A FRAMEWORK FOR DEVELOPMENT OF A KNOWLEDGE DATABASE FOR USE WITHIN THE CONSTRUCTION INDUSTRY

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In recent years the concept of Knowledge Management within business organizations has gained increasing interest as companies begin to recognize the value of their intellectual capital. The adversarial culture of the construction industry, differing allegiances, varied backgrounds and the temporary nature of project teams does not easily allow for KM practices to be used. Currently, critical lessons learned during a project becomes lost in explicit data and dissemination of useful information for future projects is often vague, resulting in common mistakes being repeated on future projects and valuable tacit knowledge being lost once the team disperses. This paper proposes a framework for capturing both explicit and tacit knowledge gained during a construction project, which also addresses the problems associated with temporary design teams and presents a mechanism for project knowledge to be disseminated throughout the construction industry.

Keywords: case study, database, knowledge management.

INTRODUCTION

Although there has been a large amount of research into Knowledge Management (KM), learning and sharing between temporary multi-organizational project teams is still rare. This is caused by the non-willingness of different organizations to disclose their sensitive information on best practices and innovations to others and the lack of framework or infrastructure that will enable communication and sharing between different teams and organizations. Added to that is the adversarial culture dominating the construction industry and the lack of a partnering and sharing spirit (Egan 1998, Latham 1994).

Successive independent reviews of the UK construction industry have emphasized the need to improve the culture, attitudes and working practices which have existed for many years. A review of these reports have identified a number of fundamental barriers which need to be overcome if construction performance and cost efficiency is to improve (Bourn 2001). The most significant barrier would appear to be the lack of culture in learning from previous projects, which is reinforced by a culture of responsibility transfer and inadequate investment in to research and development. As a result, projects are affected by the same continuously occurring problems and the industry continues to suffer criticism from both private and public sector clients.

The main cause for the same mistakes being repeated on varied projects is due to the temporary nature of the supply chain and the adverse effect that this has on knowledge sharing. Currently, critical lessons learned during a project become lost in explicit data and dissemination of valuable information for future projects is often vague. Given the

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time constraints established in current building contracts, the discontinuity of design teams and that each individual is only exposed to a limited number of projects, each for a relativity short period, there is little opportunity for a learning process to develop and individual experiences to be shared.

Corrective action, conflict resolution, innovation and best practice are constituent parts of the construction project life cycle, yet the multi-disciplinary and organizational nature of the construction industry often results in critical knowledge gained on a project being lost once the team disperses. Without a structure or process for capturing this knowledge, valuable lessons learned on a project are archived along with the project data. An effective knowledge-sharing framework for use on future projects would therefore, help the construction industry to be more efficient, productive and innovative.

THE AMBIGUITY OF KNOWLEDGE MANAGEMENT

The concept of Knowledge Management (KM) is not readily defined and many definitions supplied in literature are highly ambiguous, which makes KM amenable to multiple interpretations and remouldings (Scarbrough 1999). The ambiguity of the concept has enabled KM to potentially extend its relevance across varied communities of practice and as a result many organizations are embarking on their own KM initiatives, as the subject receives greater attention.

Following Scarbrough *et al.'s* (1999) methodology, a search of refereed journal papers printed between 1996 and 2001, utilizing the Integenta Journals search facility, has identified 411 papers published on the theme of KM, with the majority of publications being made in the last three years. The varied topics utilizing KM clearly demonstrates that the multifarious nature of the concept does not limit the practice to a particular discipline. Consequently, the increased interest in the subject has lead to diverse research at a number of UK universities. The majority of these studies are organization focused and consists of knowledge and information generated as a result of business activities or development projects where knowledge is captured and communicated within the same organization so that it can be utilized in the future. Whilst construction organizations stand to benefit from these developments, the reward to the construction industry as a whole is only partial. This is mainly due to the fragmentation of the construction industry and the nature of project teams who often comprise of different organizations, disciplines, cultures and level of experience.

The consistent conclusion of these research projects is that IT alone does not function adequately as a mechanism for KM and relying solely on IT systems for information sharing is likely to have a random effect, resulting in understanding being driven out by information (Alavi and Leinder1997). This is because Knowledge Management is a combination of mechanistic and humanistic disciplines, of which Hansen *et al.* (1999) proposes that there are two strategies; codification and personalization. Organizations that pursue a codification strategy gather knowledge, codify and diffuse the externalized knowledge throughout the organization via Intranet/Internet systems. This is a 'people to document' approach which is limited to the transfer of explicit knowledge. In using these tools, explicit knowledge becomes the main focus and tacit knowledge is often overlooked, toned down or removed from the context altogether, despite the perceived strategic importance (Johannessen *et al.* 2001).

