COLLABORATIVE ENVIRONMENTS IN SMALL AND MEDIUM-SIZED ENTERPRISES IN ARCHITECTURE, ENGINEERING AND CONSTRUCTION

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Abstract. The general picture of Architecture Engineering and Construction (AEC) is of a sector that is a pyramid with control being in the hands of large players with a large base of Small and Medium Enterprises (SMEs). It ensues naturally that SMEs are key players in supporting the large companies. This suggests that, the AEC sector has a continuous demand for collaboration. Collaborative working has been implemented in numerous companies. These efforts have resulted in the wide recognition of the opportunity that emerging technologies offer the AEC sector. It is, however, commonly observed that SMEs are likely to magnify the sector trend and to be less technically forward thinking than large companies. The main focus of this paper is, therefore, to explore the use of IT within AEC, and the barriers and different implementation factors that can influence SMEs to develop, in response to business pressures using the opportunities provided by collaborative technologies.

1. Introduction

The short-lived, multi-disciplinary, multi-company, multi-location nature of the AEC sector poses the problem of what are the most appropriate collaboration methods available to accommodate the virtual organisation like modus operandi. With Building Information Modelling (BIM) being imposed by the United Kingdom government on AEC projects by 2016, the development of new technology for collaboration purposes is one solution to this problem. Unfortunately information technologies in the United Kingdom have failed in productivity growth despite previous government's attempts, most famously, with the 2004 Latham and 2008 Egan reports. In fact, companies frequently fail in achieving the full profitability from their implementations, partially attributed to the common observation that SMEs are likely to magnify the sector trend and to be less technically forward thinking than large companies.

The main focus of this paper is, therefore, to explore the level of utilisation of IT within AEC, and the different implementation factors that can influence SMEs to develop, in

response to business pressures. The paper concludes that, collaborative technologies are effective methods to support collaboration within the AEC and meet the demands of the sector. It enables SMEs to engage more effectively in collaboration initiatives to meet the demands of the over growing AEC sector, while increasing their overall competitiveness. The paper leads to further empirical investigation of the factors affecting the collaboration to propose a guide for the implementation.

2. The Utilisation of IT within the AEC Sector

The AEC sector is predominantly project-oriented, SMEs get together with large organisations to deliver a project, and are then disbanded after the project has been completed. The definition of SMEs in this research is based on the numbers of employees, where organisations with fewer than 250 employees are considered SMEs as adopted by the Department of Trade and Industry in the UK (DTI, 1999), the Small Business Service in the UK (2000) and the European Union (2003).
Large AEC businesses in the UK have already begun to preach IT. However, literature shows that large AEC companies adopting emerging IS/IT frequently fail in achieving the full benefits from their implementations (Gladwell, 2001; Brandon et al, 2005; Abbott et al., 2006; Manley, 2006; eBusiness W@tch, 2007; Manley, 2008; Hardie and Newell 2011). The fact of the matter is that the ever changing development of IT has brought the increasing figure of investment within AEC, the result has led to a certain level of innovation on the one hand. On the other hand, these investments did not generate large returns.
From an investment perspective, in the 1990s, the AEC sector was notably slow to adopt IT. While it is acknowledged that heavy investment in IT has occurred since then, there is ample evidence to denote that IT has failed in productivity growth in spite of heavy investments being made. In fact, the rate of IT failure, in achieving its intended business performance, is increasing manifest in 40% in Lientz and Larssen (2006), 70% in Alshawi (2007), and failure stories in Heeks (2002), Xia and Lee (2004), Michaelson (2006), and eBusiness W@tch (2007). As such, cost of IT coupled with not being able to realise the benefits constituted a tremendous loss for companies.

This can be partially attributed to the fact that most of the companies within the AEC sector in the UK fall into the category of SMEs. Having said that SMEs command around 50% of the volume of AEC business (DETR, 2000; Stokes and Wilson, 2006; Maguire et al., 2007) with the remainder being carried out by a very small number of large players, it is, however, widely recognised that SMEs perish quicker than large companies, partly due to lack of profitability, and that their profitability is linked to performance.

It can be deduced, as such, in view of the foregoing that early efforts permitted IT as a tool to improve business performance, via a flux in disparate software applications. However, this had an adverse reaction and created islands of automation. Indeed, from the AEC sector perspective, the scenario is more complex clearly manifested in the need to shift from organisation-centred improvement that is utilising IT as a tool to improve business performance, to better managing collaboration. Those collaborating usually have varying levels of IT capabilities, size, and the like; however, they all work together. It is therefore necessary to review the barriers to collaborative working and collaborative technology in the AEC sector.

