Construction Collaboration Technologies: Human Aspect

The relationship between collaboration technology in construction industry and individuals using the technology

By

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ABSTRACT

An increasingly significant proportion of the construction industry has come to adopt collaboration technologies in recent years. Nevertheless, the technology is still not being used by the entire industry on every project to the full capacity. There remains a significant number of organisations that would benefit from using such technology but are reluctant to employ it.

As it is often the case with newer technology, a major barrier relates to the doubts that many potential users have regarding the practical usefulness of the technology. These people may be highly skeptical about what such technology could do for them, what exactly the benefits will be and whether the benefits can be quantified.

This report attempts to find the reasons for resistance to use collaboration technology on an individual level as well on the industry level in general, and suggest possible ways to overcome the resistance, thus making benefits of successfully implemented collaboration technology available to every construction project.

Keywords: web-based application, project collaboration, extranet, resistance to technology, electronic data management system (EDMS)

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1. INTRODUCTION

In the years since Sir Michael Latham (1994) emphasized the advantages of partnering approach to project delivery (he made 53 recommendation to change industry practices, to increase efficiency and to replace the bureaucratic, wasteful, adversarial atmosphere prevalent in most construction projects with one characterized by openness, co-operation, trust, honesty, commitment and mutual understanding among team members), industry estimates still show that the majority of the construction projects are procured via traditional, often adversarial approaches.

In 2002 Egan provided explicit endorsement of the impact that integrated Information Collaboration Technology (ITC) could have on supporting collaborative working. The vision expressed in 'Accelerating Change' (Egan, 2002) referred to 'integrated teams created at the optimal time in the process and using an integrated IT approach'.

This year also marks ten years since the Egan (1998) report, yet industry has more or less failed to adopt the recommendation made by Sir John ('I would give the industry four out of 10 for trying', (Egan, 2008)).

The industry champions say the Egan report is still on the agenda, but although the industry is moving in the right direction, it still has a long way to go in order to reach the targets formulated by Egan (1998, 2002). This partly reflects inertia when it comes to contemplating more open, collaborative approaches.

1.1. Defining Construction Collaboration Technology

It is difficult to overestimate the importance of information exchange in such an industry as construction. Success of a construction project depends on many factors, one of which is timely exchange of most up-to-date information

among the parties involved in the project - the appropriate information must be provided and obtained by the relevant project participants at the specified time. Clearly, clients and projects teams need a way to communicate, centralize and share information quickly and efficiently, building up a data bank that can be re-used in the future at the same time.

With the Internet being an established means of communication, collaboration technology in construction seems to be an answer to project success. Instead of linear communications and separate 'islands' of information, contraction collaboration technologies offer a more efficient way to manage communications. The essence of collaboration software is to develop a process whereby documents are electronic, thus enabling them to be stored at a secure central location that can be accessed by those to whom access rights have been given.

Figure 1.1. illustrates traditional project team communications process whereas *Figure 1.2.* shows the concept of web-based communication. It can be noticed that the two differ significantly when it comes to the centralization of the information. Web-based project communication means an instant, on demand, secure online solution for every team member to communicate, share documents and collaborate using a standard web browser.

Electronic document management (EDM) and collaboration systems are usually outsourced to the companies specializing in providing EDM and collaboration solutions. Such solutions include workflow management service for the design, engineering, and construction industry and provide specialized tools for all the individuals involved in the building process.

The collaboration technology promotes the concept of partnering, enabling project owners, planners and architects to collaborate and to jointly determine how best to achieve the goals of the project. In order to insure effective coordination of the numerous partners that make up the project team, it is critical to get everyone to communicate as quickly and efficiently as possible,

and in order to develop values of partnering it is critical that all project players remain in regular contact with each other and have access to the same data.

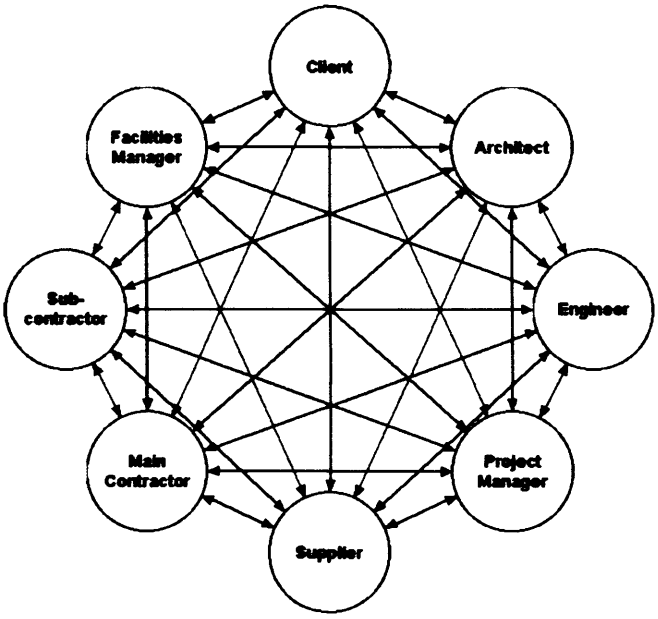

Figure 1.1. - Traditional Project Team Communications (after Wilkinson, 2005)

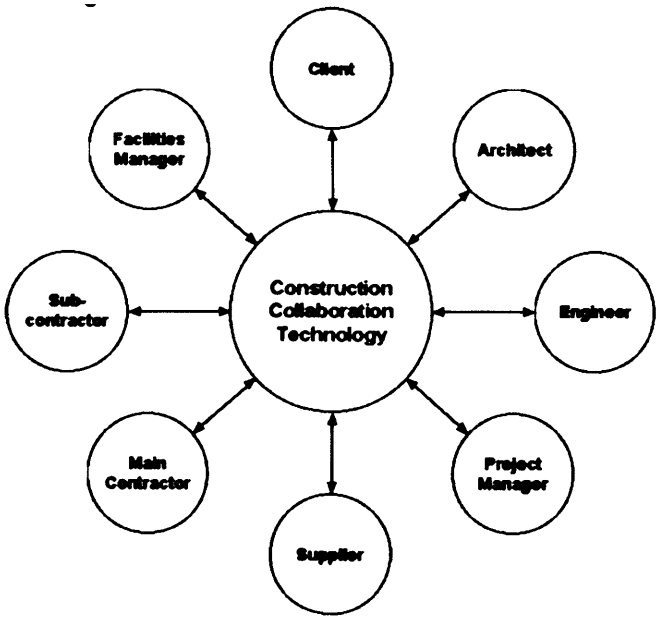

Figure 1.2. - Web-Based Project Team Communications (after Wilkinson, 2005)

Wilkinson (2005) defines construction collaboration technology as

> *'a combination of technologies that together create a single shared interface between multiple interested individuals ..., enabling them to participate in creative process in which they can openly share their collective skills, expertise, understanding and knowledge ..., and thereby jointly deliver the best solution that meets their common goal(s), while simultaneously creating an auditable electronic record of the people, processes and information employed in the delivery of the solution(s)'.*

The ultimate mission of collaboration technology is to provide project teams with rapid, secure, and easy access to project information. Thus, it is hardly surprising that it is becoming increasingly commonplace in many organisations on medium-to-large projects.

Wilkinson's definition is - in essence - focused on people working productively together with software providing a platform for relationships based on openness and trust. He however warns that successful collaboration is greatly dependent on the culture of the team, and much less on the technology it implements.

The market for collaboration technologies in construction is still maturing and have not yet reached the stage when each consultant and trade contractor adopt this holistic approach to sharing information. A part of the construction sector still thinks of the online world as something unknown and strange, and, consequently, have more difficulties in adapting to this world.

The construction industry needs to move from simply reproducing paper-based processes in an electronic form, and enable machine-machine and person-machine communication (Finch, 2000). The most effective communication is to transmit and respond to the right message to the right person at the right time. As the communication in the industry is often multi-party, a centralized system is preferred in order to avoid misinterpretation during transmission.

1.2. Growing Use of Collaboration Technology and Changes in its Perception

Information exchange relies on trust and on the necessity to behave in a cooperative manner. Kellogg (1971) identifies 'the need for removing the legal, social and labour restraints presently burdening the construction industry'. Both Latham (1994) and Egan (1998) promote the concepts of partnering and strategic alliances.

Ever since the first project extranet was established in 1995 (Stephenson, 2005), computer systems for document handling have become essential to keep track of drawings revisions and have provided an authoritative record of document distribution and transmittal. These systems are known as electronic document management systems (EDMS) (Sun and Howard, 2004) (Figure 1.3.).

In the recent years there have been significant developments in technologies to support cooperative work between multiple users in organisational environments. These tools range from shared text editors and drawings tools (Olson et al., 1990) through to systems, which support group meetings and decision-making (Winograd and Flores, 1986). The impact of Information Communication Technology (ICT) on collaboration is growing, presently extending and managing the information flow of activities across the whole supply chain (Alshwi and Ingirige, 2003).

Arguably, the successful application of collaboration technology depends more on people and their attitude towards embracing new knowledge than on the technology itself. Technology has been developing much faster in the past century than it has done in the entire history of mankind before that. People are trying to keep up with it to the best of their abilities (Howard, 1998).

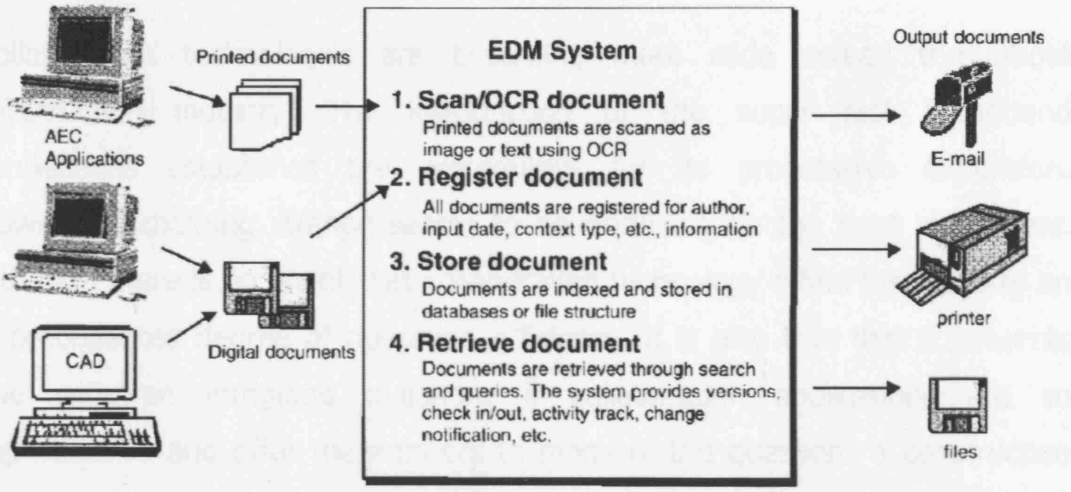

Figure 1.3. - Configuration of an Electronic Document Management System (after Sun and Howard, 2004)

Attitudes gradually change over time, but in order for attitudes to change, alternatives to habitual activities have to be presented and promoted. Similar to Einstein's 'one cannot solve today's problems with the pattern of thought that created them' adage, Latham's (1994) view was that 'if you always do what you always did you'll always get what you always got'.

The movement of construction collaboration technology towards the architectural, engineering and construction (AEC) industry mainstream has met with some resistance. Experience suggests that failure to understand and adapt human behaviour, rather than technology, is the biggest single impediment to successful collaborative working (Tsao et al., 2004)

1.3. Research Objectives

Collaboration technologies are becoming more wide spread throughout construction industry. The introduction of the super fast broadband connections establishes the prerequisite for its progressive expansion. However something strange seems to be occurring on the road to success. Although there is no doubt that collaboration technology offers the industry an unprecedented degree of operation efficiency, it is also true that it presents one with an intriguing question: if collaboration applications are so sophisticated and offer the answers to many of the questions a construction project can pose, why are they usually used to only a fraction of their capacities?

The answer may well lie within the domain of human psychology. Behavioural aspects have been identified to be significant constraints in the adoption of collaboration technology. Successful implementation of collaboration systems depends 80 per cent on tackling the people and process issues, and only 20 per cent on resolving the technology aspects (Wilkinson, 2005).

Promoting awareness of the collaboration technologies among business, highlighting its benefits and providing continuous training and support to the end users can make the change in perception of collaborative working. Considering human factor when exercising management of change tactics is crucial in ongoing productive collaboration technology implementation and use.

Certain developments however must be mandatory in order for the technology to progress and ultimately establish the new ways of doing things (Howard, 1998), because, in order for a technology to be implemented successfully and eventually meet the requirements of business, a holistic approach towards the effects of the technology is of a significant importance (Winch, 1998).

By the means of this report we will attempt to achieve the following:

- evaluate the potential contributions of web-based application to the value chain in project delivery;
- analyze the importance of people and process issues in successful implementation of collaboration technologies;
- consider reasons why individuals (end users) might resist the idea of collaborative working;
- explore practical barriers that might be raised to the introduction and use of the technologies, including selection, timing, protocols, training and cost; and
- identify the human element issues that, if successfully addressed, can facilitate the introduction and use of the technology.