The personalization strategy, in contrast, is person based and focuses on communication and dialogue between individuals. Personal knowledge is externalized

and transferred through meetings and conversations in the form of tacit knowledge. Although much of this tacit knowledge becomes compressed (Boisot 1995), the organization benefits from a wider distribution of knowledge and becomes less vulnerable from employees leaving organizations before their undivulged knowledge is externalized. Although tacit knowledge in not readily codified and by definition it can not be articulated or expressed, it is this form of knowledge, which will typically be of more value to an organization (Leonard and Sensiper 1998). The tacit dimension is also strongly implicated in organization innovation and when compared to explicit knowledge it tends to reflect more closely the reality of how work actually gets done (Horvath 2000). This is because what is 'best' about a practice often fails to be included in a process map or specification (Szulanski 1996). As a result much of the important research into KM has concentrated on the process of capturing tacit knowledge and seeking to successfully make it explicit (Nonaka and Takeuchi 1995).

Despite the recent interest, the concept of KM is not new. Literature on the subject is included in the writings of Plato (427-347 B.C.) and Aristotle (348-322 B.C.). In today's post-industrial society KM has become a decisive process of creating, acquiring, capturing, sharing and using knowledge, wherever it resides, to enhance learning and performance in organizations (Scarbrough 1999). This new concept of KM is a direct result of the cultural change and evolution of core business activities and the realization that the basic economic resource is no longer physical assets, but intellectual capital (Rivette and Kline 2000). The value of this commodity continues to escalate as the balance between the knowledge component and the resource component dramatically changes. Therefore, as knowledge becomes a vital organizational resource, the process by which knowledge is created, acquired, communicated, applied and utilized must be effectively managed (Egbu 2000).

In order to remain competitive many organizations have developed their own KM programmes with the belief that the practice provides a source of alchemy for the new knowledge economy. However, as the concept increases in attention, organizations become susceptible to commercial exploitation, as KM solutions becoming heavily biased towards technological solutions and the re-packaging of tools and practices, previously developed in a different context (Scarbrough 1999). In this respect KM is in danger of becoming a discredited term. This is because many organizations have failed to realize that establishing KM procedures takes time and too much emphasis on short term results will hinder successful implementation (KPMG 1999). Furthermore, organizations that solely rely on IT as a KM solution will not achieve sustainable competitive advantage, as IT alone does not function adequately as a mechanism for KM.

It would therefore appear that the barrier to successful KM implementation is due to a lack of understanding of what KM involves. In a rush to increase competitive advantage using KM tools, organizations often fail to recognize that knowledge is only an output of learning and it is not the knowledge itself that enhances an organization, but the quality and the process of utilizing the knowledge that has been acquired. Organizations that intend to initiate KM must realize that the concept is a combination of IT, business processes and people management and without a clear framework a successful KM strategy can not readily be established.

TEMPORARY PROJECT TEAMS

In recent years the construction industry has seen the traditional temporary project team becoming more complex as the specialization of the contributors to construction projects has continued to grow. Even within these specialist occupations there are often specialist subdivisions involved in a construction project at varied stages. Furthermore, client organizations are also subdivided into specialist groups, all of, which have a contribution to make in terms of project definition, resulting in an intricacy of interrelationships.

This differentiation of skills together with their reinforcing sentience is clearly evident in the construction industry (Miller and Rice 1967). Sentience is particularly strong in members of a professional body and arises from the allegiances to ones own firm, professional body or to both (Walker 1996). To compound the interrelationship complexity, there is also a lack of recognition of interdependency with in the project team, which Walker (1996) believes is the fault of the education process as each discipline is educated in relative isolation from others. As a result many team members view other disciplines with a certain amount of scorn and criticism.

As many project teams working together for the first time need to go through various stages of growth before it becomes committed to the common purpose, goals and methods (Kattezenbach *et al.* 1993), it is unlikely that in the short period a project team interacts with other members, an environment conducive to learning and sharing could be established. Only as the project progresses, can members identify others strengths and weaknesses, establish how they will work together and eventually develop mutual trust and understanding.

