COLLABORATIVE ENVIRONMENTS AND THEIR EFFECT ON CONSTRUCTION COMPANIES: THE CURRENT CONTEXT

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ABSTRACT

The research reported in this paper was aimed at exploring the introduction of IT enabled collaboration to construction companies and managing the changes required to obtain full benefits. The paper firstly presents the results of a literature review on the current collaborative working approaches in construction and general causes of failure in IT implementations. This revealed that 80 to 90 per cent of IT investment in large construction companies did not meet their performance objectives. It can be partly attributed to the fact that use of collaboration technology remains low among 99% of companies in the UK construction industry usually referred to as Small and Medium Enterprises (SMEs < 250 employees) whom are key players in supporting large construction companies. Secondly, the paper presents the results of a literature review on the organsiational factors affecting the success of collaborative environment implementations. The paper then concludes with the necessity to investigationg the right combination of factors which contribute towards the improvement and implementation of collaborative environments and some insights into how the current perspectives of the construction SMEs on the implementation of collaborative environments can be obtained.

Keywords: Collaboration, Collaborative technology, SMEs, Organsiational, Sociocultural, Conractual

1. INTRODUCTION

There is a high collaboration requirement in construction due to its multi-organisational and geographically dispersed project nature. The UK construction industry has come a long way since the Latham report was published in 1994 and the subsequent Egan process since 1998. Many of these reports' recommendations have been implemented, and numerous companies have begun to adopt more collaborative working. This gradual but, inevitably, irreversible shift towards collaborative working and enthusiasm about the adoption of collaboration technologies can be said to be two faces of one coin. In fact, to an industry that was and still is synonymous with delay, waste and inefficiency, the opportunity to use collaboration technologies is too good to miss. It ensues naturally that demand for those technologies that allow collaborative working may only grow as the enthusiasm for team working grows.

It is encouraging that some major UK construction businesses have already begun to preach collaboration technologies. However, the literature review revealed that 80% to 90% of IT investments in the UK do not meet their performance objectives (eBusiness W@tch, 2006; Alshawi, 2007). This can be partly attributed to statistical evidence proving that the majority of SMEs whom are key players in supporting the large construction companies (Maguire et al., 2007; Stokes and Wilson, 2006) lag behind. In fact, the use of collaboration technologies remains low among 99% of companies in the UK construction industry usually referred to as SMEs. The reason for this is found to be rarely technical. Focusing too much on technical issues and ignoring or underestimating the organisational factors has been mentioned in other research efforts (Laudon and Laudon, 2000; Clegg et al., 2001; Kuruppuarachchi et al., 2002; Wilkinson, 2005; Shelbourn et al., 2007). Modifying the IT life cycle by adding a new stage to measure the IT

capability of companies prior to the commencement of the implementation fails to provide the implemntation expectations for SMEs at project organsiational level since most SMEs are still at the first level. It can be said that the benefits of collaborative environments are not yet proven industry wide (Barbour 2003; Allen et al, 2005; Wilkinson, 2005; eBusiness W@tch, 2006; Hassan et al. 2007; Erdogan et. al, 2010).

This poses the problem of what are the most appropriate working environments available to match the SMEs in the construction industry. The construction reports push for collaboration technologies as one solution to this problem, i.e. to improve performance. While there is an increasing attention levelled at the importance of the integration of IT in business environments in general, previous research related to the implementation of IT enabled collaboration seems to be directed at the very large organisations, with little attention being directed at SMEs. Given that SMEs deliver 52% of the construction industry's workload in monetary terms (DETR, 2000), it ensues naturally that they are key players in supporting large construction companies. Therefore, SMEs good performance and survival in the industry is vital. This is the reason to why this research attempts to investigate ways of getting the SMEs to engage more effectively in collaboration initiatives to meet the demands of an over growing industry, while increasing their overall competitiveness.