1.4. Report Overview

This report is an attempt to develop and expound upon some of the most fundamental aspects of implementation of collaboration technology. In many ways the author's desire to research this topic was raised from having witnessed a number of well-intended implementation efforts go wrong.

This report is organised in five chapters.

First chapter provides background information on collaborative working and collaboration technology in construction projects.

Chapter two is the result of secondary research. It presents a review of specialist literature on the subject and is included in the report as theoretical basis for the primary research. The chapter introduces the fundamental concepts for this research.

In chapter three the process of the collecting the primary data for the research is explained. Chapter four provides detailed analysis of collected data.

The report concludes with chapter five which summarizes the finding discovered during the research process. The emerged findings are compared with the original hypothesis, and future developments of the collaboration technology are considered.

2. LITERATURE REVIEW

Nohria & Eccles (1992) believe that all organisations are networks of relationships and Winch (2002) suggests that the construction project alliance is a network of information flows.

Alongside with the technical mastery of various project elements, the most important factors contributing to project success are behavioural and managerial ones, such as leadership style, motivation, maintaining effective working relationships with other project stakeholders and team building (Baker et al., 1988).

Trust and confidence developing between project teams and throughout the supply chain are paramount for long-lasting working relationships and greatly contributes to project success.

One of the purposes of web-based applications is to build relationship between organisations, so with the application of collaboration technology, the process and communication across the project team develops.

Wigand (1997) believes that 'trust and efficient information and communication systems foster market for task completion'. Arguably, the question of trust becomes more important in the virtual world than in the real world. Handy (1999) made a paradoxical observation that 'the more virtual the organisation, the more its people need to meet in person'.

2.1. Interpersonal Communication in Construction

Successful communication enables the coordination of tasks and results, but it can also help to manage change and is necessary to motivate employees (Howard, 1998).

Communication concepts have been identified as (Dainty et al., 2006):

- Transfer of information
- Bridge a distance
- Social skill involving effective interaction between people
- Convey facts, feelings, values and opinions
- Between groups and organisations
- Transactional process

Communication may be categorised by the extent to which feedback is allowed. A linear flow of information, from sender to receiver with no opportunity to feedback, is faster and less expensive, whereas a reciprocal flow of information with numerous of opportunities for questions and answers, secures trust, mutuality and spirit of cooperation (Wilkinson, 2005).

In the construction environment, personal interaction is the main form of communication and probably the most important (Dainty et al., 2006). Exemplarily, sending the drawings electronically does not conform to traditional practices and as such have not been well received in the industry (Alshawi and Ingirige, 2003). The concept of a document is fundamental to communication of information. The construction industry is used to paper documents but in order to make information available to all project parties, the paper documents need to be transferred into an electronic environment (Winograd and Flores, 1986).

Whereas large firms tend to give the lead in innovation, medium to small size firms are still reluctant to adopt collaboration technology (Howard, 1998).

2.2. Collaborative Working and Collaboration Technology

The goal of collaboration has always been the same: get things done better, faster and cheaper by bringing together a variety of resources and harnessing their collective knowledge and abilities (Sun and Howard, 2004). Effective collaboration improves productivity, streamlines and optimizes decision-making, and helps to capture valuable intellectual property (France, (2002).

The concept of collaboration platform is to build a single network for communication among members of that network. Such integrated network would encourage users to collaborate in order to make decisions jointly.

Biggs (1997) believes that bad or lack of communication is the reason for most failures. It could be due to the fact that typical project management practices are often isolated and have a lack of integration within the supply chain.

Wilkinson (2005) acknowledges cooperation as a 'creative process undertaken by two or more interested individuals, sharing their collective skills, expertise, understanding and knowledge in an atmosphere of openness, honesty, trust and mutual respect to jointly deliver the best solution that meets the common goal'. The effectiveness of technological developments is ultimately dependant upon the ways in which the information is encoded, transmitted, decoded and interpreted by the people involved (Dainty et al., 2006)

So, it can be assumed that the success of implementing a collaboration solution largely depends on the people that use it. The very nature of the solution – to support collaboration across the project – means that all project participants need to be using the system, and using it correctly. For this reason, customer service, support and account management are as important as the product itself (Smit et al., 2005).

2.3. Collaboration Technology and Construction Sector

The relationships are considered to be easier to manage when the technological co-operation is involved (Ford et al., 2003).

Consider construction projects. They always involve the collaboration of a multi-disciplinary project team that can be located in different parts of the country or the world: some may be on-site, others at administrative offices in different cities. During the design stage, collaborative design requires easy flow of information among all participants (Austin, 2001).

There is now a wide range of ready-made tools aimed at supporting projects where participants are potentially widespread (Heath and Luff, 1992). Adoption of a web-based application helps to facilitate interactions between the companies involved with a construction project.

2.3.1. Electronic Document Management in Construction

The construction industry has been dependent on electronic information since the first appearance of mainframe computers in the early 1970's (Howard, 1998). Electronic Document Management Systems (EDMS) have become integral to auditable and effective collaborative working. Systems are designed to improve collaboration between the teams working on a project, reducing potential risks and helping to ensure that the project is delivered on time. They serve as a repository for all the documents, drawings and communications relating to the project and are used by all project participants to access, read, print, and edit material according to authorizations set up by the project administrator (Wilkinson, 2005).

In simple terms, they are electronic libraries of documentation where a user can find the latest documented information relating to their own specific area

of work, whether that is drawings for the designers or business reports for the project managers (Paulson, 1995).

Key advantages are claimed to be reduced risk, controlled costs and optimized project programmes though quantification of these is often difficult. EDMS bring a higher level of organisation to documentation within a project or enterprise through version control, auditable history, and increased security (Wilkinson, 2005). They will often include collaboration tools such as automated process workflows, task management and time management tools and can easily be web-enabled to ensure geographically dispersed teams can work closely on identical data without the risk of misinformation (Forquer et al, 2006).

The aim of EDMS is to create an environment within which various forms of information can be linked together in the context of a project or organisation to achieve easy access and control (Emmitt and Gorse, 2003). The EDM environment addresses the following aspects of data management (Paulson, 1995):

- efficient location and delivery of documentation
- the ability to manage document and data regardless of the originating system or form
- the ability to encompass and integrate with existing computer or paper based systems in the context of a construction project
- control of the access, distribution and modification of documents, with the ability to mirror existing company procedures
- the provision of tools to edit documents and add mark-up information whatever the source of the document
- the support of both paper-based and digital documentation, including importing of scanned documents

The concept of EDMS is to create a definable, centralised, controlled and secure environment where information can be shared and exchanged (Cole, 2000).

Many construction projects rely heavily on EDMS through all stages of the project for document sharing, e.g. for tenders at the bidding stage and for contractors to exchange information during the design and construction phases.

EDMS could be configured to deal with all asset records as well as typical documentation with the creation of an asset specification document for each asset relevant to the project. This information could stay live during the project as long as the reports that feed into the asset specification documents are continually updated and could also evolve into an archive of as-built information as the project draws to its conclusion. Information can be stored at its point of origin and transmitted to where it is needed, eventually succeeding the cumbersome process of writing, printing and distribution (Dainty et al., 2006).

2.4. Resistance to Change

Toffler (cited in Howard, 1998) suggests that there must be a balance, not merely between rates of change in different sectors (for example, construction and IT), but between the pace of environmental change and the limited pace of human response. Technologists see the value of their novel products as self-evident and wonder why people are slow to adopt them. For users these products must fit into a broader business base and they need reassurance, from other users, for example.

Slevin's (1991) ideas of organisational validity and acceptance demonstrate that the battles for successful implementation of an information technology are usually won or lost not by resolving all technical issues relative to the

technology, but by appealing to members of organisation and attempting to address their concerns.

The usage of a project extranet as a collaboration tool is still in its infancy within the construction industry. Typically, once members of an organisation are put into a comfortable position with well-established procedures, they are loath to abandoning this comfort for change and potential hardship (Howard, 1998). Management first needs to establish willingness on the part of organisational members to consider the proposed changes. One of the best methods for creating a climate of cooperation is to demonstrate the effectiveness of the new system and its advantage over old ways of doing things (Forquer, 2006).

Wilkinson (2005) distinguishes four categories of resistance that can occur on construction projects when adoption of collaboration technology is concerned:

- Individual resistance
- Intra-organisational resistance
- Inter-organisational resistance
- Industry resistance

2.4.1. Individual Resistance

People are the actors in organisation and only they can determine whether collaboration technology will facilitate communication (Howard, 1998).

Individual carrier growth in the construction industry has often depended on obtaining professional qualifications and years of project experience, using familiar, traditional, tried and trusted techniques (Wilkinson, 2005).

Many people within organisations have developed a 'protective' attitude towards information they possess: 'knowledge is power' is a phrase often used. As a result, some individuals build entire philosophies about their roles

and responsibilities based on a non-sharing concept. Collaborative approaches will be of little or no value unless people believe in them.

2.4.2. Intra-Organisational Resistance

Just as individuals have at times adopted 'knowledge is power' attitude, there can be departmental resistance within an organisation to the notion that they should share information. Technical barriers are far less significant than the organisation and managerial issues which have to be addressed (Goodwin, 2001). Even if individuals do move towards more collaborative approaches in their activities, this may have a little value if their employers do not also encourage and support such approaches. According to Davis (2003), it is important to 'create an environment where people are not only comfortable, but also positively enthusiastic about collaboration'.

2.4.3. Inter-Organisational Resistance

Construction projects are often fragmented, complex and almost always temporary. Poor information, lack of collaboration and trust - the situation, which can create competitive and adversarial attitudes amongst participants of construction projects, is not an uncommon scenario (Cole, 2000).

The industry has 'mastered the art' of allocating blame when things go wrong especially in projects involving uncertainty, integration and urgency (Turner and Muller, 2003). The larger the supply chain, the more intermediate stages exist between project participants increasing transaction costs (Greenberg and Ive, 2000). Generally the whole contractual relationship system in construction is vastly dependant on the flow of information, the reason why project participants would want to engage in strategies to manage and minimize their

own costs to the disadvantage of the value of the project as a whole (Dainty et al., 2006).

Specifics of construction projects is that the project participants are often involved with each other only for a short time, i.e. the duration of the project. The temporary nature of such relationships generated adversarial tendencies, focused on cutting costs/ maximizing profits from the transaction, while minimizing defects and delivering the project on time. Organisations want to see collaboration technology adding value to their own operations (Lamont, 2002).

2.4.4. Industry Resistance

Construction as an industry is not so different from manufacturing: it designs, costs, assembles and manages. The differences are mainly in scale and in the fact that most projects are unique and temporary (Howard, 1998). Yet, unlike, for example, manufacturing, the construction industry is arguably slower to take up collaboration technology. Those sectors that do adopt the technology do not always use it very effectively.

The resistance to ICT in construction is rooted at higher levels than expected. Structure of the construction industry creates an underlying low climate of trust (Green et al., 2004). The industry is under-capitalized, fragmented, project based with tight margins (Howard, 1998); consequently collaborative working has been an established norm for a progressive minority, whereas the majority is set in its 'old ways'.

As Murphy (2001) observes:

> *'the certain sectors of the construction industry showed greater resistance than others to the implementation of construction project extranets ... Regarding contractors, there seems to be a significant divide between those entrenched in more dated methods of operating and those who have adopted a more progressive approach. In this case progressive refers to companies that are actively integrating partnering, supply chain management and other such core developments into their management process'.*

2.5. Technological Awareness and Implementation of Change

Generally, theory in information technology (IT) is constrained by technology. Thus, if the theory is not applicable through the state of technology the theory consequentially adapts or new theories are initiated (Howard, 1998). Thereby, technology appears to be the main limiting factor in the implementation of theory. However, Winograd and Flores (1986), Pinto and Millet (1999), Dainty et al. (2006) have identified behavioural aspects to be the more significant constraints in the convergence of technology to actual practice.

Bassala (1988) describes technological evolution in relation to four basic concepts: diversity, continuity, novelty and selection. Successful implementation of a technology has been defined in terms of changed behaviour on the part of organisational members (Slevin, 1991).

Two of the earliest models of implementation of change are the Lewin/ Schein theory of change (1952) and Kolb and Frohman model of implementation (*Table 1.1*).

Lewin and Schein argued that any form of organisational change must focus not on the technology, but on the organisational members who will be affected by that change. In this light, the technology, although important, becomes secondary to concerns about managing the shifts in attitude by potential users of the new technology. Their theory suggests a three-stage process.

Each of the stages – unfreezing, moving and refreezing – is concerned with changes in the power relationships, and the degree to which they lead to (or prevent) organisation-wide resistance to the change. Unfreezing concerns any managed efforts or programmes by top management to reduce organisational inertia.

Kolb and Frohman (1970) developed the earlier ideas by proposing a model of the change process, which focused on addressing the important stages of implementation.