3. Barriers to collaborative working and collaborative technology

Many AEC sector organisations have been skeptical about the claimed benefits of collaborative technologies and have therefore been slow to adopt them. In fact, prospective users of collaborative technologies need to be alert to the resistance that many employees within the AEC sector still have to the basic idea of collaboration. From individual isolation attitudes, through inter-departmental turf battles and inter-company distrust, to wider industry conservatism, there are many factors that can militate against project teams being able to work together effectively (Wilkinson, 2005). Even assuming the ability to overcome resistance to the notion of collaboration, a wide range of factors that affect the ease with which teams use collaborative technologies successfully are addressed in this paper.

It is fair to say that while end-users are resistant to change or failing to understand the potential benefits offered by collaborative technologies, most of the time, they are the last ones to see the new environments. In this kind of top-driven approach, the system is imposed on users, and any hesitation or unwillingness from them is not appreciated. This hesitation and unwillingness are usually due to the fact that the users are kept away from all decisions at the design stage. Therefore, the needs of the user should be captured carefully. It can be deduced, as such, in view of the foregoing that the communication problem between end-users and technology professionals means a high risk of failure and results in technically perfect systems not serving the needs of the end-users.

It is worth noting that the technologies movement towards the UK industry mainstream has been slowed down. The late 1990s implosion fuelled uncertainty about financial stability and long-term prospects, and provides a convenient excuse for some to delay decisions about using them alongside sometimes spurious issues. They include lack of clearly defined vision and goals for the collaboration and poor delegation of tasks (Olson et.al, 2000; Wilkinson, 2005), people who do not want to work differently (Vadhavkar, 2001; Nitithamyong and Skibniewski, 2004), different organisational cultures, imbalance of the time spent on collaboration, staff turnover/continuity of participants, lack of understanding of participants expertise and knowledge (Alshawi and Ingiringe, 2003; Shelbourn, 2007). Others relate to security concerns, legal admissibility of electronic documents, absence of industry standards, additional telecommunications, hardware and software requirements, internet connectivity, participants using a variety of different methods of communication, imbalance of the cost and investment put forward (Becerik, 2004; Wilkinson 2005; Rezgui, 2011) barriers.

Attitudes to technology can also vary according to the size of the AEC organisations involved. In this respect, some large AEC businesses in the UK have already begun to preach collaborative technologies (NCCTP, 2009). Looking at contractors, for example, stratagem/DTI (2003) found project collaboration was an important e-business issue for 57% of companies with more than 250 employees but was important to only 35% of companies with between 50 and 250 employees. They noted: ‘the gap between larger companies who want to use project collaboration with their supply chain is limited by the inability of smaller sub-contractors to take it up’. Their study highlighted: ‘a large gap between large main contractors activities in e-business (91% use email, 58% project collaboration), with their supply chain and small sub-contractors ability to respond, (only 48% use e-mail and 12% project collaboration)’. While it is difficult to get reliable and consistent statistical information, evidence in Barbour (2002, p.31) reveals that, on average, 2% of projects in 2001 were managed using collaborative technologies, 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

collaborative technologies to collaborate online. The DTI benchmarking study (2004, p.52) found 17% of construction businesses claiming to be collaborative technologies users. 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 collaborative technologies. Research amongst RIBA architects by NBS found that in 2011 31% of practices were using BIM, compared with 13% a year earlier (BIM Task Group, 2012). While BIM adoption in the UK remains at about 35%, interest in the implications of the technology has grown substantially since government construction adviser Paul Morrell's announcement of BIM requirements in the government's Construction Strategy (Autodesk BIM Conference, 2011). However, use among SMEs remained low. A BCIS survey of RICS members has revealed a generally low use and awareness of BIM, with few respondents recognizing its potential benefits and fewer than 5% indicating any frequent use (RICS news, 2011, p.44).
In view of the foregoing, it may be deduced that IS/IT makes it easier to create and share data, but the essence of BIM is collaboration between multiple interested parties. Although there are many definitions of what BIM is, the government's mandate of BIM use on projects from 2016 and specification of level 2 as minimum has focused the sector's attention on the three maturity levels. This research focuses on levels 2 and 3 technical and collaborative levels (Government Construction Strategy, 2011).
In this context, BIM software may be classified into two categories; authoring and coordination. As the technology matures single software packages may be used that contain both elements. It is worth noting that the government is not mandating any specific software platforms. The fact of the matter is that the technology market includes numerous different applications that provide an environment that the sector can use for collaboration. Based on the aforementioned plethora of collaborative technologies, it is worth developing an understanding of factors to overcome the aforementioned barriers which resulted in the well-known failures.

