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COLLABORATIVE TECHNOLOGIES FOR SMALL AND MEDIUM-SIZED ARCHITECTURE, ENGINEERING AND CONSTRUCTION ENTERPRISES: IMPLEMENTATION SURVEY

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SUMMARY: *Although emerging technologies offer the AEC sector many opportunities for collaborative working, unfortunately the companies adopting these technologies usually fail in achieving the full benefits from their implementations despite previous government's attempts. With Building Information Modelling (BIM) being imposed by the government on AEC projects by 2016, it is commonly observed that SMEs have fewer chances to get it right and so they need guidance. This paper aims to review how collaborative technologies promote collaborative working between large companies and SMEs in the AEC sector and to present the current approaches adopted by construction organizations implementing collaboration environments. In order to achieve these aims, the paper identifies the key elements to focus on during the collaborative technologies implementation to enhance successful collaboration. The results of quantitative study are summarised to show the current IT implementation and collaborative working approach in SMEs. The paper concludes with some insights into how SMEs in the AEC sector can improve the implementation of collaborative technologies.*

KEYWORDS: *AEC sector; Information Technology (IT); organisation readiness and maturity; survey*

REFERENCE: *Aisha Abuelmaatti, Vian Ahmed (2014). Collaborative technologies for small and medium-sized architecture, engineering and construction enterprises: implementation survey, Journal of Information Technology in Construction (ITcon), Vol. 19, pg. 210-224, http://www.itcon.org/2014/12*

1. INTRODUCTION AND BACKGROUND

Architecture Engineering and Construction (AEC) sector has a continuous demand for collaboration due to the multi-disciplinary nature of this sector. The AEC sector has come a long way since the Latham report was published in 1994 and the subsequent Egan report since 2002. These efforts to accommodate unique work settings to improve quality, competitiveness and profitability and to increase value to clients have resulted in the wide recognition that emerging technologies offer the AEC sector an opportunity to address its unique work settings. In fact, for the highly information-dependent and cost-conscious AEC sector that was and still is synonymous with delay, waste and inefficiency, the opportunity to use IT is too good to miss.

The type and nature of IT investments and applications in the AEC sector, over the past 15 to 20 years, have taken several shapes and followed many themes. During the 1990s, organisations invested heavily in IT (Alshawi, 2007); however, there is ample evidence to denote that the AEC sector lagged behind other sectors in the speed of its adoption of technologies (Issa et al., 2003; Aranda-Mena, 2004; Wilkinson 2005; London et al., 2006). This may be attributed to the fact that large investments were mainly propagated by advances in IT which has led to technology focused solutions to business problems (Sun and Aouad, 2000). However, this had an adverse reaction and created islands of automation. The full potential of IT is yet to be explored. Such potential lies in its capabilities for collaboration, hence, meeting the demands of the AEC sector.

Collaborative technologies, defined as, a combination of technologies that together create a single shared interface between two or more interested individuals, can have great potential to promote the required collaborative working in AEC. This enables them to participate in a creative process in which they share their collective skills, expertise, understanding and knowledge in an atmosphere of openness, honesty, trust and mutual respect. Thereby jointly deliver the best solution that meets their common goal (Rezgui, 2011). This is encouraged by the Government Construction Strategy (2011), stating that 'government is that the AEC sector has not fully taken advantage of the full potential offered by digital technology' (Cabinet-Office, 2011). This detailed programme aims to reduce the cost in the sector's activities up to 20% at the end of the UK parliament in 2016. One of the notable objectives within this document is the requirement of using full collaborative Building Information Modelling (BIM) as a minimum for projects by 2016 (Whyte et al., 2011).

Previous research shows that large AEC companies adopting emerging collaborative technologies frequently fail in achieving the full benefits from their implementations (Gladwell, 2001; Brandon et al, 2005; Wilkinson, 2005; eBusiness W@tch, 2007; Rezgui, 2011). 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. The general picture of AEC is of a sector that is a pyramid with control being in the hands of large players with a large base of SMEs. It ensues naturally that SMEs are key players in supporting the large companies. This suggests that, only through developing a clear understanding of SMEs' needs, can an effective collaborative situation through the use of technologies take place. This highlights the importance of recognising how end-users collaborate.

It is commonly observed that SMEs are likely to magnify the sector trend and to be less technically forward thinking than large companies. Although an extensive body of literature exists on the topic of technological delivery by AEC companies, it tends to concentrate on big businesses, and the experience of SMEs in this area has gone largely unreported. While there are some notable exceptions (Acar et al., 2005; Abbott et al., 2006; Manley, 2006; Manley, 2008), Baker (2012) quoted David Saffin, senior partner at Consulting Engineer SME which uses BIM "smaller firms have fewer chances to get it right and so need guidance to chart a clear path to implementation". As such, SMEs need to undergo dramatic changes in order to keep up with a changing sector. According to Philip (2012), "ensuring SME whole-sector adoption of BIM is fundamental to the success of the Government Construction Strategy's 2016 BIM objective".