Galegher and Kraut (1990) suggest that the relative failure of the adoption of a new technology derive from the technology's 'indifference' to 'what we know about social interaction in groups and organisations'. They argue that design and development of collaboration technologies could be a fruitful area of research for social scientists, who would be able to make their important contribution with regards to human interaction 1) within a group and 2) with the computer applications.

Stage	**Activities**
Scouting	Client and consultant determine each other's needs and abilities; the departments targeted for the new system is assessed
Entry	The initial statement of the goals of the system. Steps are taken toward team building and natural commitment and trust between the system's installers and the targeted department. Efforts are made to create a need for change.
Diagnosis	Data gathering to determine what specifically the client seeks. How can the geographical information system help them? What resources have been made available to implement the system?
Planning	Definition of specific targeted objectives, milestones, work (activity) breakdown, integrated planning, and resource allocation.
Action	Putting the system in place, making necessary modifications to the plan or systems events and contingencies.
Evaluation	How well did we meet our objectives? Does the system do what it promised it would do?
Termination	Transfer ownership of the system to the targeted department perhaps establish periodic follow-ups for downstream troubleshooting

Table 2.1. - Kolb and Frohman's Model of Implementation (1970)

Amongst three issues crucial for successful implementation of technology identified by Pinto and Millet (1999) the behavioural one is arguably the most significant:

> *'We have failed and continue to fail because we insist on viewing the creating of new information system as our ultimate goal rather than its successful introduction'. (Pinto and Millet, 1999)*

The construction industry has one of the lowest levels of connectivity and network technology (Wilkinson, 2005), that makes the successful adoption of collaboration technology is ever more complicated since moving from negative to neutral to positive is considerably more difficult than moving from neutral to positive. It is necessary to identify the unique characteristics of both the system and the users to most effectively fashion a strategy for the adoption of technology (Howard, 1998).

User satisfaction also must be taken into consideration – that is, users must have confidence that the application is being utilised to its fullest capacity, affecting and improving the performance of the maximum number of people (Howard, 1998).

Although, implementation theory and research have long isolated the point that problems with the diffusion and adoption of new technologies are often based on human issues rather than on technical difficulties or concerns (Slevin, 1991), it is not suggested that a system does not need to be ethnically adequate in order to be accepted.

2.6. Summary

It may take a long time for many individuals to adopt more collaborative attitudes and behaviours, much like it may take many construction firms a long time to change their organisational structures, cultures, management processes and leadership styles (Wilkinson, 2005). Moreover, these firms may need to work with similar organisations in order to develop new inter-organisational collaborative processes. Lastly, it may take even longer for the early champions of collaboration to demonstrate long-term advantages and

convince the rest of the industry of the strategic need to adopt more progressive attitudes and behaviours.

Collaborative environment helps to place a particular importance on the relationships between organisations. The internal culture of each prospective partner becomes a good starting point. Partners should 'analyze each other's goals, philosophies and cultures' (Bennett and Jayes, 1995). Both sides of a potential long-term partnership may need to present themselves as trustworthy and, more importantly, adhere to values of partnering. Organisations may have to reconsider their internal cultures and managerial protocols in order to make themselves open for collaborative way of working with their partners (Handy, 1999). Teams should be prepared to work in an open and honest way to develop the right processes.

Professional bodies defining codes of conduct (Winch, 1998) and top management (Howard, 1998) are at the forefront to change attitude and cultural barriers.

3. RESEARCH METHODOLOGY

It was decided to choose quantitative and qualitative methods (Creswell, 1994), to carry out the research. In order to attempt to obtain a high level of response, a 23-questions questionnaire was designed. In addition, 2 interviews with end-users of collaboration technology were intended in order to gain a better understanding of end-user experience with collaboration technology.

3.1. Hypotheses of the Research

The following hypotheses were considered prior to the primary research:

- Successful implementation of collaboration technology depends more on project members willing to adopt the technology than on the technology itself.
- Training and continuous support plays an important role in promoting the use of technology and changing negative attitudes among the project team.
- Collaboration technology contributes to project success.
- Project team builds stronger relationships through electronic communication channels.

3.2. Quantitative Method

The main survey was carried out by collecting the primary data in July-August, 2008. A questionnaire was designed by the author and distributed to a random selection of construction related companies via email. Assumption was made that a more accurate result should be obtained if a relatively large number of completed questionnaires were taking into consideration.

3.2.1. Defining the Research Sample

At first, a sample selection of the researched area was drawn and the group of respondents was identified. Pursuing the values of partnering and collaborative networking the author has included into her research sampling the members of companies with which she has worked and/ or liaised through collaboration technology. Thus the sampling was spread through client organisations, main contractors, architects, trade contractors located both in the UK and abroad. Approaching the professionals in person and referring to the common past experience secured a large volume of responses to the questionnaire.

3.2.2 Questionnaire Design

The quantitative method was chosen in order to observe the attitudes of individual users towards adoption of collaboration technology in construction projects, and whether - and if so, how - it could affect the patterns of changing collaboration as a whole.

The questions were designed with a view to obtain the most relevant information for the proposed research. The syntax of the questions and format of the questionnaire is simple and straightforward. Out of 23 questions that comprise the questionnaire 17 are closed and six are open. Five leading questions are provided with option of choice; four of them are presented in Likert scale format, which suggests that respondents select an appropriate answer. Four questions are structured as ones with a quantity of possible answers out of which respondents may select as many applicable answers as they wish. *Table 3.1* illustrates the categories of questions and lists the questions within each category.

First five questions and the question 19 are aimed to determine the degree of exposure to project collaboration technologies. Question 19 was specifically

designed to find out whether the respondents lived through a change of collaboration technology provider during a project.

	Category	**Question Number in the Questionnaire Sheet**
1.	Respondent's experience in collaboration technology	1-5, 19
2.	Respondent's opinion about project collaboration technology	6, 15, 22-23
3.	User satisfaction with the technology	7, 13, 16
4.	User loyalty to the technology	8, 20-21
5.	User's direct involvement in decision making about the adoption of the technology	9
6.	Training-related questions	10-12
7.	User's awareness of completeness of usage of technology	14
8.	User's opinion about possible reasons for resistance to using collaboration technology	17-18
9.	Respondent category	Final questions

Table 3.1. - Categories of Questions

Questions 6, 15, 22 and 23 concern respondents' subjective view about the collaboration technology. These are related to connection between successful collaboration technology and project delivery, the benefits that the user has experienced directly through the technology, the respondents' views about future of the technology and the past ways of working.

Questions 22 and 23 are intended to identify the changing culture in the way of working in the construction industry.

Questions 7, 13 and 16 relate to user satisfaction with the technology. The questions were design to obtain the information regarding subjective perception of the technology by users based on their own experience. Closely

related to the questions about user satisfaction are the questions about user loyalty to the particular collaboration technology application - questions 8, 20 and 21.

Purpose of question 9 was to find out how many respondents were directly involved in making the final decision to adopt one technology over the other.

Questions 10 to 12 are training-related and are designed to support (or indeed deny) our hypothesis that training and personal approach to project members can greatly influence the technology adoption and usage on a construction project.

Question 14 intends to find out to what extend the end-users think the collaboration platform is being utilized on their projects.

Questions 17 and 18 are aimed at finding out reasons for resistance to technology as deemed by those who use the technology.

Questions 15 to 17 are statements related to the effect of web-based applications to project and possible causes of resistance to use such applications on construction projects. The various statements are partially extracted from materials of Network for Construction Collaboration Technology Providers (NCCTP) and partially formulated by the author.

The final four questions were included in the questionnaire in order to find out respondents' personal details including their age, professions and the average size of projects they are working on. The questions were marked as optional (privacy of such questions was taken in consideration); therefore they were not responded to by all respondents.

In order to test whether the questions are comprehensive and clear, the questionnaire - once prepared - was sent to colleagues in construction industry for evaluation. The colleagues were not requested to complete the questionnaire, but only comment on its structure and meaning. The feedback was taken into consideration and the questionnaire was amended to reflect suggested changes. The final draft is available as Appendix A.

The questionnaire was emailed to the previously defined sample, and the quantitative data was obtained when the completed questionnaires were returned to the author. The answers were treated in confidence, so the names of respondents remain non-disclosed. The data was analyzed and the findings drawn out.

3.3. Qualitative Method

Individual interviews with two end-users were chosen for the second part of the research. This method is believed to be the best way of obtaining detailed answers (Creswell, 1994). So long as the research was intended to take into account the direct effect of the web-based application on user's experience, therefore individual in-depth interviews were preferred.
The interviews included open questions that do not appear in the questionnaire and the questions that were inspired by the questionnaire. Interviewees were also able to freely give own opinions regarding the topic.

Mr. Roger Moorey and Mr. David Goodfellow of Parsons Brinkerhoff Ltd. were selected as the interviewees for this research. Roger Moorey is a configuration manager directly involved with collaboration technology in his firm and is a champion of the technology on the project and among his colleagues. David Goodfellow is a project manager with the extensive experience in IT system implementation. Both have strong opinions in regards to the web-based applications on their projects.

3.3.1. Formation of Interviews

The interviews were purposely semi-structured and flexible. The broad areas of questions for each interview were designed separately were used as

guidelines only. The interviewees were reminded that there could be no right or wrong to answers.

On the whole the questions dealt with resistance to collaborate on different levels, difficulties with implementation of a successful collaboration system. One of the interviewees was asked to compare old ways of document management with the modern ones. The full transcripts of the interviews are presented in Appendices E and F respectively.

4. ANALYSIS OF SURVEY

The research study comprised of sending questionnaire to 71 end-users of collaboration technology and conducting semi-structured interviews with two users of collaboration technology. Out of 71 approached professional 42 responded by completing the questionnaires. The respondent score sheet, results matrix and answers matrix are available as Appendices B, C and D respectively.

Respondents were identified as author's colleagues - present and former, and the users of collaboration technology whom author has met at the industry events. The final sample therefore represents the views of a wide mix of people with experience in using the collaboration technology.

4.1. Presentation of Data Extracted from Questionnaire

Out of 71 professionals approached, 29 refused to participate in the research. Thus the survey generated an overall response rate of 59%. Out of 29 who refused to participate, 13 individuals (45%) stated that they have never used the collaboration technology and have nothing to say about it.

The 71 individuals on the original distribution list were drawn from 33 different companies. The 42 completed questionnaires were drawn from 19 of these companies. Therefore the questionnaire was completed by at least one respondent from 58% of the companies on the original sample list.

The analysis is arranged in accordance with the categories of the questions (see Table 3.1.)

4.2. Processing Data

4.2.1. Respondent Experience with Collaboration Technology

The respondents have had a cumulative experience in using the following EDMS and collaboration solutions: eB, Asite, Expedition, CCMS, Business Collaborator, Build Online, Collumbus, Inforworks, ASSA, Needlemans, Convero, Hummingbird, Livelink, Cimage, BIW, Clarity, PIMS, Aconex, Expedition, 4Projects, Documentum as well as non-branded bespoke online data portals

The respondents varied in terms of the degree of experience they had in using the technology. 31% used collaboration technology on just one project, 57% used it on 2 or 3 projects, 7% used it on 4 or 5 projects, and 5% - on more than 5 projects with one user having used collaboration technology of some sort on more than 20 projects. Therefore the overall sample contains a mixture of users from highly experienced to relative novices.

Number of Projects	Number of Users	%
1	13	31
2 - 3	24	57
4 - 5	3	3
More than 5	2	3

Table 4.1. - Respondent Experience with Collaboration Technology

45% stated that they use EDMS every day, whereas 41% use the technology between two-three times a week and two-three times a month; 14% of respondents use the system occasionally. No users stated that they have gone through a change of EDMS on a project.

43% of respondents consider themselves competent at using the collaboration technology and the rest know 'enough to get by'. In 26% of cases there could be observed direct dependency between frequency of use of the collaboration platform and the user's competence.

None of the respondents was involved in decision-making process about selection of a particular collaboration platform. This may be because either a particular system has been used throughout the organisation and the decision to adopt it was made before the respondents joined the firm, or the decision was made on senior management level and the respondents did not include any of those.

4.2.2. Respondents Opinion about Collaboration Technology

Overall, 72% of people that have made use of collaboration technology stated that it could benefit project delivery. The following reasons were given:

- Adoption of collaboration technology reduces time in developing new document management system.
- EDMS provides a single source of project information where all the documents are readily available.
- It allows speeding up process of finding the latest drawings.
- It allows desktop access to historical documents/ records.
- It provides a centrally accessible information storage and retrieval facility, thereby reducing e-mail traffic and, in particular, difficulties with transmission of large files.
- It facilitates version control.
- Proactive and regular usage can encourage information sharing, communication and transparency, thereby helping to build trust and collaborative working relationships.

- It controls the data in a central location so that it is easily available.
- Without an EDMS and a process for its use (including schema for tree structure) locating documents would be difficult and configuration management impossible.

Some users stipulated that in order to contribute to project success EDMS should meet with a number of conditions:

- The system must be set up right and administered correctly.
- It should be geared around the user.
- The system should have a flexible file structure and develop as the project needs are evolving.
- Document recovery should be enabled.
- Users must be aware of the filing structure of the system
- Procedures for the usage of the system should be in place and complied by all users.