The aforementioned would lead one to raise the following questions regarding collaborative environments implementation in construction SMEs:

- What are the main challenges SMEs face in implementing collaboration initiatives in the construction industry?
- What are the technologies used and how effective are they for collaboration in SMEs in the construction industry?
- To what extent do collaborative environment initiatives impact on competitiveness in SMEs in the construction industry?

This paper is based on extensive literature review intended to provide answers to all of the aforementioned questions and insights for the deficient research. An attempt to answer these questions leads to the following objectives:

- To develop an understanding of collaborative environments in the construction industry;
- To explore the efficacy of different technologies for collaboration in SMEs and their current collaborative working approaches in construction;
- To identify the failure reasons for ICT and the factors that facilitates effective collaboration environments implementation in SMEs.

The results of this research can be beneficial to construction SMEs that are planning to implement collaborative environments, and they may shed some light on unexplained deviations in the performance of collaborative environments. The intended users of such environments can better understand the benefits behind changes or improvements in areas of implementation, and the important factors that need to be considered to ensure the success of collaborative environments implementation. Altogether, the results of this research can lead to an improvement of collaborative environments utilization, management, and more widespread acceptance of such environments among SMEs in the construction industry.

2. COLLABORATION TECHNOLOGIES IN CONSTRUCTION

Having said that there is a high amount of collaboration requirement in construction due to its multi-organsiational and geographically dispersed structure, collaboration technologies have the potential to enable this requirement. The collaboration environment concept addressed in this paper refer to an environment created using different collaboration tools and technologies where all organisations involved in the construction project can communicate, exchange data and information, and carry out joint activities in order to realise the successful completion of this project. Researchers in this area tend to categorise collaboration technologies using different criteria. Chinowsky and Rojas (2003) divide existing technologies used for collaboration according to their interaction scales as: communication, cooperation

and collaboration. However, the boundaries between communication, cooperation and collaboration are not usually very clear since these concepts are interlinked. Sun and Howard (2004) believe that collaborative working using computers is covered by two research areas, computer mediated communication (CMC) and computer supported cooperative work (CSCW), which often overlap in producing the actual technical solutions. Depending on the way they are used, Baldwin (2004) groups collaboration technologies under five categories: communication technologies, shared information space technologies, meeting support technologies, coordination technologies and integrated products. Depending on the time and space factors, collaboration can be considered to have four modes (Anumba et al., 2002): face-to-face collaboration, asynchronous collaboration, synchronous distributed collaboration and asynchronous distributed collaboration.

Much of the recent work aiming to improve this collaborative working on construction projects focuses on development of web-based technological solutions, collaborative visualisation, virtual reality and CAD applications (Bouchlaghem et al., 2005) and knowledge management systems and technologies. The enhancements in internet and web-based technologies have led construction research to focus on the development of solutions for distributed collaboration mainly for design or project management purposes. Examples include: a collaborative design system developed to improve design coordination for building projects (Hegazy et al., 2001; Zaneldin et al., 2001), a multi-user workspace as a medium for communication in collaborative design (Woo et al., 2001), an internet-based shared virtual reality environment for design and management (Caneparo, 2001), the CODE system which is an integrated industry foundation class (IFC)-based, internet-enabled collaborative building design environment (Roshani and Tizani, 2005), the COMMIT project aiming to improve information management to support decision making in collaborative projects (Rezgui et al., 1998), TITS which is an internet-based project management system (Deng et al., 2001), and a collaborative project management system for real-time collaboration between geographically dispersed project teams (Pena-Mora and Dwivedi, 2002), a system enabling collaborative supply chain preplanning through a multi-agent systems approach (Tah, 2005), the CODE system which is an integrated Industry Foundation Class based, internet enabled collaborative building design environment (Roshani et al., 2005), HyCon virtual reality tool which provide an immersive, interactive and information-rich environment through which design solutions can be explored (Zhang et al. 2006); to mention a few. There are many factors that are likely to influence the success or failure of working collaboratively with technology. Wilkinson (2005) refers to an industry rule of thumb which suggests that 80 percent of the successful implementation of collaboration systems depends on tackling the people and process issues whereas 20 percent is related to resolving the technology aspects.