To be effective, teams require sufficiently diverse knowledge to properly assess and understand the problems they face (Gray 2000). Inadequate problem assessment can lead to poor decisions, inferior products and unreasonable high costs associated with searching for information and evaluating solutions (Tushman and Nadler 1978). If organizations transform their natural anti-learning and projective defence routines (Argyris 1985) and recognize the inherent cultural problems of temporary teams, it is possible that sharing between different projects and organizations will allow for the extraction of consensus and tacit knowledge.

KNOWLEDGE TRANSFER FRAMEWORK

The proposed research is KM based, but it also encompasses the concept of Learning Organizations (LO), which has recently been overtaken in terms of interest by KM. Although some may believe KM is only a relabelling of LO (Scarbrough 1999), the two fields do derive from distinctly different foci, perspectives, disciplines and discourses and also emphasize different aspects of the knowledge creation process. The LO emphasis is cultural management and leadership as a means of encouraging socialization, which allows tacit to tacit knowledge to be shared and explicit knowledge to be internalized in to the tacit understanding of employees (Nonaka 1997). In contrast KM emphasizes information systems as a means of externalizing tacit knowledge and combines different types of explicit knowledge (Scarbrough *et al.* 1999).

During a construction project there is a great deal of knowledge generated from a large diversity of data, which includes drawings, cost reports, analysis, calculations, contract documents and minutes. However it is rare that knowledge generated from a

construction project is used for any other purpose than project information and the explicit knowledge contained therein is rarely exploited. Whereas, the project data could be a valuable source of explicit knowledge which future design teams can gain ideas, identify pit falls and generally, learn from. Furthermore, if the tacit knowledge of a design team could be codified, the total project knowledge would be of much greater value.

Therefore, this paper presents a KM framework that could be used to capture the critical knowledge gained on a construction project, using both humanistic and mechanistic disciplines. It is proposed that the dissemination of the captured knowledge will be via a knowledge database available to all subscribers using the World Wide Web as the implementation platform.

CAPTURING PROJECT KNOWLEDGE

It is proposed that the framework (figure 1) will involve capturing both the explicit and tacit knowledge gained during a construction project, which uses a multi-disciplinary project team. Explicit project knowledge is captured by reviewing all the project data and extracting the useful information, to form part of a case study. In order to avoid a subjective view of what is considered useful, a filtering process is used to identify critical episodes, innovations and problems that occurred during the project. Within all projects these areas are clearly defined within the minutes and through interviews with individual members of the design team. The model shown in figure 1 illustrates that the transmission process of the project data is the most trivial and least problematic stage of the information transfer process, yet would appear to be the main focus of KM research (Finch 2000).

Tacit project knowledge is captured by documenting the individual project team members' subjective views, experiences and lessons learned at critical stages of the project phase. The first phase where tacit knowledge is captured is at the formation of the team and takes place during the initial project team meeting, where the team is exposed to similar projects stored within the knowledge database. Exposure to case studies allows the team to gain an understanding of the critical choices and problems they may face during the course of the project, whilst providing various options for resolving complex issues. Also, by developing an environment conducive to learning prior to the project start date, will reduce the time normally taken for a team to progress from a working group into a real team (Katzenbach and Smith1993). This is because a platform is created at an early stage where team members can question core elements of others experience, making explicit the tacit knowledge that each member holds. The acquired knowledge and understanding of other team members will also provide potential for individual behavioural change and will assist in decision making and the identification of knowledge sources with in the team, resulting in strategic alliances being formed.

During the project, tacit knowledge is captured by informally documenting personal comments and responses to various project issues. Recording is carried out by an independent appointed knowledge co-ordinator that interviews individual members at varied intervals of the project phase. Each interview is subsequently analysed for reoccurring themes and alternative solutions to problems that have occurred during the course of the project and documented, anonymously, in the case study. The purpose of anonymity is to help focus on the universal roles, responsibilities and relationships that people have during a construction project, so that future individuals can easily

identify their own situations reflected in parts of the case study (Kleiner and Roth 1997).

The final stage of the framework is the summary and reflection phase that is carried out at a project review meeting. Collaborative best practices and innovative solutions used to solve problems are documented together with a reflection on what could have been done in hindsight. This forms the final chapter of the project case study, allowing for the knowledge gained on the project to be disseminated for future projects via the knowledge database available through the World Wide Web.