The opinion was expressed during the subsequent interviews that it is of a particular significance for larger projects as it provides a good platform to ensure that documents are properly filed and information is not mislaid.

Some of the respondents think that EDMS do not contribute to project delivery, but only make internal document control easer. They think that the EDMS is not flexible, is suitable only as a document repository and doesn't work well. For this reason it is very hard to find required information because the search functionality is not intuitive and user-unfriendly.

One of the respondents said that the EDMS used on their project lacks notification tool, consequently it was their reason to disagree with the statement that `EDMS helps successful project delivery. The author happens to know that the notification tool in the system exists, the respondent just was not aware of its existence. This case only confirms the author's hypothesis that ignorance might be a root of dissatisfaction with EDMS, which can be effectively eliminated by training.

4.2.3. Benefits from Collaboration Technology

Users were asked to identify the business benefits that collaboration technology could bring to the project delivery. Each of 42 users of collaboration technology who completed the questionnaire identified at least two benefits. Table 4.3 summarises these findings against each of the various attributes.

	%
Better communication between involved parties	79
Designs revised and changes agreed faster	48
Designs produced faster	55
Less "re-inventing the wheel"	17
Lower design cost	24
Better audit trail	76
Better accountability for all parties	50
Less confusion over which version is current	62
Ensures everyone works from same version	43
Easier to find what you want quickly	19
Helps with quality standard compliance	41
Less risk of litigation disputes	5
Clear who needs to do what and when	31

Table 4.2. - Benefits Identified by Users of Collaboration Technology

The area where users are by far the most likely to acknowledge a substantial benefit is in terms of the ability of the technology to improve communications between everyone involved in the design process.

Traceability, audit trail and accountability clearly represent some of the most significant benefits that collaboration technology can bring.

One of the benefits users acknowledge to a significant extent is the better version control. This aspect was also identified in the interviews. For a designer and a project manager alike it is increasingly to be confident that they work on the latest available version/ revision of a document or a drawing, and clearly, collaboration technology offers this confidence.

There was no significant difference between the attributes chosen by the more experienced users and those of novices. Both groups tend to recognise much the same kinds of benefits.

4.2.4 Use of Technology in the Future

None of the respondents thought that the industry should revert to old paper based documents, and all of them believe that the technology will be omnipresent in construction industry by 2018. However one of the interviewees disagrees. He argues that virtual collaboration is not natural in the work environment, although it is wide spread on the social level, i.e. online forums, message boards, etc. He agrees with the rest of the respondents in that the document management systems will be used on every project in ten years time for storage and retrieval of information.

4.2.5. User Satisfaction with the Technology

Most respondents (62%) were moderately satisfied with the technology, with only 26% expressing dissatisfaction.

Respondents were asked to provide a satisfaction score for six different factors. A score of 4 or 5 represented high satisfaction, while 1 or 2 represented low satisfaction. As Figure 4.4 shows only 12% were dissatisfied with most factors. However, 38% were dissatisfied with upload/ download speeds, meaning the technology may work less well with certain IT infrastructures. 51% of the most experienced users (those who have used the technology on 4-5 different projects) were more satisfied with the

upload/download times – unlike the 36% who had only used the technology on one project.

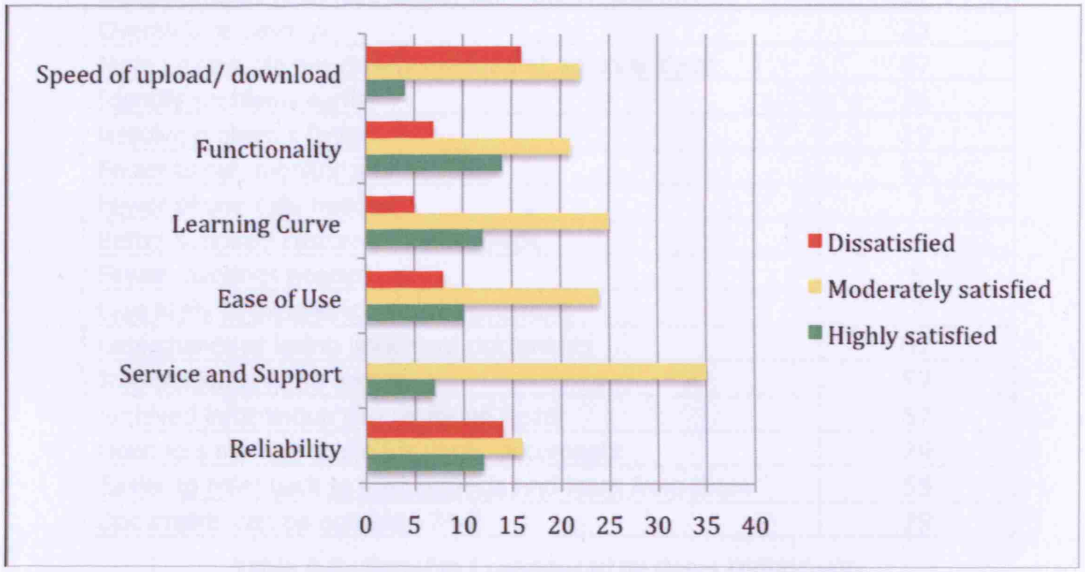

Figure 4.1. - Satisfaction with the features of technology

What is unclear is whether the problem mainly lies in the technology, or within the customers' own IT infrastructure. Both people that were interviewed emphasized that collaboration technology advance would be much faster if IT infrastructure of organisations provided fast network connection.

4.2.6. Benefits Experienced by Individual Users

The most highlighted benefits that users have experienced with collaboration technology relate to documents availability at a central location, documents accessibility at any time from any location and opportunity to involve the key people at the beginning of the project. The last point was also made during interviews. This would suggest that projects involving people spread over a wider geographic area experience significant benefits from the technology.

	%
Project information available in central location	72
Less money spent on couriers and postage	36
Geographically dispersed teams work better together	57
Overall time savings	21
More key people are closely involved at an early stage	67
Identify problems earlier	36
Resolve problems faster	19
Easier to set, monitor and hit KPIs	53
Fewer phone calls needed	7
Better supplier/ customer relationships	31
Fewer meetings needed	5
Less likely to experience project overruns	7
Less chance of losing important documents	62
Information is more secure	57
Archived information can be found faster	67
Need less storage space for paper documents	29
Easier to refer back to past projects and learn from them	55
Documents can be accessed 24/7	79

Table 4.3 - Benefits Experienced by Users Individually

The main benefit offered by the technology in terms of document management is less chance of losing important documentation according to 62% of respondents.

4.2.7. Commitment to Collaboration Technology

82% of respondents expressed the view that they would not like to change the project collaboration software. Even if a respondent were dissatisfied with the EDMS/ collaboration application, they would still prefer to stay with that system until the end of the project, because hanging the system in the middle of the project is often not the best solution to a problem.

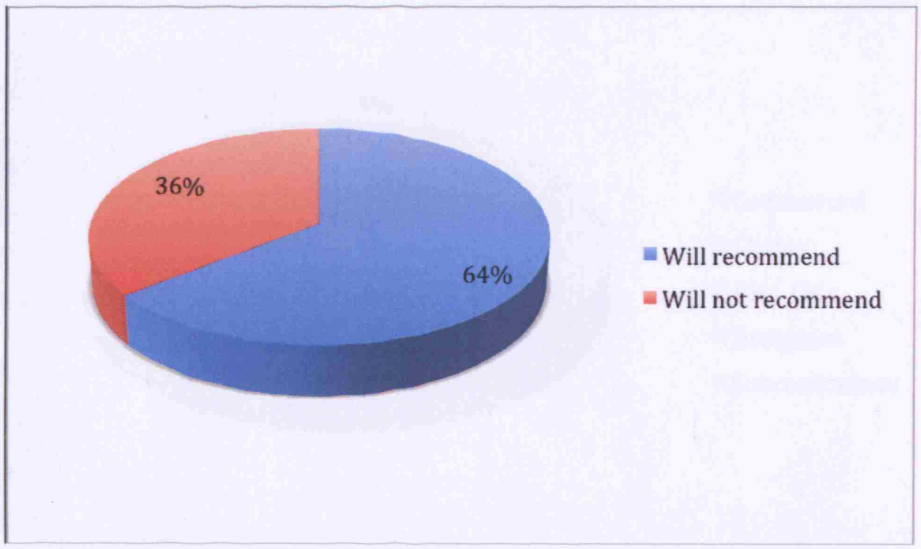

Figure 4.2. - Likelihood of Recommendation

Out of 42 respondents 27 stated that they would use the technology again, moreover they would recommend the technology to their business partners in the future (Figure 4.5). It is not surprising that those who were not satisfied with the technology would not recommend it for future use, neither would they want to use it again.

Some sectors of the industry seem to feel more loyalty to the technology than others, as this Figure 4.5 shows. Main contractors were the most loyal, followed by the clients. It's unsurprising that subcontractors were the second least loyal, since the decision to adopt collaboration technology is more likely to be taken by either the clients or the main contractors. Commercial managers seem to be least loyal, however it should be noted that only two commercial managers participated in the research, thus making the overall loyalty of commercial managers average at 50%.

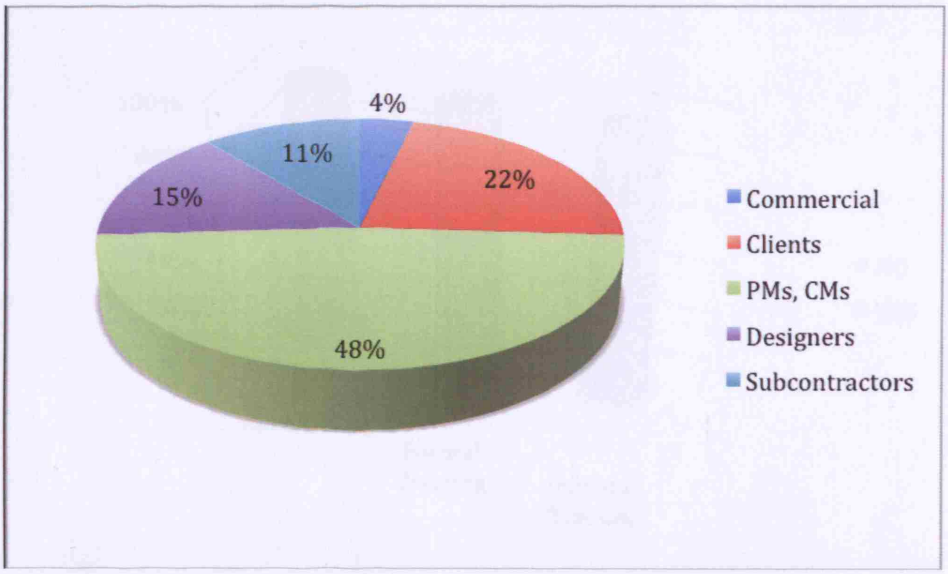

Figure 4.3. - Proportion of Loyal Advocates by Type of Respondent

Experienced users are more likely to be loyal, whereas those that have only used the technology on a more limited number of occasions are more likely to be less committed. It seems clear that more frequent exposure to the technology is linked with higher levels of loyalty.

4.2.8. Training in Collaboration Technology

48% of respondents did not have induction on how to use the EDMS when they first joined the project. Almost 40% of respondents have not received any formal training. Not surprisingly that these users tend to be less satisfied with the technology than those who have attended formal training courses.

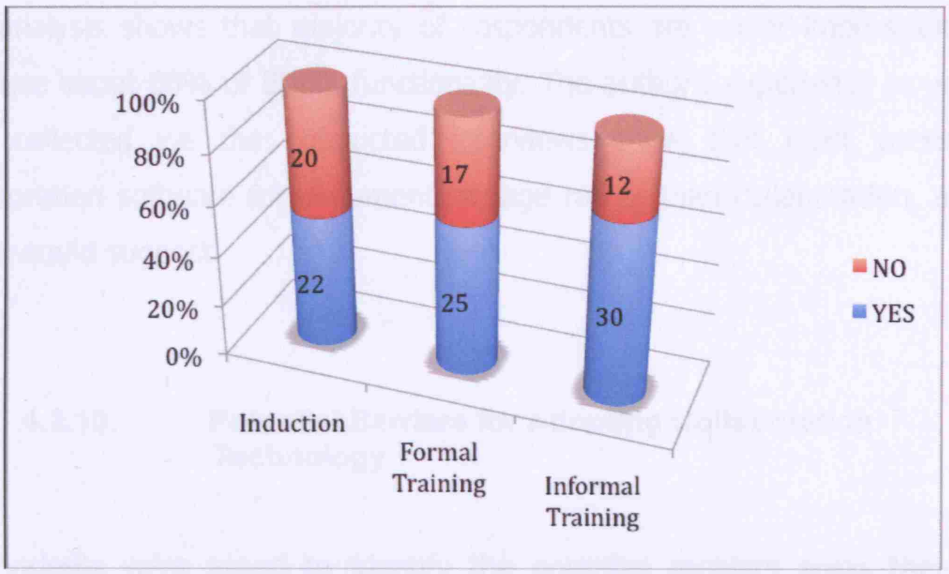

Figure 4.4. - Training in Collaboration Technology Received by Respondents

4.2.9. Using the Technology to its Full Capacity

This question was included in the questionnaire because the researcher was interesting in determining the level of general awareness about the extent to which collaboration technology is being utilised on projects. In other words, is the system being used to its fullest capabilities, or are they content to use collaboration platform to perform a few minor functions without really testing its capacity.