3. BARRIERS TO THE IMPLEMENTATION OF COLLABORATION ENVIRONMENTS IN CONSTRUCTION

When the previous research on the reasons for failing to achieve the full benefits from implementation of IT systems is investigated, it is seen that most of the authors refer to similar or related issues as the failure reasons, which can be grouped into six barrier categories: poor user requirements capture (Andresen et al., 2000; Laudon and Laudon, 2000; Anumba & Ruikar, 2002); user resistance to change (David & Songer, 2002; Suwardy et al., 2003); lack of user involvement (Laudon and Laudon, 2000); lack of proper planning/project management (Laudon and Laudon, 2000; Suwardy et al., 2003); lack of strategic approaches (Andresen et al., 2000; Clegg et al., 2001; Kuruppuarachchi et al., 2002; Baldwin, 2004); technical characteristics (Suwardy et al., 2003); Risk (Laudon and Laudon, 2000; Kuruppuarachchi et. al, 2002).

Collaboration environments implementation requires a focused perspective on collaboration as well as IT. However, collaboration is difficult to establish even as a soft issue regardless of the accompanying IT. Each IT implementation is a source of resistance and confusion on its own unless special attention is paid while it is being introduced to the organisation. Focusing too much on technical factors may result in

technically excellent systems which are incompatible with the organisation's structure, culture and goals since it neglects to consider how the new technology interacts with working practices, work organisation structure, job design and work processes (Laudon and Laudon, 2000; Clegg et al., 2001). Tanyer (2004) categorises the barriers identified for computer integrated construction (CIC) under six main headings; namely: industry level problems related to the fragmented structure of the industry; organisation level problems readiness of the organisation for the new technology, cultural issues, people issues, incompatibility of the processes and technologies between organisations collaborating on a project; project level problems uncertainties and risks at project inception, multiple project information management systems implemented for different projects; technology related problems coordination and management of information (data access rights, data change rights, database transactions), data exchange standards; legal problems ownership of data, insurance and indemnity requirements; end-user level problems usability issues, training. Many research projects on collaboration environmets implementations in construction mention similar barriers. Alshawi and Ingirige (2003) identify security issues, cultural issues, legal issues, incapability of telepresence to replace face-to-face meetings and not being integrated to a common database for web-based project management tools as key barriers. Nitithamyong & Skibniewski (2004) identified data ownership and collaborative maturity. Ruikar et al. (2005) identify security issues, multiple-vendor issues, cost issues, cultural issues, legal issues, connectivity issues and technology issues as barriers to project extranet-based collaboration environments.

In this respect, it is encouraging that some major UK construction businesses have already begun to preach collaboration technologies. See NCCTP (2009) for examples of collaboration technology implementations in large organsiations. However, large construction companies adopting emerging collaboration technologies usually fail in achieving the full benefits from their implementations (Gladwell, 2001; Brandon et al, 2005; Wilkinson, 2005; Alshawi, 2007; Shelbourn et al. 2007). This can be partly attributed to statistical evidence proving that the majority of SMEs whom are key players in supporting the large construction companies (Maguire et al., 2007; Stokes and Wilson, 2006) lag behind. Barbour (2002, p.31) found that, on average, 2% of projects in 2001 were managed using project collaboration tools, with use greater among larger enterprises; a year later (Barbour 2003, p.14), it said 13% claimed their teams used such technology. In 2004, according to the IT Construction Forum, 34% said that they used project extranets to collaborate online. The DTI benchmarking study (2004, p.52) found 17% of construction businesses claiming to be extranet users. Use among SMEs remained low, however (Wilkinson, 2005 p. 105; eBusiness W@tch, 2006). A 2004 survey of more than 800 members of the National Federation of Builders which represents over 3,000 SMEs found that only 3% of respondents had used project collaboration tool. While it is difficult to get reliable and consistent statistical information, it can be deduced that collaboration technologies had begun to achieve credibility with some leading enterprises. Therefore, within the context of this research, the focus lies in how SMEs can develop in response to business pressures using the opportunities provided by collaboration technology.

