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PRELIMINARY CASE STUDIES OF KNOWLEDGE FLOW IN CONSTRUCTION SUPPLY CHAINS

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ABSTRACT

A critical issue in Construction Supply Chain Management (SCM) is the effective management of knowledge through the whole project lifecycle. This issue involves the enhancements of the flow of knowledge within and between different sectors of construction supply chain as well as the accumulation, coding, and storage of knowledge in the organizations. A typical construction project is one-of-a-kind, temporary, and involves different tasks which are held by different professional and trade disciplines of construction supply chains. These different disciplines of the supply chain have to work closely in an intense environment over a period of months or even years. The information shared between these organizations varies from technical drawings and legal contracts to purchase orders, project reports, and schedules. Moreover, project knowledge which has to be shared within and between the organizations is interconnected and includes all the knowledge about the end product. Within such a complex environment, the efficient flow of project knowledge between all the sectors of construction supply chain will directly improve all the SCM efforts. This paper presents the findings of preliminary case studies on knowledge flow in construction supply chains. The supply chain management approach and the main problems regarding the supply chain and the knowledge management practices in two supply chains are discussed. It also presents the research method to identify the knowledge requirements of different sectors of the construction supply chains. It concludes that the application of a systematic approach to knowledge management in construction supply chains will bring enhance knowledge flow and enable these supply chains to become construction knowledge chains.

Keywords: Construction, Knowledge Chain, Knowledge Management, Supply Chain Management.

INTRODUCTION

Construction Supply Chain Management (SCM) can be defined generally as managing the process of knowledge flow, financial flows, materials, activities, tasks and processes involved within various networks and linkages (upstream and downstream) of organisations in order to develop high quality construction products and services to clients in an efficient manner (Akintoye et. al., 2000; Tucker et. al. 2001). In construction supply chains where there is huge knowledge and information flow between the contractors, subcontractors, suppliers and distributors, it is essential to create a collaborative environment during the projects from the bidding phase to the delivery to customer. Construction projects are generally unique and may need different supply chain configurations for each project. There are also important issues regarding to the creation, and storage of the knowledge. Creating a collaborative working environment within this variable and complex supply chain context can be problematic. Thus, cross-discipline coordination and knowledge exchange are crucial for these multidisciplinary collaborative processes in the construction supply chain management (Aouad et. al., 2002). For effective supply chains, all elements of the supply chain must be connected to enable the flow of knowledge (Desauza et. al., 2003). This creates heavy reliance on information and knowledge management to coordinate the whole supply chain (Tucker et. al., 2001). As a result, the flow of knowledge within both the downstream and upstream of supply chains is considered a critical issue in construction supply chains.

An investigation of supply chain management (SCM) with a knowledge management perspective will support the main objectives of supply chain management and create an innovative environment for knowledge cultivation, transfer and diffusion during construction projects. The integration of KM practices by considering both the social and technical perspectives can be very helpful to produce high quality, lower costs, and just in time knowledge sharing within construction supply chains. This integration can benefit significantly from a systematic approach. The application of a systematic approach facilitates determining that a problem exists, refining the problem, generating possible solutions within a defined set of limiting conditions (constraints) and determining which solutions are best according to the stated criteria (Jewell, 1986). This approach recognizes that a problem and its solution have many elements or components and there are many different relations among them (Sage & Armstrong 2000). Therefore, this will help to define components, decide which components should be included in the system, and define how the components are related to each other (Holmberg, 2000). Parnaby (1995) states that organisations which use a systematic approach in their operations deliver better engineering solutions throughout all their activities. Using this approach can be very helpful in anticipating a variety of viewpoints and requirements and planning for accommodating these viewpoints and requirements (Jewell, 1986). The structivist character of the systems approach can be very helpful in building the structure, processes or operations of the construction supply chain in a systematic manner assuring its effective functioning (Vrijhoef & Ridder, 2007).