4. Implementation Factors

4.1 ALIGNMENT OF STRATEGIES AND BUSINESS COMPETITIVENESS

Planning collaborative technologies in SMEs becomes more critical as it becomes more central to the SMEs' processes where planning needs to be integrated with business strategy (Blili and Raymond, 1993; Agarwal, 1998; Levy et al. 1999).

Ward and Griffiths Model (1997) called for the distinction to be made between IS strategy and IT strategy. They suggested that IS strategy be concerned with the organization's required information systems or application set, in essence addressing the 'what' question; and the IT strategy be concerned with the technology, infrastructure and associated specialist skills, or the 'how' question. This relationship is depicted in Figure 1.

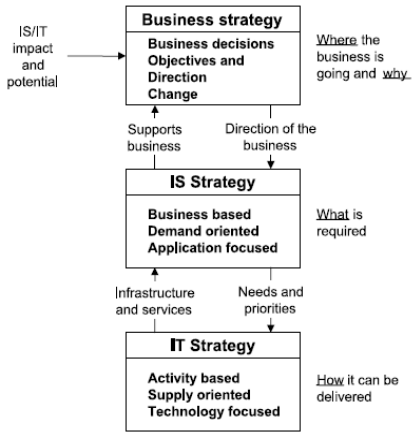

Figure 1. Business, IS and IT relationship model (Ward and Griffiths 1997)

Alshawi framework (2007) proposed a top-down framework for aligning Business strategy, IS strategy and IT strategy in Figure 2 consisting of seven independent but related tasks suggesting two levels of analysis; strategic and detailed.

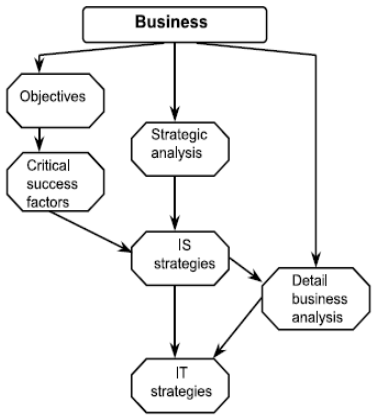

Figure 2. Diagrammatic representation of the proposed framework (Alshawi, 2007)

It can be derived that IT can only be used effectively in SMEs if it is utilised as part of the IS strategy that reflects work practices, people and information. However, an additional complexity is the fact that collaborative technologies permeate all participating organisations' activity. These models are perhaps too simple to deal with high collaboration demand but clarify key relationships. The underlying principles of the aforementioned provide a useful guide to addressing the strategic implementation adoption where change is necessary.

4.2 IS/IT VS. PROCESS MANAGEMENT

It is important to achieve a balance that appreciates the strategic needs of the business and the benefits and functionalities that collaborative technologies can bring about to achieve the business process. The relationship between the nature of business and the supporting IT

infrastructure is dynamic. The variation in business processes, within and among partner AEC organisations, will not only affect the internal performance of partners but also affect the efficiency of the collaboration process between the partners.
The nature of the relationship between maturity in process management and IS/IT, portrayed in Figure 3, in four quadrants which link the level of maturity of organisations to manage process improvement with their maturity to utilise and manage IT.

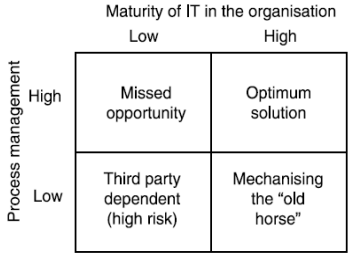

Figure 3. Relation between process and IT maturity (McKinsey, 2005)

McKinsey model (2005) top right quadrant shows that the best business benefits can be achieved from IT when the level of the organisation's maturity is high in both IT and process management.

What can be concluded is that technology push is not sufficient to improve the efficiency and effectiveness of work environments without carefully considering improvement to current business processes. In the scope of this research, it is extremely important to examine the efficiency of SMEs processes and how they match practices embedded in collaborative technologies in order to avoid a painful struggle to integrate the two. Literature reviewed in this section provides a useful guide to the exploration of the vision on how collaborative technologies should be integrated into the business.