Whereas some users are aware of such functions of software such as discussion forums, polls, news channel, etc, these features are not being used. Document management and collaboration software is primarily used as document repository according to the majority of respondents. Many users are not aware of what is available in their extranet site, such features as meeting management, sending notifications, distributing documents via email (or within the collaboration platform itself).

The analysis shows that majority of respondents are under impression that they use about 60% of EDMS functionality. The author's experience as well as data collected via the conducted interviews show that most users use collaboration software for document storage rather than collaboration, as the name would suggest.

4.2.10. Potential Barriers for Adopting Collaboration Technology

Respondents were asked to identify the potential problem areas they had encountered which might slow the adoption of the technology. The results from this question are shown in table Table 4.4.

For most respondents including the interviewees, the need to be trained on different systems for different projects proved to be a significant concern. This finding supports our hypothesis directly linking training and level of user satisfaction. 'Getting everyone to agree to use it' and 'setting it up' were flagged up by large number of respondents. Not surprisingly 69% of respondents stated that using alternative, more habitual communication media could be one of the reasons for relatively slow uptake of collaboration technology.

The problems identified by respondents varied by profession. Engineers and architects were the biggest complainants, as larger percentage of them complained about nearly two thirds of any given problem than any other sector. 79% of them complained about the time-consuming processes, while more than a half of them complained that different training was needed on different systems for different projects. Meanwhile, clients and commercial managers seemed to be the happiest with the technology - a lower percentage of them complained about most things.

	%
Hard to get everyone to agree to make full use of the technology	69
Some system processes can be very time consuming	64
Takes a while to set up (agree protocols, train staff etc)	57
Need training on different systems for different projects	72
Easier communications encourage more changes/ amendments	31
Time saved on some processes is cancelled out by time added elsewhere	53
Cost of initial IT investment is high	48
IT literacy in the construction industry is poor	45
Another source of information - email, post, fax, extranet	69
More people getting involved - too many cooks spoiling the broth	36
Not easy to mark up or add notations to electronic drawings	29
Reduced personal contact makes working relationship harder	53
Creates more work, having to do the same job twice	48
Makes things too transparent/ places you at a competitive disadvantage	10

Table 4.4 - Potential Barriers for Adopting Collaboration Technology

Other significant barriers identified by respondents included:

- Resistance to change - people are wary of new technologies. The time, trouble and cost associated with implementation is perceived as prohibitive, when other more familiar, tried and tested communication and information sharing methods are available and already in use.
- EDMS is seen as a burden and if IT skills are low then there is very high resistance.
- Those using it are not well-versed in how to use it properly and effectively - usually people only know enough to get by.
- Network speed and reliability.
- Lack of knowledge within the organisation on the status of documents in distinct areas of the EDMS.
- Lack of control in use of stored documents e.g. external issue during procurement.
- EDMS Systems that are badly set-up (e.g. act only as Document Storage System) lead to poor perception by users.
- Lack of understanding of benefits.
- Different clients use different systems.

- Inevitably an EDMS is cumbersome and inflexible. It is difficult to take short cuts and the full procedure of process has to be followed, making minor tasks into major procedural issues.
- Potential users are really ignorant of the system.
- Poor understanding of the need for effective configuration control.
- Every project has its own characteristics and complications, such as organisation and relationship between the parties. No EDMS on the market can cover such diversity.
- Communication between involved parties is not effective through EDMS.
- Speed of access - having fast Internet links is a must or else the system falls into disrepute.
- Not use friendly, often counter-intuitive.
- Connection speed too slow. Leads to people finding alternatives and work around so that they don't have to access this painful system.
- Poorly set up systems hinder users ability significantly.
- Poorly briefed document controllers who do not input important information at the time of registering the document.
- The system is not sufficiently rationalized. It tries to do everything and ends up doing lots of things but badly.
- Complicated systems requiring training may put people off using them.
- Slow download speeds frustrating the end user.
- Download and upload times.
- Location of relevant documents especially when they have been misfiled.

4.3. Respondent Categories

4.3.1. Respondents Occupation

The 42 completed questionnaires were divided into the following segments (Figure 4.1.):

Main contractors, project managers, construction managers = 17
Sub-contractors and suppliers = 8
Designers (civil engineers or architects) = 6
Commercial Managers = 2
Client organisations = 9

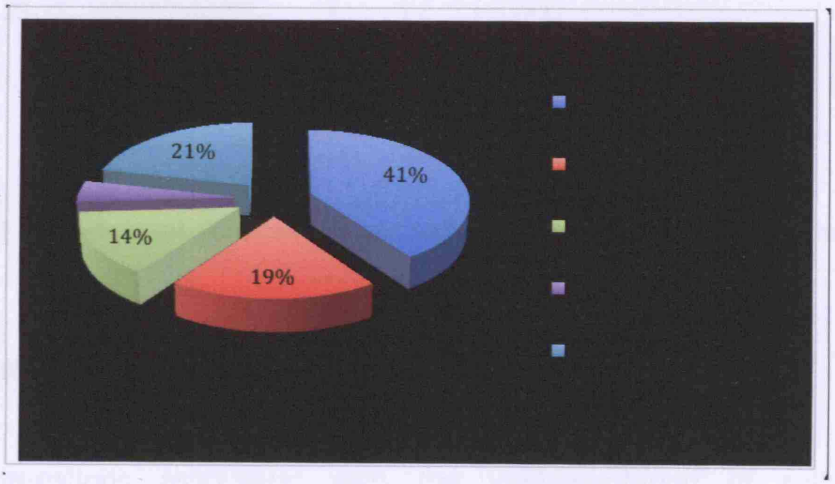

Figure 4.5 - Respondents Occupation

4.3.2. Age and Collaboration Technology

It was interesting to find out the correlation of the knowledge level of collaboration technology to age. An assumption could have been made of the younger generation (under 35) would have a higher computer literacy and a

better understanding of collaboration technology. However the result (Figure 4.3.) shows that respondents' age has no direct effect on the level of adoption and, therefore satisfaction with the technology. It has also transpired during the interviews that generally age was not a decisive factor in adopting collaboration technology. The issue is more likely to lie within individual inclination towards using IT tools and applications.

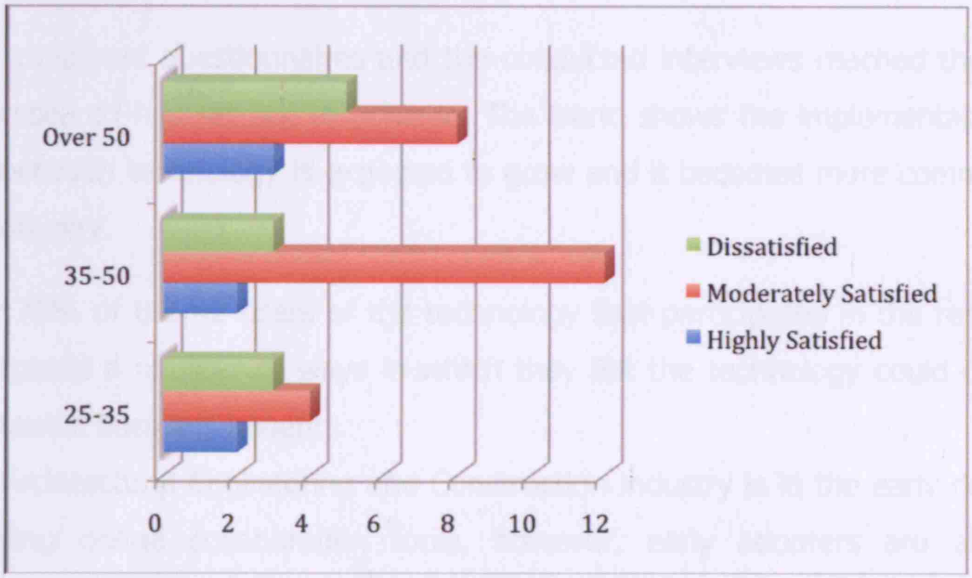

Figure 4.6 - Correlation Between Age and Satisfaction with Collaboration Technology

4.3. Analysis of Interviews

Opened questions associated with the implementation of collaboration technology in construction projects were asked in the interviews. The summaries of the two interviews are presented in Appendices E and F.

Collaboration technology was considered to be a contributive factor to project success, provided it is full to a certain degree by all parties involved. Both interviewees highlighted the importance of ongoing training for the successful implementation of collaboration technology and its subsequent use.

Reasons for possible resistance to adopt collaboration technology among individuals were identified as specific to the personality of individuals, their natural inclination to learn or lack of thereof.

4.4. Summary

The completed questionnaires and the conducted interviews reached the goal this research has set out to achieve. The trend shows the implementation of collaboration technology is expected to grow and it becomes more common in the industry.

Over 70% of the 42 users of the technology that participated in the research highlighted a number of ways in which they felt the technology could deliver substantial business benefits.
The Architectural Engineering and Construction industry is in the early days of adopting online collaboration tools, however, early adopters are already realizing some of the benefits to be gained.

In general, architects, engineers and general contractors are adopting collaboration technology and understand the benefits to be gained. On the other hand, reasons for resistance to use collaboration technology can be attributed to the lack of exposure and education about these tools within the industry.

With the advance of collaboration technology project management has become easier in tracking progress.

Regular face-to-face meetings are still important because business relationships are developed through people interaction, not by a tool.

Successful implementation involves more than simply buying a collaboration platform. While many users are highly satisfied and have made tremendous use of the various applications available through collaboration technology,

others have not been as enthusiastic in their evaluations. Many of the most cited reasons for the failure of the new system introduction are behavioural, or people oriented, rather that technical: 'nobody wants to take the time to learn the system'; 'we never had any proper training' or 'there is no incentive to use the system'.

Prospective users of collaboration technology must first be confident that the technology they are considering works with the platform that their own infrastructure provides as well as accomplishes the tasks its advocates claim it can perform.

5. CONCLUSION AND RECOMMENDATIONS

5.1. Advance of Collaboration Technology in Construction Industry

Collaboration technology offers a modern ways of dealing with information management, i.e. transferring, storing, retrieving and archiving data. Once successfully adopted, collaboration technology enhances the process of project management by tracking and accessing documents and drawings. It means that architects, engineers, surveyors and clients can work on the same plans without leaving their desks.

There is broad appeal for collaboration technology among most users – and its popularity can only increase as improvements are made to platforms for collaboration. However, it should be taken into consideration that the rate of development of technology is almost always underestimated, while that of human take-up is almost always overestimated (Howard, 1998). Notably, due to the nature of the construction industry being more labour-oriented than machine-orientated, taking up a new technology is relatively slow. Besides it is impossible to separate personal communication from the construction process, as the project success is arguably much more dependent on people interactions than on the instant availability of the Internet.

It is essential that construction is viewed as a social activity within which communication plays a vital role because, effectively, success of collaboration technology depends on how it is used. The way in which people use the technology can enable revolutionary ways of working.

5.2. Relationship Growth and Partnering

The construction industry is seeking to bring in change allowing an improvement of quality, competitiveness and profitability whilst increasing value to clients. In order for the change to occur the industry must develop a culture of co-operation, teamwork, and continuous improvement in performance.

The implementation of web-based tools has been hampered by the reluctance of participants to practice comprehensive sharing of knowledge. Once competitive and adversarial barriers are overcome, collaboration and trust can be established; the realisation of a common goal anticipated, and an effective information exchange process can evolve.

In other words, the situation could get better if (or, one hopes, when) partnership is a common practice in the industry. In this case the unnecessary cost incurred by supply chain using various collaboration platforms will be reduced due to economies of scale. In addition, the repeated business between the project organisation and collaboration technology supplier could establish more favourable terms and internal training can be put in place in order to save the direct cost.

5.3. Future Developments

Collaboration technology will have a wider market in future and more projects would make use of it. This could help the industry to move forward and achieve the best result from making use of new technology.

Egan (1998) says that the construction industry needs standardization to eliminate the long-lasting fragmentation; therefore standardization of the collaboration technology systems seems to be a logical step in achieving this goal. It would help to contribute to the better quality for project delivery.

A standard off-the-shelf EDMS will be able to deliver a data management and collaboration solution that would meet the requirements of information sharing within a specific stage of any project, however, with a full review of the users requirements for the EDMS and the technical infrastructure behind it, the application could be developed to ensure that all requirements within the full scope of a specific project are met and allow the systems use to be extended past the tender stage and into the design and construction phases of the project.

Although progressive activities such as virtual meetings and teleconferencing are becoming more popular, still the stage hasn't reached whereby the periodic project meetings can be totally dispensed with. This stage, in the author's opinion, will never be reached, no matter how advanced collaboration technology may become, however the web-enabled tools can enhance the productivity of the face-to-face meetings by providing timely and concise information in order to make more effective decisions.