In this paper, project knowledge is treated as a large system and the subsystem of the project knowledge is defined as the knowledge belonging to each supplier of the project. Within the construction domain, project knowledge is interconnected and includes all the

knowledge about the end product, the processes involved in its creation and the resources needed (Anumba et. al. 2005). The main aim of investigating the project knowledge with systematic approach is to clarify the following:

- *What knowledge is needed by each supply chain actor to undertake his/her own tasks?*
- *With which supply chain actors does the supplier share this knowledge?*
- *How is knowledge transferred from one supply chain member to another?*
- *How is the knowledge stored?*
- *Which are the problem areas in ensuring smooth knowledge flow?*

To address these questions, a case study was undertaken and is described below.

CASE STUDIES

Introduction

The main aim of this case study is the identification of the knowledge requirements of different parts of the construction supply chain and investigating the interdependencies across the supply chain. To achieve this aim, the study has the following objectives:

- Investigate what are the current issues of construction supply chains;
- Investigate how/what knowledge is diffused through the supply chain from the beginning of knowledge creation; and
- Investigate how/what knowledge is shared between different supply chain actors.

To achieve these objectives a three stage case study was undertaken. The study started with sending the request letters to the contractor organizations. After acceptance from the companies, there were three main stages which involved a set of interviews in each company and its supply chain for a particular project (see Figure 1). This paper reports on the findings from stages 1 and 2.

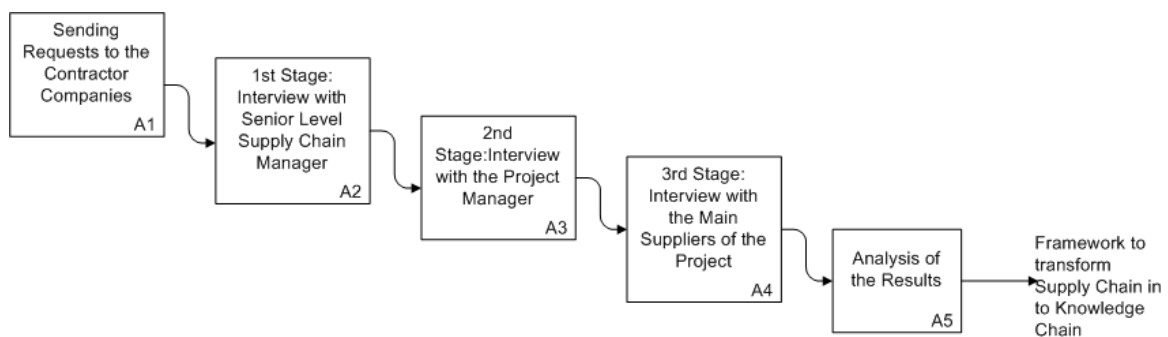


Figure 1: Workflow of the Case Study.

The main reason for planning the case study in three different stages comes from the need to access different types of knowledge in each stage of the case study with a systematic approach. The main output of the first stage is the understanding of the general supply chain management problems of the contractor organisation. The second stage is planned as an interview with the project manager of a recently finished or nearly finished project so as to review the knowledge management practices in the supply chain throughout the

project life cycle. This will provide an insight into the general project management approach, and access to the knowledge flow within a real project. The third stage is intended to review how the knowledge was created, transferred and stored throughout the whole project lifecycle in the supply chain

The Case Study Organizations

Two large construction organizations were targeted as the case study companies based on their large volume of work and previous links with the university. Company A is based in the UK and has revenue of £1.8 billion and a workforce of 50,000 people worldwide. Its portfolio of work includes facility management services, project services (construction, infrastructure, consulting), specialist services as equipment hire, M&E services, PFI investments and consulting. It operates in the UK (56%), Middle East and Africa (30%) and Rest of the World (14%). Company B is also based in the UK, and has revenue of £3.2 billion and a workforce of 31,000 people worldwide. It is working in project services (construction, infrastructure, consulting), PFI investments, specialist services such as equipment hire, manufacturing, M&E services, and consulting. It operates in the Europe 76%, Middle East and Asia (10%), Australasia (14%).