4.3 READINESS OF ORGANISATIONS

Once the phase of aligning IS/IT strategies with business strategies is completed, the focus of the implementation shifts to ensure successful development (or customised, if it is a third-party product). The 1990, Massachusetts Institute of Technology Management research project about the impact of IT on business strategy, process management and organisational structure concluded that there are five elements linking IT and organisational transformation. The five elements are end-user skills and roles, strategy, management processes, structure, and technology. It highlights the influence of factors from both internal and external environments. However, Yetton et al. (1994) claim that Massachusetts Institute of Technology Management's model lacks a direction on how organisations should begin their transformation. They extended the Massachusetts Institute of Technology Management's strategic change into three main interactions and show the path of IT strategy that occurs during the collaborative technologies implementation. Figure 4 illustrates conventional technology transformation starting at the beginning of an IT strategy by adjusting the structure and then management process relating to technology and end-user skills and roles.

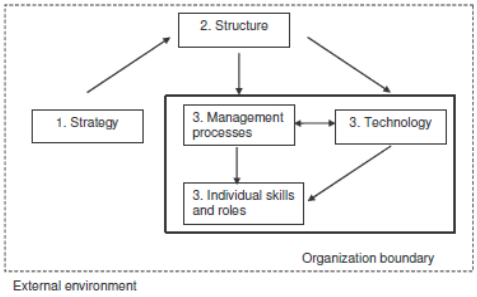

Figure 4. Traditional path of strategic fit (based on Yetton et al. 1994)

The strategic path framework illustrated in Figure 5 shows the influence beginning from introducing technology and then training end-users. The role of end-users should be extended in order to reflect the benefit of using IT. The structure of a company should be adjusted to match the end-users skills and responsibilities. At the same time, management processes should be integrated to improve technical infrastructure that supports collaboration.

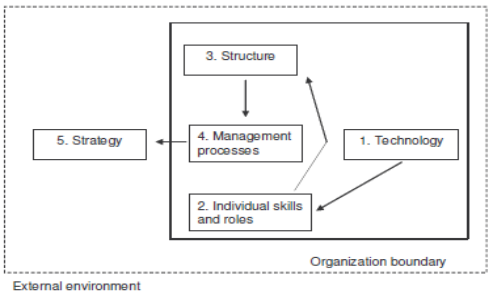

Figure 5. The path of strategic fit (based on Yetton et al. 1994)

Having highlighted previously the importance of strategy and process management, it can be deduced, as such, that IT transformation strategies are either conventional way or strategic path. In view of the foregoing, structure is developed involving people who implement the technology using defined roles and responsibilities. Therefore, amending the existing organisational structure is at the core of collaborative technologies implementation.

Alshawi (2007) came up with a list that is more or less similar but better suited for the purpose of this research in an attempt to modify the IT life cycle by adding a new stage to measure the IS capability of organisations prior to the commencement of the implementation phase in a model of four success elements, namely: (1) process, (2) people, (3) work environment, and (4) IT infrastructure. It can be said that the model focuses on building IS capabilities of organisations and measuring their readiness gap prior to IT investments as can be seen in Figure 6.

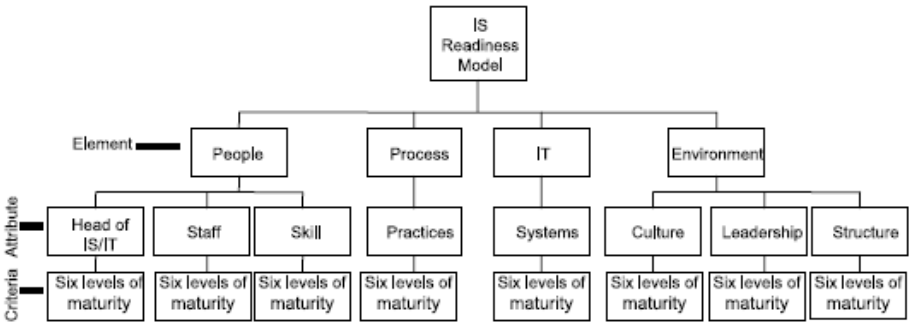

Figure 6. Structure of the IS readiness model (Alshawi, 2007)