4. SMALL AND MEDIUM ENTERPRISES IN THE CONSTRUCTION INDUSTRY

The number of employees or the annual company turnover are usually employed to define an SME. As agreed by Storey (1994) and OECD (2002), there is no single, distinct and uniformly acceptable definition and the choice of measure is flexible as it does not matter much in practice which measure is adopted, for most measures are highly correlated with each other. It has been stated that for practical reasons, it is advisable that only one measure of size is used or chosen at any one time. The definition forwarded by the Department of Trade and Industry, UK (DTI, 1999), the Small Business Service, UK (SBS, 2000) and the European Union (2003) is adopted hereby in the research as the standard for the classification of companies. Enterprises employing more than 250 employees, are not within the domain of this research work.

SMEs are important in the economic life of most countries and their competitiveness is arguably indispensable to a country's growth and success. It is worth noting that companies below 50 employees constitute 99.1% of enterprises, employ 44.7% of the workforce and attain 39.5% of the UK turnover. Extending these figures to companies below 250 employees, it can be deduced that SMEs constitute 99.8% of UK businesses, employ 56.8% of the workforce and attain 53.8% of the overall business turnover.

It was seen that there is very little research on the factors affecting the success of collaboration environments and barriers to implementation in SMEs. Even more, attempting to provide a general solution for all types of SMEs does not provide specific answers to construction SMEs. Assisting SMEs in implementing collaboration technologies could have a significant effect on business improvement and might lead to long term sustainability and economic development.

5. KEY ISSUES IN IMPLEMENTING COLLABORATION ENVIRONMENTS

Since previous research showed that the technical characteristics are rarely the reason for the failure of collaboration environments, this section focuses on the other factors and discusses key factors in implementation of collaboration environments. Construction is characterised by the presence of organisations that each has core business functions which identify its speciality. Each core business function is accomplished through a number of high level functions at a project level. Each high level function is accomplished by a large number of low level ***processes*** which are mainly concerned with low level data capturing and manipulation (Cornick and Mather 1999; Harris and Harris 1996; Howell 1996; PIECC, 2006; Alshawi, 2007). At this point in time, ***teams*** which are organised around business processes are the key to organisational development (Schnitt, 1993; Cornick and Mather, 1999; Fischer et al., 2005; Alshawi, 2007). It ensues naturally that a discussion of the ***structure*** can not therefore rest content within the inside of the organisation. Being the one and only structure in the construction process that guarantees response to project delivery does not imply that teamwork is entirely without its own issues. As a result of emphasis on teamwork, collaboration technologies have been developed. Surprisingly enough, the picture becomes more complicated when technology is considered. Research has identified main ingredient that describe a team that has been fully integrated, namely: it has a single focus and objectives for the project; operates without boundaries among the various organization members and work towards mutually beneficial outcomes; shares information freely among its members such that access is not restricted to specific professions and organisational units within the team; has a new identity and is co-located; operates in an atmosphere where relationships are equitable, offers its members equal opportunities to contribute to the delivery process and all members are respected (Bromley et al. 2003; Dainty et al. 2001; Evbuomwan and Anumba 1998; Strategic Forum for Construction 2003; Vyse 2001). These ingredients assist in indicating the team's full, partial, or no integration and how it overcome the challenges of the critical key components of teamwork processes. ***Process standardisation*** is raised as of utmost importance to facilitate the integration of applications (Alshawi, 2000; Wilkinson, 2005; Alshawi, 2007). By implication, technology brings about ***change*** at an organisatioanl and individual level (Rezgui et al., 2005; McAdam and Galloway, 2005; Goudling, 2007), and is therefore likely to be met with ***resistance***. Resistance to change is most likely when change is imposed on individuals; laying emphasis on the vital role for leadership to play. Underlying the technology enabled collaboration there is a perception of ***risk*** arising from the technology adoption (Hammer and Stanton, 1995; Alshawi, 2007; Murdoch and Hughes, 2008). In order for organisations to survive the risk of change, the literature on ***strategy*** ranges from business strategy manifested in what is termed strategic planning which should be underpinned by the technology strategy (Robson, 1997; Feeny and Willcocks, 1998; Alshawi, 2007).