First Stage of the Case Study

The first stage interview in Company A was undertaken with the following: a supply chain manager (with 40 years industry experience, 10 of which are within Company A) and a bid manager/cost estimator (with 16 years industry experience, 11 of which are within the company). In Company B, interviews were held with a supply chain manager (15 years in industry and 10 within the firm) and a design leader (30 years in industry with 25 of these within the company).

Results of the First Stage

Company A:

Company A has three main business divisions within the construction business as follows: Strategic Projects (£15 million- £300 million), Infrastructure (civils, roads, water treatment), and Regional Building Construction (9 independent regional offices in UK). Each of these business divisions has its own supply chain and, currently, they have 600 suppliers within their construction supply chain.

Assessment of Supply Chain:

The list of supply chain members is regularly reviewed on a national database with respect to their performance and project delivery. At the end of projects, suppliers are reviewed according to a standard assessment and scored out of 10. Similarly, subcontractors are assessed in order to evaluate project performance. Apart from standard measures such as financial stability, on time delivery, and cost, Company A looks for ethics, outlook and openness of supply chain partner.

Knowledge Sharing and Relations with Supplier:

Company A has a completely different supply chain compared to 10 years ago due to shifting its focus from private sector to public funded projects. Public projects required another type of supply chain to carry out the projects successfully. However, Company A still keeps 60%-70% of the previous supply chain actors within the projects and has good

relations depending on reputation, trust, paying on time, and paying fairly. Although they keep the old relationships, they are also open to new partners. They tend to use supplier protocols rather than partnering agreements. These protocols define the responsibilities of both parties involved in the supply chain relationship. Apart from written protocols and agreements, Company A arranges regional supply chain meetings once every two years in order to improve the relationships and get closer.

Problematic Areas and Knowledge Management:

The main problem areas and knowledge management issues identified include:

- Within some framework type public contracts, Company A uses BIW collaboration software for sharing project information (design, specifications, documents, etc.) with the supply chain. For the individual projects, it is quite difficult to use extranets (collaboration software) due to lack of IT skills and infrastructure in the supply chain. Within 20% of the projects, the use of BIW is encouraged through the contractual agreements with the client and supply chain. However, the rest of the projects mostly involve the same supply chain such that knowledge is kept within the projects and organization.
- Due to not having an established KM strategy and system, Company A has to review the tender package for every project rather than bringing in a supply chain partner to assist with some of the deliverables within the tender package.
- Company A does not have a collaborative database (repository) for storing or extracting project knowledge and information - this results in serious knowledge and document management problems. Knowledge management is a key issue and they are also looking for a decent knowledge management tool for their supply chain.
- Suppliers are not qualified enough to use new systems and integrate into new working models.
- Innovation mainly comes from material suppliers rather than design suppliers. Innovation is good to share with the supply chain members; however, sharing commercial knowledge can be dangerous in some circumstances.
- Company A struggles with the flexibility of their supply chain because clients do not provide any visibility on the forecasted work load. Clients are not able to agree on continuous work load due to not allocating the budgets earlier; therefore, the suppliers of the Company A work on a demand driven supply chain model.

To overcome the obstacles in their supply chain, Company A has developed some programmes and activities within the organization:

- They started to use the BIW software for storing the project knowledge by the suppliers, but it is not used efficiently for every project because it is difficult to use.
- They do not develop specific programmes but have some internal courses available to their supply chain, and suppliers can define specific areas in which they need help.
- They have Supplier Days every two years on a regional basis.

Company B

Company B is the one of the largest contractors in the UK and has a large number of supply chain partners. However, in each business unit, there has been a tendency to reduce the number of supply chain members over the last couple of years. This is because they would like to have a leaner supply chain and get closer to the better supplier. Over

the last 12 months (2008-2009), they reviewed the companies in their supply chain and agreed a collaboration framework for a 3 year period.

Assessment of Supply Chain:

Company B uses an objective performance management tool which produces a league table of best performances. Key supplier selection criteria are based on health and safety audit, financial stability, collaborative working, consistent delivery, reliability and strategic positioning. Company B records the performance of the suppliers regarding these categories and attributes through Web-based software running on the Intranet. The results are reviewed by the board members every 3 months.