Given that the meaning of readiness is still debated by various groups, Alshawi (2007) comes in handy, in the context of this research, to provide a holistic overview that encourages understanding and assessing the required level of capability, and organisational readiness prior to any IT investment decision. Readiness is seen as a tool to unlock the fear and the way forward for adopting IT within a company. As such, companies can make a plan for improving their IT maturity. By extending readiness to include the use, awareness, and barriers to IT, it can be deduced that readiness is in general proportional to size, and hence larger businesses are the most ready. SMEs are low on readiness not only because of the low level of infrastructure, but because of the barriers. In view of the foregoing, it can be deduced, subject to empirical evidence, that neither small nor medium sized AEC companies could be considered close to e-ready. On the other hand, large businesses present modest potential. As a result, a large gap exists between large business ideas and concepts on one hand, and practical implementation in SMEs, on the other. It may suffice to say that unlike other technologies, collaborative technologies 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 company but also within all companies involved in the project life cycle. As such, the readiness concept fails to provide the implementation requirements for SMEs at project level. However, the above-mentioned elements are of particular relevance to this research which investigates *how SMEs implement a new collaborative technology, and how SMEs handled the transformation occurring.*

4.4 MANAGING THE HUMAN/TECHNOLOGY ASPECTS

Many AEC studies found that lack of enough training is one of the main failure reasons of implementing and using IT applications (Songer et al., 2001; Stephenson et al., 2001; Weippert et al. 2002). According to Akins and Griffin (1999) and Nitithamyong and Skibniewski (2004), training is vital to ensure the success of implementation. Echoing the already-mentioned distinction between different sizes of organisation, the Construction Industry Council's professional services skills survey (2004) also found professional IT skills are a larger problem in smaller firms and general IT skills are a larger problem among larger firms. Therefore, users require training programme and support to help them clearly understand how to effectively use collaborative technologies; the question of which learning method they prefer underpins an empirical study to investigate whether *end-users have clear training program, what are the courses and what further IT training is needed.*

It is interesting to note that the resistance to technology is investigated as a combination of resistance to the strategic principle of collaborative working and the resistance to the adoption of the technology itself (Kast and Resenzweng, 1974; Wilkinson, 2005). Literature reviewed in this section provides a useful guide to the exploration of *employee resistance and coping with it*. Collaborative approaches demand that individuals from various organisations work together to achieve common attainable project goals through the sharing of information. This means that different company processes and organisational cultures have to be aligned in a collaborative manner. Previous research has identified six main dimensions that describe a team that has been fully collaborative. Following on from these findings, the delivery team in an AEC project can be described as collaborative when it: 1) has a single focus and objectives for the project (Anumba and Evbuomwan, 1998; Anumba et al. 2002); 2) operates without boundaries among the various organization members and work towards mutually beneficial outcomes (Love and Gunasekaran 1998; Baiden et al. 2003); 3) shares information freely among its members such that access is not restricted to specific professions within the team has a new identity and is co-located, usually in a given common space (Comick and Mather 1999; Vyse 2001; Baiden et al., 2006); 4) operates in an atmosphere where relationships are equitable (Moore and Dainty 1999; Dainty et al. 2001); 5) offers its members equal opportunities to contribute to the delivery process and all members are respected (Bromley et al. 2003; Baiden et al., 2011); 6) has a no blame culture (Anumba and Evbuomwan, 1998; Dainty et al. 2001; Anumba et al. 2002; Baiden et al., 2006; Baiden et al., 2011). The picture becomes complicated when technology is introduced to team based organisation process. Following on from above literature based on dimension of teamwork, empirical research will use the six key dimensions of collaborative team-working to *assess the extent of teamwork efficiency within the various delivery teams*.

The importance of employee empowerment in reducing employee resistance to change has been mentioned by many authors. It can be said that end-user empowerment is an effective element leading to the success of IT implementation, since it promotes self-management and collaborative working (Kitchen and Daly, 2002). The above-mentioned elements are of particular relevance to studying *the most important impacts that should be achieved by collaborative technologies* and will be referred to as a guide for the study of *empowerment, relationships, attitude and trust undertaken in this study.*

5. Summary and Conclusions

Literature reviewed in this paper suggested that the organisational and end-user dimensions are very important for the success of collaborative technologies, and that technical characteristics are rarely the reason for the failure of collaborative technologies implementation. The paper investigated main key points gained from the literature reviewed relevant to how collaborative technologies promote collaborative working for AEC sector to increase productivity and improve quality to meet the high collaboration demands. To test the validity of the proposed factor approach for the implementation of collaborative technologies in SMEs, future research is recommended to develop a methodology. Based on this methodology, an empirical study ought to explore, depending on the previous research, the factors that contribute to the implementation of collaborative technologies and assess their level of importance.

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