Followed by personal notes (9 interviewees), drawing boards (3 interviewees) and newsletters (3 interviewees) as knowledge capture techniques in SMEs in the AEC organisations.

When the interviewees had discussed about the techniques, they were then questioned about the efficacy of the techniques that the interviewees had stated. From the interviews it emerged that the most efficient technique in an SME in AEC organisation are: Face to face discussion (21 interviewees) which included financial review and project reviews; Paper based project folders (13 interviewees); personal notes (5 interviewees) and documentation of frequently asked questions developed by experts (2 interviewees).

Face-to-face discussion helps in increasing the organisation’s memory, developing trust and encouraging effective learning. Lang (2001) considers it to provide strong social ties and tacit shared understandings that give rise to collective sense making. This can also lead to an emergent consensus as to what is valid knowledge and to the serendipitous creation of new knowledge and therefore new value. It is interesting to note that in Egбу and Botterill (2002) study face-to-face discussion was ranked as being one of the most effective techniques for KM, supporting the notion that social interaction is a pre-requisite for successful KM (Davenport and Prusak, 1998). This view has been supported by Ingo Hoffmann (2000) who suggests that transfer of information and knowledge occurs primarily through verbal communication (experiential knowledge, rules-of-thumb, tips and tricks).

The interviewees were asked to volunteer information on the techniques they were likely to use for knowledge capture in the future (next 5years). Twenty one interviewees expressed the need for formal procedures to see why a particular task went well or wrong. Use of technology as an enabler to capture, store and share knowledge
was suggested by 21 interviewees. Thirteen interviewees suggested that they would like to have seminars by experienced staff on right and wrong things by devoting time and resources.

**KM Technologies (IT Tools)**

Information Technology supports the collection, storage, processing and communication of information by electronic means (Armstrong 2001). Construction organisations have been slow to acknowledge the benefits of IT in managing knowledge (Egbu et al., 2001), suggesting that the role of IT for KM in these organisations, needs to be addressed. During the semi-structured interviews the interviewees discussed various technologies that they use in their job role and in their organisation to capture knowledge (see Figure 2).

![Figure 2: Technologies for knowledge capture in AEC organisations](image)

The first technology that emerged is telephones (41 interviewees) followed by fax (41 interviewees), emails (41 interviewees), internet (40 interviewees), project database (39 interviewees), digital camera (23 interviewees), scanners to convert the drawings into electronic format (14 interviewees), technology to convert hand written material into text or drawing format (12 interviewees), Intranet (11 interviewees), teleconferencing (8 interviewees), collaborative tools (5 interviewees), electronic board (3 interviewees) and video recording (3 interviewees). When interviewees had discussed about various technologies, they were then probed into the efficacy of the mentioned technologies for knowledge capture. Interviewees suggested that the most efficient technologies in an SME in AEC organisation are: telephones (16 interviewees) followed by project database (15 interviewees), emails (6 interviewees), intranet (2 interviewees), electronic board (1 interviewees) and collaborative tool (1 interviewees).

Collison and Parcell (2001) suggest that in an ideal world, people would all share knowledge in a face-to-face discussion and never need to capture knowledge. The only difficulty is none of the person is omnipresent (cannot be everywhere at once). In this study it was revealed that the owner/partner/managers were available to be contacted by their staff members at any given point of time through telephone.
An empirical study by Department of the Environment, Transport and the Regions, (DETR, 1999) reveals that almost all construction professionals are computer users, particularly in word processing, spreadsheets and CAD, with high rates of emails and internet access. However, some felt working with drawings on the screen was difficult. The DETR study reveals that for many users the technology is not yet used to its full potential and capacity. This was evident in this study as 39 interviewees had electronic project databases but it was only 15 interviewees who said project databases are an effective explicit knowledge capture technology. These project databases contained the aspects of projects as discussed earlier in this paper under knowledge capture techniques for paper based folder on projects.