Knowledge Sharing and Relations with Supplier:

Company B believes that if suppliers become best friends then they will share knowledge freely. They would like to work with suppliers even at the design stage of their products and share knowledge from the beginning so that they can have more innovative and more cost effective solutions at the end. They arrange collaborative workshops with the same category suppliers and discuss the results of the performance measurement tool. The aim of the workshop is to share the best practice and compare the relative performances of the suppliers. Although they have generally old relationships they look for new actors in the business to improve the project delivery, capacity and innovation.

Although the company has a supply chain strategy, they also have some problems in their supply chains which are explained below.

Problematic Areas and Knowledge Management:

Key problem areas and knowledge management issues identified include:

- **Organizational Resistance:** The major problem is internal resistance to change working principles in the company's supply chain strategy. Individual project members tend to work in their own way with their existing suppliers. However, Company B has a vision to identify a certain number of suppliers depending on the performance management tool.
- **Client Request and Cost Concerns:** Clients look for suppliers that offer cheaper costs. However, Company B is trying to work with a standard set of suppliers based on the performance management tool from the bidding stage to handover with a minimum cost. The challenge is to convince the client so that they can understand the proactive relationship with suppliers.
- **Knowledge and Design Management:** Knowledge sharing between design consultants and contractors is problematic. Historically, designers were designing depending on their parameters and aspirations. There can also be some communication problems between the organization and its design supply chain. However, more recently, there is a greater need to collaborate with designers at the early stage of the design.
- **Knowledge Sharing and Confidentiality:** One of the critical knowledge sharing problems with the supply chain members is that they might share the best practice and competitive knowledge with the competitors. Therefore, it is important to have internal agreements and develop trust within the supply chain in order to keep the knowledge secure.

- **Waste Management:** Monitoring and managing the waste created by suppliers during the project lifecycle is very critical in order to improve profitability and sustainability. Therefore, there should be some agreements with the supply chain actors in order to minimize the physical waste they produce on sites.
- Knowledge transfer and management between project teams and supply chain is the key enabler for eliminating the waste and decreasing the cost of project. However, there are some other barriers to share the knowledge between Company B and its supply chain as follows:
- There are not any existing contractual agreements with supply chain members to share and manage their knowledge;
- The knowledge coming through supply chain and created during the specific projects are retained with people and it is not diffused to other parts of the business;
- The competition between various suppliers;
- Lack of using technological drivers as videoconferencing, extranets, Building Information Modelling, etc.

To overcome the obstacles in their supply chain, Company B has developed some programmes and activities within the organization:

- **Building Constructive Relationships:** Company B established the Building Constructive Relationships (BCR) framework in order to be more involved at the early design stage of the projects and get closer to the designers in the supply chain. In this way, construction projects can be built with the standard design parameters and specifications. Basically, it is a 5 year commitment to bring the relations and working principles to a certain level within the supply chain. At the end of two years of commitment to the framework, suppliers are reviewed using agreed criteria. The key issue is to know the supply chain members in detail in terms of turnover, direct employee numbers, financial position and their working partners.
- **Performance Management Evaluation:** It is critical that the workload within the organization is fairly allocated to the supply chain actors so as to maintain good relationships. In the long term, supply chain actors are evaluated based on performance and poor performers are terminated.
- **Preferred Supplier Agreements:** Providing opportunities to its subcontractors and manufacturing suppliers to buy from preferred suppliers. This helps subcontractors to reduce their operational costs by benefiting from cheaper than market prices.
- **Early notification of Project Scheme:** Company B informs its subcontractors and manufacturing suppliers every month through e-mails about current and potential projects and their characteristics, so that workload is visible to supply chain partners.