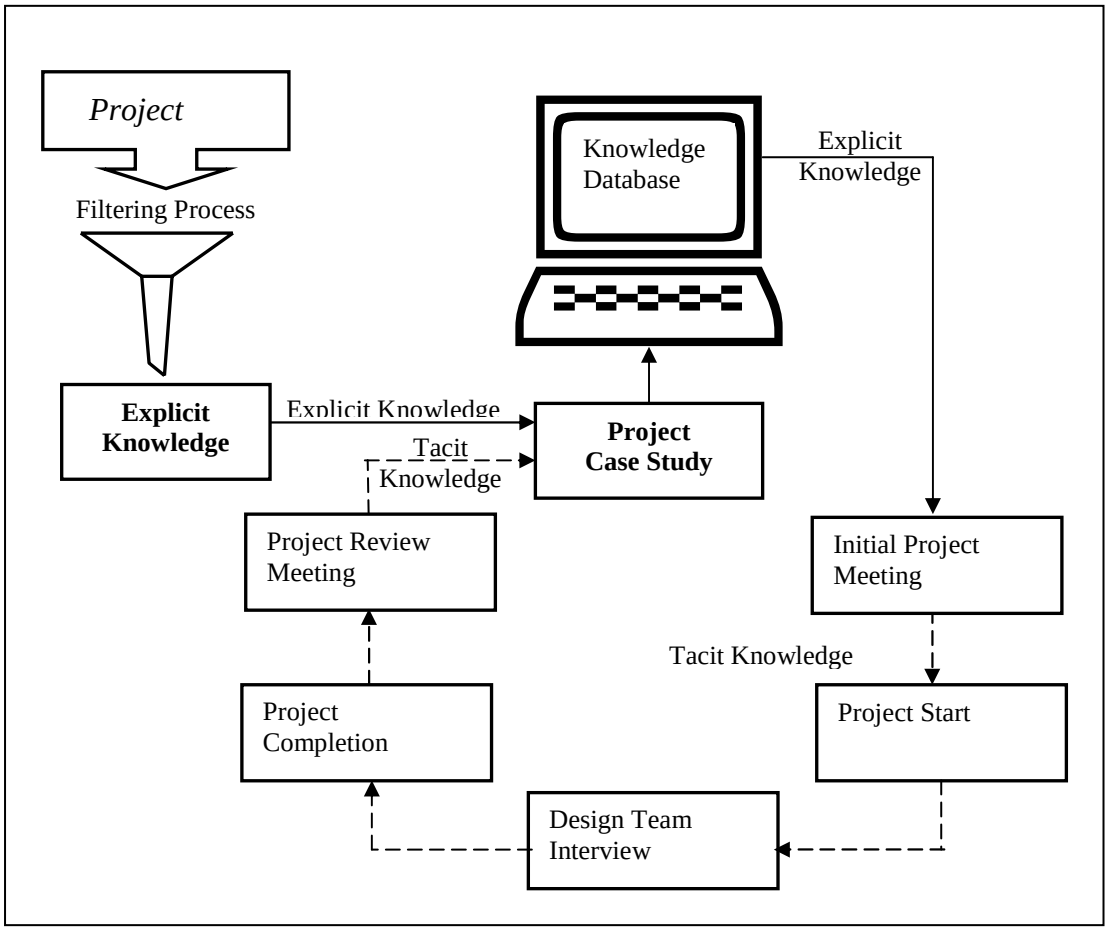

Figure 1: Model for the Capture of Project Knowledge

METHODOLOGY

The proposed KM framework is being developed and undertaken as part of a three year, on-going research project. The methodology represented in figure 2 comprises of four clear stages: Stage 1; Background and literature review, Stage 2; Framework development, Stage 3; Evaluation and refinement of the framework and Stage 4; Dissemination.

The main component of the KM framework is the process by which knowledge is captured. Knowledge here entails the solutions to critical episodes and problems, innovations used to solve these problems, how problems could have been avoided and how they could have been resolved in hindsight. Stage 2 of the methodology therefore involves the development of pilot case study, from which useful knowledge will be extracted.