The interviewees were asked to volunteer information on the technologies they are likely to use for knowledge capture in the future (next 5 years). They suggested: wireless gadgets that could facilitate in capturing knowledge (20 interviewees) namely laptops with wireless network connection; Software like AutoCAD that could enable 3D drawings (2 interviewees); provide internet access to clients for enquiries (2 interviewees); develop intranet to inform employees about: the projects, new recruitments, events scheduled to take place and discussion groups was suggested by 2 interviewees followed by extranets that enables to work on a single building model and also clients could have access to it (1 interviewee). The other interviewees suggested that they did not know as technology as been changing at a rapid rate.

4. CHALLENGES FOR KNOWLEDGE CAPTURE TECHNIQUES AND TECHNOLOGIES

There are many barriers associated with KM in construction industry such as the need for new organisational culture, the requirement for changing the attitude of employees, the significance of the time required, the importance of sufficient budget, and the identification of the most appropriate KM tools for the business (Al-Ghassani et al., 2002). As organisations proceed in implementing their KM strategies, they realise that if KM tools are not carefully selected, the likelihood of success is very limited. Knowledge management tools (techniques and technologies) are important for any KM strategy. In fact, they consume one third of the time, effort and cost required to develop and use a KM system (Davenport and Prusak 1998). This requires careful selection of these tools based on the organisations’ needs and the functions that these tools can perform. When interviewees were asked about the present challenges for knowledge capture techniques, it was revealed that lack of communication with colleagues (16 interviewees); time constraint (10 interviewees); lack of commitment from the staff (5 interviewees); lack of motivation (5 interviewees); people’s negative attitude to capturing their knowledge (4 interviewees); unable to use existing knowledge (4 interviewees); lack of structure to keep explicit knowledge updated (3 interviewees); cultural issues (3 interviewees); lots of bureaucracy (2 interviewees) and budget constraint (2 interviewees). Future issues for knowledge capture techniques highlighted by the 21 interviewee were to ensure: information flow between and across required teams in the organisation and structure in place so that progress can be captured, reviewed and managed.

When interviewees were asked about the present challenges for knowledge capture technologies, it was revealed that legal issues (3 interviewees), speed of change in computer industry (2 interviewees), communication issues (3 interviewees), advice
from experts (5 interviewees), need for training (18 interviewees), people attitude to adopt technology (6 interviewees), need for in-house IT knowledge (10 interviewees), security issues (3 interviewees), culture issues (9 interviewees), utilisation of the existing IT (10 interviewees), finance issue (9 interviewees), IT selection (6 interviewees), lack of time (2 interviewees) and upgrading issues of technology (3 interviewees). Future issues for knowledge capture technologies highlighted by the interviewee were more training needed with regards to software packages (20 interviewees) such as computer aided design and file management. Followed by effective utilisation of present technology resources (9 interviewees), for example at present buyer’s and planning department do co-ordinate by word of mouth and through regular meetings; in the future it could be put on the IT system. The last issue emerged was upgrading the IT systems which emerged in 6 interviewees.

It is interesting to note that the present challenges for knowledge capture techniques and technologies emerged from this study can be summarised as lack of: culture, communication, structure, time and finance. People attitude to adopt technology and their attitude to capturing knowledge is a challenge as well. The results of this study are in line with Liebowitz (1999); Skyrme (2000) and Heisig (2001) who have identified few critical success factors/key challenges for knowledge management.

5. CONCLUSION

Knowledge capture helps to improve performance and increase productivity within organisations by: avoiding work duplication; preventing the repetition of mistakes; aiding problem solving; supporting decision-making; retaining tacit knowledge; facilitating staff training; managing and improving work practices and processes; generating competitive advantage so as to lead market (due to increased chances of innovation) and improving business performance. Knowledge capture techniques and technologies are important for any knowledge management strategy. Organisations that have implemented knowledge management strategies seem to have realised that if techniques and technologies are not carefully selected, the likelihood of success is very limited. This requires careful selection of techniques and technologies based on the organisations’ needs and the functions that these can perform.

The paper concludes that capturing knowledge in SMEs is not easy. It is an integrated and complex social process, which has culture, people, technology, communication, leadership and organisational structures at its core. Similarly, face to face discussion is the most effective technique to capture tacit knowledge and project database is the most effective technology to capture explicit knowledge. It is suggested that a qualitative research has been adopted in this research study is necessary to uncover many of the complex and intricate issues associated with knowledge capture in SMEs.

6. REFERENCES