Cross Case Analysis

The key findings from analysing the two case studies are:

- Both companies use a performance measurement tool to assess the performance of the organizations based on similar measures as health and safety, financial stability, delivery etc. However Company A makes assessments at the end of the projects whereas Company B makes live projects assessment and these assessments are reviewed by the board members in every 3 months period.
- Company A arranges regional supply chain meetings once every two years in order to improve relationships. However, Company B takes this further by organising

- workshops with their suppliers, assessing the performance of the suppliers in these workshops and sharing the reasons for high performance scores.
- Company A has a tendency to agree protocols with their suppliers whereas Company B has a tendency to make partnering agreements.
 - Company A suffers a lot from the lack of a Knowledge Manager in their organization. They do not have a developed knowledge management tool for managing the project knowledge effectively within their organization and throughout their supply chain.
 - Company B has some programmes for improving supply chain relationships and improving the level of knowledge exchange whereas Company A has a limited approach to overcoming the difficulties in their supply chains.
 - Both companies consider knowledge management a key element in construction projects and feel that the creation of knowledge chains will bring innovation, integration, long term relationships to their supply chain and increase the trust between the members of the supply chain.

Second Stage of the Case Study

The second stage of the case study involved an interview with the person responsible for the management of a recently or nearly completed project. The main output of this interview was to gain an understanding of the project context, and identification of the key people involved in the project's supply chain. Prior to the interview, three main issues were defined; having brief project knowledge, and project management approach and the supplier list in each phase of the project. This interview was planned as a semi-structured interview.

In both of the companies two Design & Build projects for the education sector were selected. Having similar projects was intended to enable better comparison of the supply chain management and knowledge management across the two supply chains.

The project phases and the supplier list for each project were discussed with the project managers of the two companies. The main suppliers of the projects were identified and contacted for a comprehensive analysis of the project knowledge management practices and supply chain problems of the projects.

Typically, in each phase of a construction project, there are different actors each with different knowledge requirements. Construction projects have definable phases for which there are many configurations. These phases are defined in many configurations such as conceptual, design and specification, construction, commissioning and handover (Anumba et. al. 2005) or conceptual, construction, maintenance, replacement and decommissioning (Edum-Fotwe et. al, 2001). In this case study, based on the information provided by the project managers, the project phases are as shown in Figure 2.

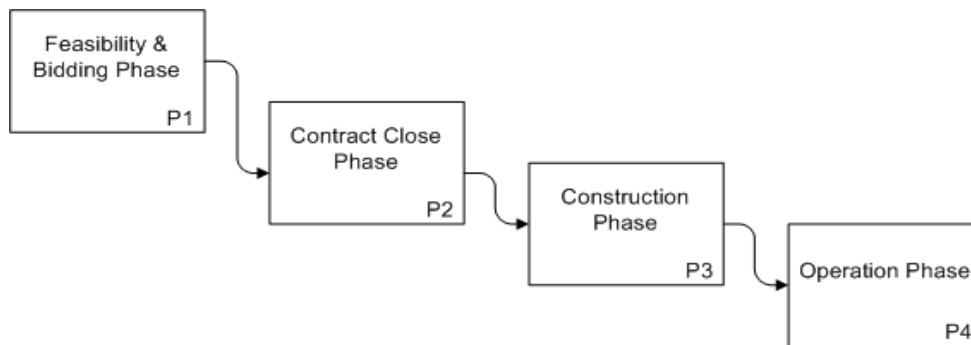


Figure 2: Phases of the Project

The main issues associated with project and knowledge management on the case study projects were:

- The Bidding & Feasibility phase is very difficult in terms of knowledge sharing, because the knowledge from the client is very limited. It is very difficult to access the right person who has the right knowledge and this seriously effects collaborative decision making during the design stage.
- Without having encouragement and vision from senior management it is difficult to share knowledge freely, and build mutual benefits and trust between the suppliers. To create a win-win situation, it should be made clear that the involvement of each actor in the supply chain will bring success for all actors.
- Supply chain and partnering are the main elements of an integrated supply chain. It is easier to work with companies which are known from previous projects. The collaborative experience is one of the most important issues in the quality of the project knowledge and vision produced.
- It is always important to understand people's feelings to understand the requirements. The solution contractors provide is not only a building, as the compatibility between the functions of the building and the requirements of the school should be fully provided. The design should cross these boundaries and this can only be achieved by understanding the user.
- The projects are predominantly won by design work, therefore the best design suppliers are highly sought after. However, it is not only the design which makes a company to be selected as a preferred bidder; relationships play a very important role.
- Engagement of specialist suppliers at the right time is very important. The lack of effective collaboration due to late engagements causes design mistakes and failures.
- The engagement of the design team and construction team is very important. If these teams are not engaged early, delays or mistakes in construction can occur.
- The construction problems or the FM problems can feed the design for future projects. As such, the knowledge created should be transferred and diffused to the project team.