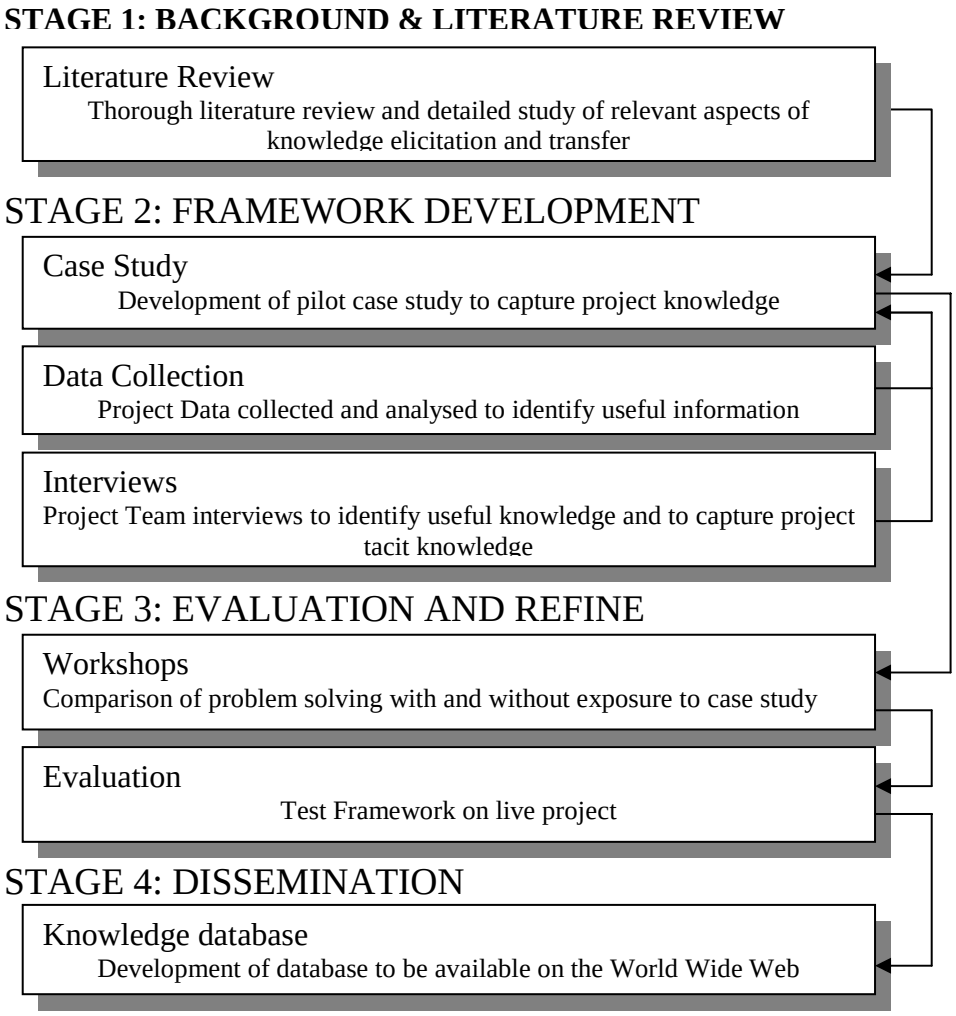

Figure 2: Methodology: Stages of Research

The research currently includes gathering detailed records of a major project undertaken by Standard Life Assurance Company in Edinburgh. Data and information are being collected about the product and process at a very detailed level and includes complete construction photographs, construction drawings, development reports and minutes of every meeting. The complexity of the project and the procurement method used (construction management) has resulted in an immense amount of data being generated over a three year contract period. Therefore the first stage of the process required in-depth meetings with the client and individual members of the project team, to ascertain the most suitable documentation which would recount the project phase. Once a level of security was established, the information was subsequently made available from each team member's own office archive in varied formats. As the collated data is provisionally stored in a local database and the proposed dissemination of the data is via an Intranet/Internet system, all information had to be digitized and made accessible for future reference. Whereas this may appear a time consuming exercise, the clear advantage of such a system is that it provides an accessible integrated database for the storage of data and processes required by various disciplines (Aouad 1996).