With regards to the legal status of ICT based collaboration, broadly, paper-based records are simply records kept in a particular medium, and electronic media are no less valid. But it is important to ensure that records are authentic, accurate, and accessible. This uncertainty is compounded by the absence of

appropriate provisions in many standard ***contract*** forms. As such, contracts need amendment to be appropriate for projects where technology enabled collaboration is employed (Wilkinson, 2005; Carter et al., 2007; Hassan et al., 2008). Some go as far as advocating an ICT contract (Camrinha and Afsarmanesh, 2005; Idlyerstern and Kocatork, 2006; Hassan et al., 2008). The issue of legal ***admissibility*** sees the light of day where a statement contained in a document is admissible as evidence in civil proceedings ought to be authenticated in such a manner as the court may approve (Wilkinson, 2005). At this point in time, the importance of what is termed ***certificate authority***, ***digital signature***, and ***digital notary*** is the utmost.
With regards to legal relationships with the software vendor, it can be said that entrusting information created by the team to a collaboration system places some strong obligation on the software vendor, particularly if it is functioning as an Active Service Provider (ASP). It is therefore vital that appropriate legal arrangements are put in place to support the key relationships; namely: between a software vendor/ASP and a client involving a ***Master License Agreement***; between a software vendor/ASP and end-user involving an ***End User License Agreement; Service Level Agreement*** to underpin security and reliability requirements. It is also useful to specify relationships between individual members stipulating use of the technology to communicate with each other covered in project ***protocol documents***. Not to mention managing service ***interruption*** and ASP ***termination***. Sharing project information in an electronic collaboration environment can make team members anxious about the ***ownership***, use, and possible abuse, of the information they contribute. Such anxieties can also extend to intellectual property.

By ***relationships*** reference is made to two paths. The first one is a deep collaboration opportunity, whereas the second one is an exploitation of a short term opportunity (Sarkar et al., 2001; Rodney, 2005; Sexton et al., 2005). To this end, several theoretical perspectives exist to explain the forms of inter-organisational relationships (Sarkar et al., 2001; Boddy et al., 2006; Phua, 2006). Although there is significant conceptual divergence underpinning each of these broad theories, an overarching assumption common to all is that organisations make rational, albeit bounded and deliberate, decisions about the types of inter-organisational relationships that they would enter into which would most benefit their organisation. In fact, collaborative value creation requires the pursuit of partners who possess similar characteristics on certain dimensions and dissimilar or complementary characteristics on other dimensions. This is where ***communication*** comes in handy so as to bridge the gap between partners as best as it can. It is primarily a matter of the existence and richness of transmission channels that matches the task relevance of the information being conveyed. This consists of four attributes (Daft & Lengel, 1984; Daft and Lengel, 1986; Trevino, et al., 1987; Fulk & Boyd, 1991; Sexton et al., 2005), namely: (1) Feedback capability refers to how quickly can the communication medium enable partners to ask for, and receive, information; (2) Language variety refers to the use of different types of language; (3) Personal focus refers to the degree of individual attention and emotional content a message contains; (4) Availability of multiple cues refers to the number of the various channels of communication available to the participants. At this point in time ***commitment*** plays a significant role. Commitment research theme proposes a typology, namely: (1) Continuance commitment refers to a need to remain in the organisation because of the costs associated with leaving. (2) Effective commitment an attitudinal process whereby people come to think about their relationship with the organisation in terms of value and goal congruency. (3) Normative commitment refers to desire to remain with the organisation based on a sense of duty, loyalty or moral obligation (Anderson and Weitz, 1992; Beach et al., 2004; Peansupap and Walker, 2006; Walker, 2006; Alshawi, 2007). High levels of virtually swift ***trust***, established between team members, may pioneer a strengthening of relationships between the member organsiations partaking in technology enabled collaboration (Grabowski and Roberts, 1998; Moore, 1999; Maskell, 2000; Moorman, 2003; Wilkinson, 2005). Although trust exists between individuals, it can be extended to relationships between organizations. () emphasise the term ***mutuality*** to differentiate genuine collaboration atmosphere of trust from other forms. A fundamental component, of relationships to facilitate team working across contractual boundaries, is formalised mutual objectives. Although there may be alternative conceptualizations of mutuality, it is generally considered to be a relationship property that reflects interdependent or reciprocal patterns of subjective events. The ***work attitudes*** factor of technology