The knowledge created and transferred throughout the school project lifecycle was planned to be investigated in the third stage of this case study. The contact details of the main actors that took part in the supply chain of the project were provided by the project managers.

CONCLUSIONS AND FURTHER RESEARCH

This paper has presented the findings from preliminary case studies on knowledge flow in the construction supply chain. The case studies focused on two large construction companies using three main stages. The first stage of the case study was based on a set of structured interviews which sought to investigate supply chain management problems and issues related to knowledge management practices. It was found that there were considerable differences between the two companies. Company A is an old and traditional company, which does not benefit from knowledge management as much as Company B does. Company B is more integrated with modern techniques and processes throughout the project lifecycle, and has a better focus on knowledge management practices. Company B's approach affects the management of their supply chain in a significantly positive way. Their close relationship with the suppliers provides them with better solutions and scope for innovation. However company A's approach is generally based on using old relationships and keeping the supply chain members based on their reputation and on time payments. Company B has a more dynamic approach and develops programmes for improvement of the supplier's capabilities and better knowledge sharing throughout the project lifecycle, and thus having better outcomes at the end.

In the second stage, semi-structured interviews were conducted with project managers and brief information regarding their most recent project was gathered. Education sector projects were selected in both of the companies and the main findings have been presented. One of the key issues for both companies was the difficulty of sharing knowledge across the supply chain.

The next stage of the research will involve conducting the third stage of the case studies and analysing the results from that, and developing knowledge maps which show the knowledge flow between the suppliers will be developed. This map will cover the knowledge needed by each supply chain actor from the beginning of the project, the knowledge they create and they share in each phase of the project. The problematic areas will be presented on these maps, and the origins of these problems will be clarified. The main output of the case studies will be a framework to present knowledge diffusion across the construction supply chains taking full cognisance of both the technical and social issues of KM practices throughout the whole project lifecycle. Finally, this framework will be evaluated and validated with the industry practitioners at the end of this project.

REFERENCES

- Akintoye A. McIntosh G. Fitzgerald E. 2000 A survey of supply chain collaboration and management in the UK construction industry *European Journal of Purchasing & Supply Management* 6 (2000) p.159-168
- Anumba C.J. Egbu C. Carrillo P. 2005, *Knowledge Management in Construction* Blackwell Publishing: Oxford
- Aouad G., Sun M., Faraj I., 2002. Automatic generation of data representations for construction applications *Construction Innovation* 2002(2) p. 151–165

Edum-Fotwe, F.T., Thorpe, A., McCaffer, R., 2001. Information procurement practices of key actors in construction supply chains. *European Journal of Purchasing and Supply Management* 2001(7), p.155–164.

Jewel K.T., 1969, *A Systems Approach to Civil Engineering Planning and Design*, Harper & Row, New York

Holmberg 2000, A Systems Perspective on Supply Chain Measurements *International Journal of Physical Distribution & Logistics Management*, 30(10), p. 847-868.

Parnaby J., 1995. Systems engineering for better engineering *IEE Engineering Management Journal* 5(6) p.256-266

Sage A. P., Srmstrong J.E., 2000. *Introduction to Systems Engineering* New York: John Wiley & Sons
Spinello 1998 The Knowledge Chain. *Business Horizons* 41(6): 4-14

Tucker S.N., Mohamed S., Johnstan D.R., McFallan S.N., Hampson K.D., 2001 *Building and Construction Industries supply chain project*. Department of Industry, Science, and Resources, Australia

Vrijhoef R. Ridder D. 2007, Integrating the construction supply chain by applying systems thinking *Proceedings of the Third Scottish Conference for Postgraduate Researchers of the Built & Natural Environment (PRoBE)*, Glasgow Caledonian University, Scotland, UK.