It is also critical at an early stage to establish a universal file structure. Therefore the Generic Strategic Project Plan as outlined in BS6079 was adopted and created within

the local database using the Columbus document management system, previously developed by Ove Arup and Partners (figure 3). Although simplistic it provides a combined navigator and viewing system which allows documents to be accessed and printed without the addition of other packages. Each document has basic descriptive information, which is supported by a detailed content file supplying the dates of input of data, format and supporting package application. The live documents can also be accessed directly from Columbus, thus enabling users to locate the required information fast and efficiently. Furthermore, it is proposed that the CDS template created from the Standard Life case study will be the universal template for future case studies to follow.

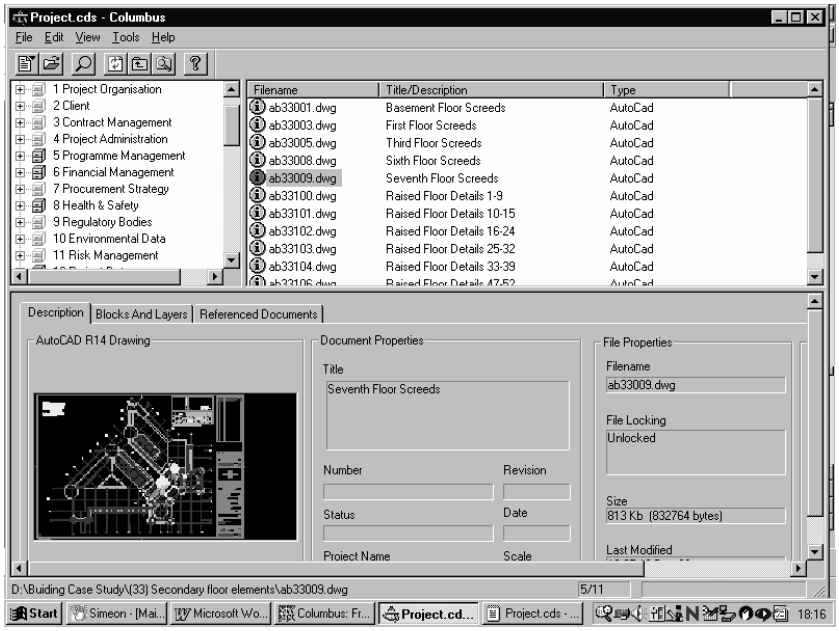

Figure 3: Standard Life Case Study on the Columbus system

Following the data collection exercise, members of the project team will be asked to identify the main decisions which contributed to the development outcomes, outputs and measures of success of the project. The timing of these decisions within the project phase will be also documented. Finally, the team will be given the opportunity to reflect on critical episodes and identify any decisions, which in hindsight were wrong and give an opinion on what should have been done. Reoccurring themes will be identified, documented and will be represented to the design team for further comment. The final outcome will be a compressive project analysis that encompasses both the explicit and tacit knowledge of the project that will inevitably form the pilot case study for the knowledge database.

CONCLUSION

The data collection at stage 2 of the methodology will complete the capture of explicit knowledge within the Standard Life project and will allow for purposeful collation of the tacit element through interviews with the design team.

Stage 3 proposes to establish the value of the case study in a workshop with a new project team, by presenting a number of real problems that occurred on the Standard Life project for the team to solve collaboratively. It is proposed that the team would be exposed to the Standard Life case study and given the opportunity to reassess their original solutions. This would enable the researchers to evaluate the framework by

establishing if exposure to the project has improved the problem solving process of the new team. This is not to say the Standard Life design team offers the best solution for resolving problems, but by being exposed to the case study, the new project teams tacit knowledge is increased and therefore are better equipped to make critical decisions.

The final stage of the methodology proposes to test the team building element on a live project. It is believed that a fast track office development would offer the greatest challenge to the framework as under this scenario the design team is under most pressure and sentience is more likely to develop. In conclusion of this final stage, it is proposed that once the framework is evaluated and refined a knowledge database could be made available to the construction industry with the assistance of IT and Web experts.

Whereas the proposed framework requires discipline and commitment from all parties, it is a long-term solution to the collaboration process. Many construction organizations are striving to reduce common mistakes, which are repeated on construction projects. Unfortunately, the economic pressures of construction contracts, the complexity of relationships within a temporary team, the adversarial nature and the inherit competitiveness of the construction industry does not easily allow for knowledge sharing. However the industrial collaboration, in allowing development of the Standard Life case study, is clear proof that major organizations realize the benefits and savings to be made if the industry develops a knowledge sharing facility.

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