Clear commercial benefits such as transparent information and speedy transfer are attractive in adopting the new application. However those benefits may be cancelled out by the hidden costs (e.g. cost of training). Typical current practice is that of different projects using different collaboration systems, which do not 'collaborate' among themselves. This brings the extra complexity in terms of sharing as well as training. Even though the extranet could facilitate project management, there are some operational problems that could obstruct the full implementation of the system. Once the collaboration technology becomes more popular and common in construction projects, the individuals and organisations may require lesser amount of training than before. As the result, the cost could drop to meet the client's demand.

5.4. Trend of Cultural Changes in Industry

Most respondents in the research believed the web-based application would become prevalent in the construction industry. However the implementation requires a cultural mindset change in the industry. At the same time, there is a concern of whether the system can be sufficiently user friendly so that the project members could use it armed just with a little training or no training at all.

Considering that adoption of the extranet is becoming more and more common in the industry, the project organisations need to understand the capabilities of the technology and its effectiveness.

The most important factors critical for successful implementation of collaboration technology tend to be behavioural as opposed to technical in nature. Team cooperation and direct contact are regarded more important than the application of a tool therefore the common perception is that collaboration technology cannot totally replace the traditional collaboration.

Encouragement is important to make things happen; therefore all companies need to take the initiative to convince their staffs to use the collaboration technology and provide sufficient their training if required. Otherwise the end-users would reject the applications and the overall scheme might fail.

5.5. Recommendations

In order for the construction industry to successfully embrace web-enabled project management tools, at a large scale, it must consider people issues as well as knowledge management.

It is important that collaboration technology is viewed as a social activity within which communication plays a vital role. Awareness, consent and growing trust between the individuals and organisations could enable change.

Effectively, success of collaboration technology depends on how people use it; revolutionary ways of working will only become possible when people are comfortable with them.

If only one recommendation could be made by the means of this report, it would be the one for the collaboration technologies providers to advance their development further in pursuit of creating their systems with the view of end-users in mind, making the collaboration software as user-friendly as possible. Integration of Web 2.0 platform into construction collaboration technology is, in the author's opinion, the most forward and practical way of achieving this. Web 2.0 means the use of web technologies and web design to enhance creativity, information sharing, and, most notably, collaboration among users. Tools range from blogs, RSS feeds, iGoogle and mindmaps to extranets, wikis, building information modelling (BIM) and virtual worlds, to name but a few (Website Extranet Evolution, 2008). As much as the author is interested in Web 2.0 technology application to construction industry collaboration, this topic is beyond the scope of this report.

One of the objectives of the electronic document management and collaboration system is to ensure ease of access to up-to-date information. Any system in place will do this, but without end user support, the system may well not be taken up completely by the project team or by other intended users and will therefore be ineffective in relaying this information. Therefore it is important that whatever system is chosen, good support, with a rapid response is in place.

This compels the author to make second - equally important - recommendation: train the users. 'Knowledge is power' is a well-known platitude, but knowledge also means confidence. It is hard to overestimate the effect that a good training can have on overall perception of collaboration technology within a project organisation. True, the change in technology perception does not happen overnight - the quality of the process must be fully addressed in order to ensure the collaboration platform is well-understood

and utilized across the supply chain, - but consistent effort proves to be an effective method in encouraging users to adopt the technology and, consequently, realise its benefits.

It is also increasingly important to ensure that the entire project chain is involved with the collaboration technology from the early stages of the projects. Training provided by the tool's vendor (or, indeed by the client's designated resources) should allow users to make the most of the technology capability. In addition, change management and consultancy services can allow the supply chain to streamline processes and maximise utilisation of the tool.

5.6. Summary

Performance of technology cannot be improved just by enhancing the product and processes; existing cultures must evolve to allow for partnering; reluctance to change itself must be overcome.

Once we are better able to understand and begin to address the process and people challenges related to implementation of collaboration technology, we could start to appreciate the full potential of the benefits the technology can bring to the success of a construction project.

References

Alshawi, M. and Ingirige B., (2003) Web-enabled Project Management: An Emerging Paradigm in Construction, *Automation in Construction*, Vol. 12, 349 – 364

Austin, S. (2001) *Design Chains: A Handbook for Integrated Collaborative Design*, Telford, Tonbridge

Baker, B.N., Murphy, D.C. and Fisher, D. (1998) Factors Affecting Project Success, *Project Management Handbook*, edited by D.I. Cleland and W.R. King, Van Nostrand Reinhold, New York, 902-919

Basalla G., (1988) *Evolution of Technology*, Cambridge University Press

Bennett, J. and Jayes, S. (1995) *Trusting the Team,* Reading Construction Forum

Betts, M., Clark A., Grilo A. and Miozzo M. (1995) A Process-Based Study of an IT Research Work Plan, *Construct IT, Occasional Paper Number 1*

Biggs, N. (1997) *Computational Learning Theory: An Introduction* Cambridge University Press, New York

Cole, T. (2000) *Electronic Communication in Construction*, Bell & Bain, Glasgow

Creswell, J. W. (1994) *Research Design: Qualitative & Quantitative Approaches*, Sage Publications, London

Dainty, A., Moore, D. and Murray, M. (2006) *Communication in Construction*, Taylor and Francis, London

Davis, M. (2003) *Earning Interest on Knowledge Capital*, Butler Group Review, June, 21-22

Egan, J. (1998) *Rethinking Construction, Report for the Construction Task Force*, London: HMSO

Egan, J. (2002) *Accelerating Change, Consultation Paper by Strategic Forum for Construction*, London: HMSO

Egan, J. (2008) *Speech at Commons Reception Marking 10th Anniversary of Rethinking Construction Report*, May, 21

Emmitt, S., Gorse, C.A. (2003) *Construction communication*, Blackwell, Oxford

Finch, E. (2000) *Net Gain in Construction*, Butterworth Heinemann, Oxford

Ford, D. (2003) *Managing Business Relationships*, J. Wiley, Chichester

Forquer, B., Jelinski, P. and Jenkins, P. (2006) *Enterprise Content Management,* Open Text Corporation, Ontario, Canada

France, K. (2002) The Future of Information Technology in Collaborative Construction, *Civil Engineering*, Vol. 150, 4-6

Galegher, J. and Kraut, R.E. (1990) *Intellectual Teamwork: Social and Technological Foundations of Cooperative Work,* Lawrence Erlbaum, Hillsdale, Hove

Goodwin, P. (2001) *Effective Integration of IT in Construction - Final Report*, Building Centre Trust

Green, S., Newcombe, R., Fernie, S. and Weller, S. (2004) *Learning across Business Sectors: Knowledge Sharing between Aerospace and Construction*, University of Reading

Gruneberg, S.L. and Ive, G.J. (2000) *The Economics of the Modern Construction Firm*, Palgrave Macmillan

Handy, C. (1999) *Understanding Organisations*, Penguin, London

Heath, C. and Luff, P. (1992) Collaboration and Control: Crisis Management and Multimedia Technology in London Underground Line Control Rooms, *Computer Supported Cooperative Work (CSCW),* Vol. 1, 69 - 94

Howard, R. (1998) *Computing in Construction*, Butterworth Heinemann, Oxford

Kellogg, J. C. (1971) A Profile of the Future Construction System, *Journal of the Construction Division*, Vol. 97, 147–161

Kelly, J., Morledge, R. and Wilinson, S. (2002) *Best Value in Construction*, Blackwell Science

Kolb, D.A. and Frohman, A.L., (1970) An Organisational Development Approach to Consulting, *Sloan Management Review,* Vol. 12, 51 - 65

Lamont, Z. (2002) IT is Not the Answer, *Building*, Vol. 19, 33

Latham, M. (1994) *Constructing the Team*, HMSO, London

Lewin, K. and Shein, E. (1952) Group Decision and Social Change, *Readings in Social Psychology*, edited by Newcomb and Hartley. New York: Holt, 459-475

Love, P.E.D., Irani, Z. and Edwards D.J. (2005) Researching the Investment of Information Technology in Construction: An Examination of Evaluation Practices, *Automation in Construction,* Vol. 14, 569- 582

Murphy, L. (2001) *Does the Use of Construction Project Extranets Add Value to the Procurement Process?* Unpublished Dissertation for MSc in Facilities Management, London: South Bank University Faculty of the Built Environment

Nohria, and Eccles, (1992) *Networks and Organisations: Structure, Form, and Action*, Harvard Business School Press

Olson, G.M. and Olson, J.S. (1991) User-Centered Design of Collaboration Technology, *Journal of Organisational Computing*, Vol.1, 61-83

Paulson, B.C. Jr., (1995) *Computer Applications in Construction,* McGraw-Hill, Inc.

Pinto, J.K. and Millet, I. (1999) *Successful Information System Implementation*, Project Management Institute

Quinn, J.B. (1980) *Strategies for Change*, Irwin: Homewood, Illinois

Smit D., Stewart J., Wall J. and Bett M. (2005) Implementing web-based collaboration platforms in construction: Evaluating the EastLink experience, QUT Research Week, Brisbane

Slevin, D.P. (1991) *The Whole Manager*, AMACOM, New York

Stephenson, J. (2005) *Building Regulations Explained*, Spon Press, London

Sun, M. and Howard, R. (2004) *Understanding IT in Construction*, Spon Press, London

Tsao, C.C.Y., Tommelein, I.D., Swanlund, E.S. and Howell, G.A. (2004) Work Structuring to Achieve Integrated Product-Process Design, *Journal of Construction, Engineering and Management*, Vol. 130 (6), 780-789

Turner, J.R. and Muller, R. (2003) On the Nature of the Project as a Temporary Organisation, *International Journal of Project Management,* Vol. 21, 1-8

Website Constructing Excellence, http://www.constructingexcellence.org.uk/ (accessed 29.06.08)

Website Network of Construction Collaboration Technology Providers, http:/lwww.ncctp.net (accessed 16.03.08)

Website Extranet Evolution, http://www.extranetevolution.com/ (accessed 08.08.08)

Wigand, R.T. (1997) *Information, Organisation and Management: Expanding Markets and Corporate Boundaries*, Wiley, Chichester, New York

Wilkinson, P. (2005) *Construction Collaboration Technologies*, Taylor and Francis, London

Winch, G. (1998) Zephyrs of Creative Destruction: Understanding the Management of Innovation in Construction, *Building Research and Information* Vol. 5, 268-279

Winch, G. (2002) *Managing Construction Projects*, Blackwell Science, London

Winograd, T. and Flores, F. (1986) *Understanding Computers and Cognition*, Intellect Books, Norwood

APPENDIX A: Questionnaire Template

Collaboration Technology in Construction Industry Questionnaire

July-August 2008

Thank you for taking time to complete the questionnaire.

A couple of things before you start:

- **EDMS is abbreviated Electronic Document Management System**
- **Every answer is right, there are no wrong answers**
- **Your subjective feelings and opinions are important**
- **For questions 15, 16 and 17 select ✓ if you agree with the statement, leave blank if you disagree**

1	What document management system do you currently use?	
2	What other document management systems have you used in the past?	
3	On how many projects have you used EDMS?	
4	How often do you use the EDMS?	Please select
5	How well do you know the EDMS?	Please select
6	In your opinion, does EDMS help the project delivery? Why?	
7	How satisfied are you with the EDMS?	Please select
8	Would you use the EDMS in the future projects?	
9	Were you involved in the processes of selection of EDMS for the project?	
10	Were you made aware of how to use the system when you joined the project?	
11	Have you attended any formal training?	
12	Have you received any informal training?	