enabled collaboration in construction springs from the fact that it is derived and based mainly on the team integration, as such, it is heavily laden with attitudes. In the midst of this social drama, cultural problems in organizations brought about by employees' deep-rooted values and beliefs raises the difference between the values and perceptions held by one person, or team and the perceptions held by others (individuals, or teams). If this gap is not effectively addressed, these differences can often instill mistrust and create communication problems, particularly when no common agreement has been reached concerning social rules (Wilkinson, 2005; Alshawi, 2007; Murdoch and Hughes, 2008). Employee ***empowerment*** by means of promoting self-management and collaborative team-working principles is an effective factor leading to the success of technology implementation. When employees are empowered, they become more involved in deciding how work (change) should be approached and which technologies to use, and they are given the chance to participate in the change and implementation process (Mumford, 1995; Arendt et al. 1995; Alshawi, 2007).

6. CONCLUSION

It can be concluded that collaborative environments present significant benefits to the construction industry, but their successful implementation in SMEs is still hindered by non technical barriers. Indeed, technology push is not the only critical success factor for effective implementation of collaborative environments. Unlike other technologies, collaborative environments are very much concerned with the collaboration across the project life cycle, and their successful implementation therefore will not only require a state of readiness within one organisation but also within all organisations involved in the construction processes, which makes the successful implementation of collaborative environments difficult to be planned and managed. Therefore unless supported by the relevant factors, the stand-alone implementation of collaborative technologies will not be able to enhance collaborative working. In order for the construction industry to successfully embrace collaborative environments, alternative though complementary factors which underpin the capability of the companies to successfully absorb collaborative environments into its work practice must be identified.

Original motivation of the work reported in this paper was to review the state-of-the-art of collaborative environments for the construction industry. The research process started with the review of previous research on collaborative environments implementation in construction. The key issues for the success and failure of collaborative environment implementations derived through the previous research identified a possible need for focus on SMEs during the implementation of collaborative environments. This has lead to a second review that was carried out on SMEs in the construction industry. The lack of present research on SMEs made additional research questions equal focus of the paper. The question remain (a) what are the success/failure factors leading to the performance of collaboration environments, and how do they affect its performance? (b) Can these factors, if controlled in SMEs, ensure the success of collaboration environments implementation in a construction project? (c) what are the relationships, if any, between the success or failure of collaboration environments implementation in SMEs and construction project success? These research questions will form the focus of future research to provide further insights into implementation of collaborative environments in construction SMEs to meet the demands of an overgrowing industry. The methodology proposed to answer the questions consists of a combination of four methods: literature review, case studies, framework development, and evaluation.

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