13	Evaluate the following features of your EDMS on the scale one (lowest) to five (highest):	Reliability	
		Service and Support	
		Ease of Use	
		Learning Curve	
		Functionality	
		Speed of Upload/ Download	
14	How much of the EDMS functionality, do you think, is being utilized on the project?	Please select	
15	In your opinion, what are the benefits of using collaboration technology in design and construction process (please mark **all** appropriate to **you**):	Better communication between involved parties	
		Designs revised and changes agreed faster	
		Designs produced faster	
		Less "re-inventing the wheel"	
		Lower design cost	
		Better audit trail	
		Better accountability for all parties	
		Less confusion over which version is current	
		Ensures everyone works from same version	
		Easier to find what you want quickly	
		Helps with quality standard compliance	
		Less risk of litigation disputes	
		Clear who needs to do what and when	
16	What benefits have YOU experienced with EDMS in terms of project management, communication and team working (please mark **all** appropriate):	Project information available in central location	
		Less money spent on couriers and postage	
		Geographically dispersed teams work better together	
		Overall time savings	
		More key people are closely involved at an early stage	
		Identify problems earlier	
		Resolve problems faster	
		Easier to set, monitor and hit KPIs	
		Fewer phone calls needed	
		Better supplier/ customer relationships	
		Fewer meetings needed	
		Less likely to experience project overruns	
		Less chance of losing important documents	
		Information is more secure	
		Archived information can be found faster	
		Need less storage space for paper documents	
		Easier to refer back to past projects and learn from them	
		Documents can be accessed 24/7	

17	What do you think is the main cause of resistance for using EDMS (please mark **all** appropriate):	Hard to get everyone to agree to make full use of the technology	
		Some system processes can be very time consuming	
		Takes a while to set up (agree protocols, train stuff, etc.)	
		Need training on different systems for different projects	
		Easier communications encourage more changes/ amendments	
		Time saved on some processes is cancelled out by time added elsewhere	
		Cost of initial IT investment is high	
		IT literacy in the construction industry is poor	
		Another source of information: email, post, fax	
		Reduced personal contact makes working relationship harder	
		Not easy to mark up or add notations to electronic drawings	
		Creates more work, having to do the same job twice	
		Makes things too transparent, places you at a competitive disadvantage	
18	In your opinion, what are the other barriers for wider adoption of EDMS?		
19	Have you gone through a change of EDMS during the life of a project? If yes, how would you describe the impact the change had on the project? In the retrospect, was the change beneficial?		
20	Would you recommend your EDMS to other firms/ projects?		
21	Do you think your project would benefit from using some other EDMS?		
22	Do you think the industry should revert to paper documentation only?		
23	In 10 years time EDMS will become ubiquitous in construction industry	Please select	
	About yourself (optional)	Job title	
		Age group	Please select
		Project cost	Please select

APPENDIX B: Respondent Score Sheet

Question Number	***Options***	***Score***
3	▪ 1 ▪ 2 - 3 ▪ 4 - 5 ▪ More than 5	1 2 3 4
4	Every day Two – three times a week Two-three times a month Very occasionally	1 2 3 4
5	Excellent Competent Enough to get by Do not know at all	1 2 3 4
6	Yes No Descriptive answers will be taken in consideration	1 2
7	Highly satisfied - Satisfied Moderately satisfied Rather dissatisfied Don't know	1 2 3 4
8	Yes No	1 2
9	Yes No	1 2
10	Yes No	1 2
11	Yes	1

	No	2
12	Yes No	1 2
13-1	Reliability	1 2 3 4 5
13-2	Service and Support	1 2 3 4 5
13-3	Ease of Use	1 2 3 4 5
13-4	Learning Curve	1 2 3 4 5
13-5	Speed of Upload/ Download	1 2 3 4 5
14	Less than 10% 10-20% 30-50%	1 2 3

	60-70% 80-100%	4 5
15	Quantity of selected options will be recorded (Total - 13)	
16	Quantity of selected options will be recorded (Total – 18)	
17	Quantity of selected options will be recorded (Total – 13)	
18	Descriptive answer required	
19	Yes No Descriptive answers will be taken in consideration	1 2
20	Yes No	1 2
21	Yes No	1 2
22	Yes No	1 2
23	Agree Disagree I don't know:)	1 2 3
i	Main contractor, project manager, construction manager Sub-contractor, supplier Designer (civil engineer or architect) Commercial manager Client	1 2 3 4 5
ii	25-35 35-50 50-80	1 2 3
iii	Under £1m £1m to £10m £10m to £50m £50m to £100m Over £100m	1 2 3 4 5

Appendix C: Results Matrix

Question Number	Respondent																																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
1																																										
2																																										
3	1	1	2	2	1	2	2	2	1	2	2	2	1	2	2	1	4	4	1	2	1	2	2	1	1	2	2	3	1	2	2	1	3	1	2	3	2	2	2	2	2	2
4	1	3	4	1	3	1	2	4	1	4	1	4	1	2	1	2	1	2	1	1	1	1	1	2	1	1	1	3	2	3	4	2	3	1	2	3	1	2	3	3	4	4
5	2	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	2	2	2	2	2	2	3	3	2	3	2	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3
6	1	1	2	1	1	1	2	1	1	2	2	1	1	1	1	1	1	1	1	1	1	2	1	2	2	1	1	2	2	1	1	2	2	2	1	1	1	1	1	2	1	1
7	2	3	2	2	2	1	3	2	2	2	3	1	2	1	2	3	2	3	2	2	2	2	3	2	2	2	1	1	2	1	2	3	2	2	2	1	2	2	2	2	3	3
8	1	1	2	1	2	1	1	2	2	1	1	1	1	1	2	1	1	1	2	1	1	1	1	2	2	1	1	2	2	1	1	1	1	2	2	1	2	1	2	1	2	1
9	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10	1	2	2	1	2	2	1	2	2	1	2	1	1	2	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	2	1	1	1	2	2	2	1	1	1	2	2
11	1	2	2	2	1	2	2	1	2	2	1	2	1	2	2	1	1	1	1	1	1	1	1	2	1	2	1	1	1	1	2	2	1	1	1	1	1	2	2	1	1	1
12	2	1	1	1	2	1	2	2	1	1	2	1	2	1	1	1	2	2	2	2	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
13	4	5	2	5	4	4	2	5	5	3	2	1	3	3	3	1	2	3	4	4	2	3	3	4	1	3	2	1	3	1	3	3	3	3	2	4	3	3	3	2	4	1
14	4	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	5	3	3	4	4	3	4	3	3	5	3	3	5	3	3	3	3	3	3
15	3	4	4	3	2	4	3	3	3	5	3	3	2	5	3	2	3	3	3	3	3	5	3	1	2	4	3	4	1	3	4	4	2	3	1	3	3	3	3	3	3	3
16	3	4	4	3	2	3	4	3	4	3	5	3	5	3	3	3	3	5	4	3	3	3	4	2	3	3	2	5	3	3	4	3	3	3	5	3	3	2	3	3	3	1
17	3	2	3	2	3	2	3	2	3	4	3	3	3	3	3	3	3	3	3	4	3	3	1	4	1	2	5	1	3	3	1	3	2	3	2	3	1	1	3	2	2	2
14	4	1	2	2	4	3	2	4	1	3	4	4	4	3	4	2	4	4	3	4	2	2	4	4	2	4	4	3	4	4	2	4	4	4	2	4	4	4	4	2	4	4
15	8	5	7	7	8	10	5	4	6	9	5	7	11	4	5	6	5	5	8	8	4	7	12	9	6	5	6	5	6	6	13	9	9	8	7	5	6	8	8	10	9	9
16	7	12	7	9	8	6	9	9	4	6	12	5	9	8	8	7	12	9	8	6	5	9	5	14	9	9	2	3	7	4	7	10	9	5	7	4	7	12	4	9	7	8
17	5	4	5	4	3	7	7	7	5	3	7	6	6	8	2	5	3	7	4	4	3	7	6	4	7	6	5	6	3	4	6	4	5	5	4	8	6	9	8	11	10	3
18																																									
19	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
20	1	1	2	1	2	1	1	2	2	1	1	1	1	1	2	1	1	1	2	1	1	1	1	2	2	1	1	2	2	1	1	1	1	2	2	1	2	1	1	2	1	1
21	2	1	2	2	2	1	1	2	2	2	2	2	2	2	2	2	1	1	2	2	2	2	2	1	2	2	1	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2
22	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
i	1	1	3	5	2	1	5	3	1	5	2	2	3	1	5	2	1	3	1	1	1	2	1	5	1	5	1	2	1	1	2	2	1	1	3	4	1	2	4	5	3	5
ii	2	2	3	2	1	2	3	1	3	2	1	2	2	1	3	3	1	2	2	1	2	1	3	2	3	3	2	3	2	3	1	3	1	3	2	3	3	2	2	2	3	3
iii	5	2	4	5	2	4	5	3	4	3	5	4	5	3	5	5	4	4	5	5	4	5	4	2	4	3	4	2	3	5	2	3	5	2	5	3	5	4	3	2	2	2

Appendix D: Answers Matrix

Number of respondents who selected each of the suggested answers to closed questions or questions with multiple choices of answers

Q.3 - On how many projects have you used EDMS?

One	13
Two-three	24
FourfFive	3
More than five	2

Q.4 - How often do you use the EDMS?

Every day	19
Two – three times a week	9
Two-three times a month	8
Very occasionally	6

Q.5 - How well do you know the EDMS?

Excellent	0
Competent	18
Enough to get by	24
Do not know at all	0

Q.6 - In your opinion, does EDMS help the project delivery?

Yes	30
No	12

Q.7 - How satisfied are you with the EDMS?

Highly satisfied - Satisfied	7
Moderately satisfied	26

Rather dissatisfied	9
Don't know	0

Q.8 - Would you use the EDMS in the future projects?

Yes	27
No	15

Q.9 - Were you involved in the processes of selection of EDMS for the project?

Yes	0
No	42

Q.10 - Were you made aware of how to use the system when you joined the project?

Yes	22
No	20

Q.11 - Have you attended any formal training?

Yes	25
No	17

Q.12 - Have you received any informal training?

Yes	30
No	12

Q.13 - Evaluate the following features of your EDMS on the scale one (lowest) to five (highest):

Reliability	
1-2	14
3	16
4-5	12

Service and Support	
1-2	0
3	35
4-5	7
Ease of Use	
1-2	8
3	24
4-5	10
Learning Curve	
1-2	5
3	25
4-5	12
Speed of Upload/ Download	
1-2	16
3	22
4-5	4

Q.14 - How much of the EDMS functionality, do you think, is being utilized on the project?

Less than 10%	2
10-20%	10
30-50%	5
60-70%	25
80-100%	0

Q.15 - In your opinion, what are the benefits of using collaboration technology in design and construction process (please mark all appropriate to you):

.

Better communication between involved parties	33
Designs revised and changes agreed faster	20
Designs produced faster	23

Less "re-inventing the wheel"	7
Lower design cost	10
Better audit trail	32
Better accountability for all parties	21
Less confusion over which version is current	26
Ensures everyone works from same version	18
Easier to find what you want quickly	8
Helps with quality standard compliance	17
Less risk of litigation disputes	2
Clear who needs to do what and when	13

Q.16 - What benefits have YOU experienced with EDMS in terms of project management, communication and team working (please mark all appropriate):

Project information available in central location	30
Less money spent on couriers and postage	15
Geographically dispersed teams work better together	24
Overall time savings	9
More key people are closely involved at an early stage	28
Identify problems earlier	15
Resolve problems faster	8
Easier to set, monitor and hit KPIs	22
Fewer phone calls needed	3
Better supplier/ customer relationships	13
Fewer meetings needed	2
Less likely to experience project overruns	3
Less chance of losing important documents	26
Information is more secure	24
Archived information can be found faster	28
Need less storage space for paper documents	12
Easier to refer back to past projects and learn from them	23
Documents can be accessed 24/7	33

Q.17 - What do you think is the main cause of resistance for using EDMS (please mark all appropriate):

Hard to get everyone to agree to make full use of the technology	29
Some system processes can be very time consuming	27
Takes a while to set up (agree protocols, train staff, etc.)	24
Need training on different systems for different projects	30
Easier communications encourage more changes/ amendments	13
Time saved on some processes is cancelled out by time added elsewhere	22
Cost of initial IT investment is high	20
IT literacy in the construction industry is poor	19
Another source of information: email, post, fax	29
Reduced personal contact makes working relationship harder	15
Not easy to mark up or add notations to electronic drawings	12
Creates more work, having to do the same job twice	22
Makes things too transparent, places you at a competitive disadvantage	20

Q.19 -Have you gone through a change of EDMS during the life of a project?

Yes	0
No	42

Q.20 - Would you recommend your EDMS to other firms/ projects?

Yes	27
No	15

Q.21 - Do you think your project would benefit from using some other EDMS?

Yes	8
No	34

Q.22 -Do you think the industry should revert to paper documentation only?

Yes	0
No	42

Q.23 – In 10 years time EDMS will become omnipresent in construction industry

Agree	42
Disagree	0

i) - Job Title

Main contractor, project manager, construction manager	17
Sub-contractor, supplier	8
Designer (civil engineer or architect)	6
Commercial manager	2
Client	9

ii) - Age Group

25-35	9
35-50	17
50-80	16

iii) – Project Cost

Under £1m	0
£1m to £10m	9
£10m to £50m	6
£50m to £100m	11
Over £100m	14

Appendix E: Interview Report I

Topic:	Resistance to Collaboration Technology in Construction
Interviewee:	Roger Moorey, B.Sc. C. Eng. FIET Technologies Manager at Parsons Brinkerhoff Ltd
Date:	29 July 2008

DW: Do you remember the time when there was no collaboration technology available on projects, no electronic document management systems?

RM: Probably, yes, but not on projects, since early part of my carrier was in manufacturing.

During that time in manufacturing –about thirty years ago – there was period when we had no computers, we only had hand-written documents, drawings, schedules, parts lists, etc. All the stock control was managed by manual methods on sheets and records.

By the time I started working on major projects, outside of manufacturing environment, most organisations had some form of computer systems, not always the document management, sometimes only for commercial and financial management.

DW: Now project controls are carried out via computer systems – it can be an MS suite application, project extranet, collaboration technology.

Does it feel different from the 'paper days'?

RM: Yes, it does feel different. I'd like to make one point, I suppose - those of us who worked on a number of projects would always like to move off one project onto another and know that the exact same set of tools is going to be there.

So if you think about something like MS suite software which people are familiar with, you can be certain that people will not have any problems using it time and time again on every new project they go.

However, in the area of specific project tools like project planning, document management or asset management systems these tools are likely to be different and one will have to adapt each time, but it would be rather nice if we moved to the next project and had the same tools that we used to use on the previous project. The learning process could be considerably shortened.

I've used three document collaboration applications and each time I had to learn how to use the system.

DW: Was project coordination and teamwork different before the advent of collaboration technology? What changed?

RM: Things now happen much quicker and are expected to happen much quicker. Whereas before you would produce a drawing and post it to your partner, now you have the ability to send everything by email and there is an expectation that you would work much faster.

In the former times, because you were constrained by the communications media, keeping the paper work up to date was a lot easier and more structured – you documents always went out of the building via document control, document control held the key to everything - literally - they kept the records, and the records were always very accurate.

Now there is a risk that - unless people follow the established procedures - the documents can be received or distributed uncontrollably.

DW: Do you think the ease of electronic communications is a contributive factor to the large number of revisions during the design process?

RM: Yes, probably. Thirty years ago you'd think twice before producing a new revision of a drawing with a minor insignificant change, you'd rather wait for more comments to come in before you sit down to re-draw your plan.

Now that a change takes seconds to make and you don't have to redraw entire plan, you are probably more likely to generate greater number of revisions than in the past. But at the same time, the ease of communication also gives the opportunity to involve people early on and speed up the design process.

DW: Has collaboration technology brought improvements to project management activities?

RM: I think that the important part of project management - which is the thinking and planning stage – is always going to remain the same and is always going to require the effort on the front end in order to successfully deliver the project. I don't think that has changed or will ever change at all.

I think, what the tools provided by collaboration technology give you better ability to coordinate teams and collaborate as a team. Previously you might have had to pull the team together to work in one location, now you can actually have the team working in different places if you want to, each member of the team having ready access to the same set of documents.

The team is able to work collaboratively much better than it could in the past. That's where the differences come, not in the thinking and planning of the project delivery.

DW: Do you think the investment in collaboration technology can cover its cost?

RM: I don't think I can easily answer this question. Intuitively, I'd say, yes, because you expect collaboration technology to provide a lot of opportunities for re-use. Once the system is set up, as a project delivery organisation, you theoretically should be able to reuse it continuously.

The disadvantage comes in a big construction environment where partners are coming and going all the time, and your partners might not have the same system as yours. This brings me back to the point I made earlier – we

would all love to have a standard system, so called 'Microsoft' of project delivery world.

DW: What do you think are the main causes of resistance to the collaboration technology among individuals in the industry?

RM: Why would one want or need to use collaboration technology? Because it would make one's work easier, more efficient, will help one do more, manage better, collaborate internally better. These reasons are the biggest incentives to use the collaboration technology. You might have to use it because the legislation or internal quality management system requires you to do so.

Without being ageist, I suspect the resistance comes partly from older people. On the whole, people seem to be less eager to learn and more resistant to change the older they get. Some people by natural inclination are always very keen to use new things. It seems to me that in general the engineering fraternity is less reluctant to pick up new technology.

DW: In practical terms, what do you think are the ways to overcome individual resistance to use collaboration technology on construction projects?

RM: Training. Training through formal or informal group presentations, 'floor walking' following up on individual training. Some people may be afraid to ask, so if the trainer is approachable and has a friendly face it can help. Training without criticizing, induction training, training by level (novice, advanced, super-user). Encourage the 'super-users' to adopt a role of 'tutors'. Also, trying to find the ways to encourage people who do not use the technology to use it –I don't' know how to do it.

DW: Can you comment on resistance to share information within a project organisation?

RM: It depends on an organisation. Knowledge is power. There can be found people in every organisation who - if they have a particular expertise, they

would try to secure their standing and reputation by keeping the information that they are expert in, close to their chest. I think it is a less of an issue now that it was thirty years ago.

DW: Why?

RM: Because the employment expectations have changed. In the past you would join a firm and would expect to stay there for life. It is not typical these days.

DW: What is the reason, in your opinion, for inter-organisational resistance to collaborate?

RM: Inter-organisational resistance is always going to be associated with commercial confidentiality and design ownership. There will naturally be certain protectiveness about some information.

DW: In your opinion, does construction industry as a whole resist or welcome collaboration and collaboration technology?

RM: Having had experience both in manufacturing and in construction, I can say that, in my opinion, there is not as much collaboration going on in construction as I might have expected. There seems to be a lot of silo mentality. But equally it seems to me that the industry is making enormous efforts to break that down and to find ways of working collaboratively.

Appendix F: Interview Report II

Topic:	Collaboration Technology in Construction
Interviewee:	David Goodfellow, Project Manager at Parsons Brinkerhoff Ltd. working on the delivery of East London Line for London Overground
Date:	3 August 2008

DW: Please can you tell me about your background and your experience with collaboration and collaboration technology?

DG: I am communication engineer, project manager with more years of experience that I can remember. The nature of my job as a communication manager for many years called for liaising with accounts and producing company reports.

Documentation-wise it was a little different to the experience I have had on East London Line project. Previously I've had a lot of experience in and exposure to Oracle, MS SQL. Project collaboration was taking place in terms of collation of reporting systems on the database.

After that I worked for London Underground and where project collaboration meant we were putting together Primavera (P3E) system for collating and collecting project information from various PPP contractors onto a sequel server, so we could do enquiries as to who was doing what, and where, and whether they were progressing and producing the goods they were supposed to produce.

So, Livelink it's the first time experience for me with a document management system. My first reaction to Livelink [a collaboration software application provided by OpenText *DW*] was that it was the most difficult thing that I've

ever had to use in terms of user-friendliness because it relied on the user having the knowledge of the structure.

The Search feature was not very helpful, it was too specific: unless you knew something about the document title, or you knew what the metadata was, you could never find the document. It wasn't until I spent considerable amount of time investigating the system that I felt relatively comfortable using it.

I think a lot of improvements have been made to the Search since. But at that time, the only way we could use Livelink to retrieve the document was to learn the structure.

In terms of usability I didn't' find it very friendly. Now I can see the system is good at retrieving the documents, although I didn't find it good at cross-referencing the documents, at searching for documents knowing just some of the title. As a user I think it is important to be able to search for a document by a little reference that I have and also to cross-reference the document with the set of documents to which it refers to.

DW: Often you have to contact Document Control who will be able to provide you with the information you require because they keep a register in MS Excel format, the format that is quite good at cross-referencing data to a certain extent, of course.

DG: There are probably two ways to secure that the required information is available.

One is the discipline of document controller who must go through the documents and actually enter the metadata – a very labour-intensive process, otherwise the documents are virtually impossible to find. (This is actually an old manual way of doing things – you cross-reference all your documentation).

The other thing to do is increase usability. If we look at what Livelink is actually capable of and start to use some of its strength, we'd be better off.

What we mostly use Livelink for on the delivery side is almost exclusively just to retrieve information. And it's just a small part of what I think Livelink should be doing.

Also, the users must understand the structure of Livelink in order to find things. As a result, as long as you are reasonably careful about your search, you can find what you are looking for.

The way the Livelink is set up on the project resembles a library. Much like in a library, if you don't know where the book you are looking for is located, you'll have to ask a librarian for help. But if the collaboration software is set up in relatively standard categories, it won't happen and you will go exactly where you need to go to find whatever you are looking for.

This kind of things happens a lot on this project. Very often we can't find information by Search, or the Search does not return the right result because we just don't know how to perform a search properly. Although, I must say it's so much better now than it was, I don't know what you've done there, but things are certainly a lot better than they used to be.

DW: I am a huge believer in the power of ongoing training.

DG: That must be it. I think there has been overall improvement in my Livelink experience lately. May be it's your training, in which case - thank you.

DW: Do you think collaboration technology is a contributive factor to project success?

DG: Yes, it could be and should be because it should provide ready reference to the documentation we get from contractor, to the contract documentation, to everything we need. As a client we should be able to easy access contractor's programme as well as the correspondence routinely. There is a whole suite of documents that we regularly need to see. What most of us used to do before we had the extranet, was to keep a copy of everything in our local drive. Most of us would have their own structure, referencing procedure, etc. What's wrong with that is

a) it is inefficient space-wise, storage-wise, because everybody keeps their own copy, but more importantly, and

b) it is dangerous because you keep a several copies that are not controlled and you are not always sure what is the latest. With an EDMS this danger can be averted because the system supports version control.

So, yes EDMS could help to delivery of a project provided it is used at its full or close to full capacity. But to be used project-wide, it has to be user-friendly. It has to be very similar to what people are used to; it has to be as friendly as our local drive. All this coming together equals efficiency.

DW: Do you use less-known features of Livelink in your work?

DG: Some. For example, very few of us use the feature of automatic notification. I do, but I am in the minority here. I receive a notification that the contractor has just uploaded the programme, I follow the link, I see the programme. I later need to include the programme into my report, I know where it is and I can extract it easily and efficiently. Many of us would not do it, though. For majority of us it is easier just to ask a colleague for a copy of that programme.

DW: Why?

DG: Because we don't feel comfortable with Livelink.

DW: Why do not we feel comfortable with Livelink?

DG: Firstly, I think we are not familiar enough with the structure of information in Livelink. We are familiar with the tree-structure of folders in our local drives, we are very familiar with the way file manager works in MS Windows and most of us who used shared drives before have an understanding of how they work.

If we had a straightforward folder structure in Livelink, if everybody understood it and found that it is as easy to use as the Windows Explorer, we'd be more inclined to do so. What people tend to do is, disheartened by

Search in Livelink, they just ask their colleague for a document. So, what's available in Livelink gets bypassed because people find it easier not to use it. I think it's a perception of the set-up issue.

If we all agreed on a protocol that enforces certain things to be put in certain folders in Livelink, if the protocol was well-publicized across the project, if everyone bought into it, everybody's Livelink experience would become more successful.

DW: We find it easier to ask a colleague sitting next to us for a copy of a document rather than spending time looking for it in EDMS. Do you think the same would apply if our project partners were based half way across the world?

DG: Yes, I do. People tend to blame Livelink for being slow, but albeit I think it is the network which is slow, the general perception of Livelink the one of being slow and unreliable. The network speed is huge contributive factor in determining attitude towards an EDMS.

If we are not relying on the EDMS to give us what we want in reasonable time, we will email to our partners abroad and ask them to email us back with the required information. People would much rather choose the simplest route. I think I should probably divide things into two problem areas: first, the usability in terms of features that Livelink offers and second, simply the response time, which is quite severe limited sometimes here.

DW: Have you received any training when you first joined the project?

DG: No, not to speak of. I've received my login details and was told about the difference between production and issued areas and that was it. I've played around and got a feel of what Livelink can do. You are the first one here who has actually done any training on how to use Livelink.

DW: This is my hypothesis. I am attempting to prove that negative perception of an EDMS can be changed through consistent, ongoing training and promotion of positive attitudes.

DG: I think that's right. The problem with Livelink is it is a not a bit of software that people have at home. Livelink is totally different from what people are used to. So, I think it is important that we have Livelink awareness sessions as part of induction for new starters. People should know about Livelink as soon as they join the project, because the very first perception is incredibly important. If during the induction the positive attitude towards Livelink is encouraged, people will have open minds about using it.

DW: Why do you think as an industry we are resisting the collaboration technology?

DG: Firstly, it's hard to get everyone to agree to use it – even on a single project. Secondly, very often the perception is that time saved on some processes is cancelled out by time lost on the others. Net benefit is not always in favour of EDMS. Thirdly, IT literacy in the industry is rather poor.

I think the cause of resistance of using EDMS is ignorance. Ignorance in the industry of what collaboration technology is capable of doing, because there is no vision. And because there is no vision, there is ignorance within the management. Management does not understand what EDMS can do, and how it can do it. If they do try to implement it, the companies do not implement EDMS properly and, therefore, it is doomed to failure before it is even started.

If managers in this industry actually understood what collaboration technology can do and then could understand the benefits it can bring, then can get someone to set it up properly to actually delivery those benefits then you'd have a whole working system and everyone would be much happier. Do you agree with this?

DW: I do, but I am also trying to find some practical solutions. What must happen within a business or between organisations or in the industry as a whole in order to change the perception of collaboration technology among senior management?

DG: That's a really hard question. How to get rid of that ignorance? For a senior management to advocate the use of collaboration technology they have to have had a positive experience with it in the past.

DW: Would you recommend Livelink?

DG: Probably, not. It works, but it is not particularly helpful, in my opinion. I found it is not very user-friendly. But I would definitely recommend collaboration technology as a concept.

DW: Do you think, in ten years time collaboration technology would be used on every construction project?

DG: No. I am looking five years back, and I see that what we thought will be spread out across the industry in five years time, has not actually caught on. One of the reasons those things didn't catch on is they do not necessarily deliver what is needed.

I don't see collaboration technology spreading out on the large scale even in ten years time. We will continue using the collaboration technology for storage and retrieval of data as we have been doing for years now, but collaborating via technology is not something that I see happening.