This paper is set out to identify the key factors that enable collaboration between large organisation and SMEs and reports on the findings from the quantitative data collection and analysis targeting end-users of advanced technologies in AEC SMEs.

2. IMPLEMENTATION OF IT - ORGANISATIONS READINESS AND MATURITY

Due to the multi-disciplinary nature of the AEC sector, the continuous demand for collaboration is not an easy task and is often faced by a number of barriers that hurdle the work process between SMEs and large organisations as they experience different maturity levels. It is therefore important to develop an understanding of IT theories with particular focus on relevant maturity theories and readiness indicators to identify the key factors that enable collaborative working.

2.1 Maturity in process management and technology

It is extremely important to examine the efficiency of organisation processes and how they match practices embedded in collaborative technologies in order to avoid a painful struggle to integrate the two. One of the most well-known models in this field is one developed by McKinsey model (2005). The nature of the relationship between maturity in process management and IS/IT is portrayed in Fig. 1 in four quadrants which link the level of maturity of organisations to manage process improvement with their maturity to utilise and manage IT.

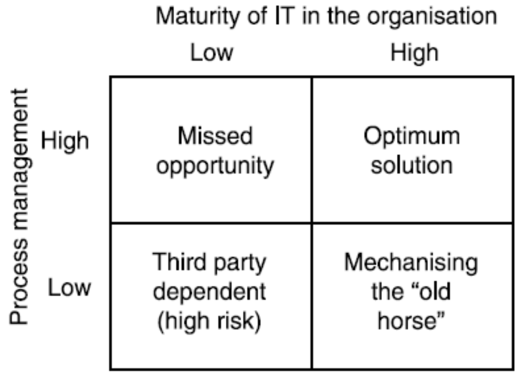

FIG. 1: Relation between process and IT maturity (McKinsey, 2005)

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. The top left quadrant shows organisations that are mature in process management but have ineffective experience in integrating IT into business processes. The lower right quadrant presents organisations with a high maturity level in IT but which have little experience in process management. This type normally invests in IT to mechanise the current business processes as they stand. The lower left quadrant represents organisations that have little experience in both the implementation of IT and process management.

It can therefore be concluded that technology push is not sufficient to improve the efficiency and effectiveness of work environments without carefully considering improvement to current business processes.

2.2 Readiness of Organisations

Scott Morton (1991) started a research project about the impact of IT on business strategy, process management and organisational structure. As a result of this research, they concluded, in Fig. 2, 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. These elements have effects on each other directly and indirectly.

The strategic change model highlights the influence of factors from both internal and external environments. Based on the model, all elements are implicitly controlled in a business strategy. 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 it into three main interactions and show the path of IT strategy that occurs during the collaborative technologies implementation.

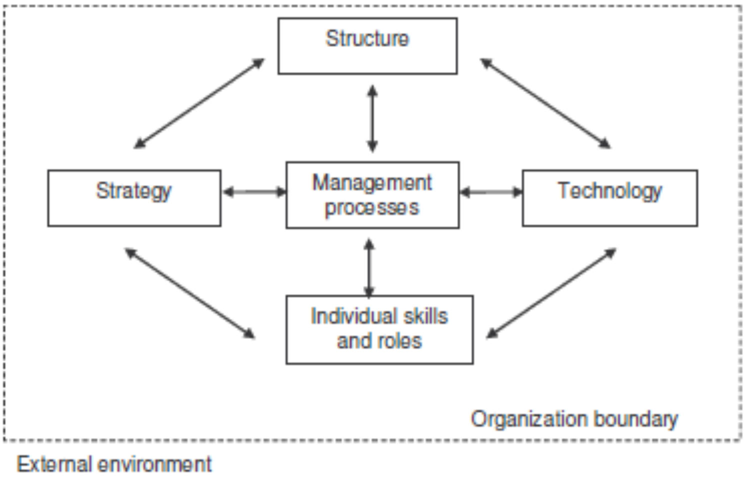

FIG. 2: The MIT's strategic change (based on Scott Morton 1991)

Two IT transformation strategies can be deduced, using the conventional way and a strategic path direction. Fig. 3 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. The widely cited MIT Management in the 1990s framework assumes that a firm's business strategy drives the subsequent alignment and fit of organization structure, management processes, individual skills and roles, and technology.

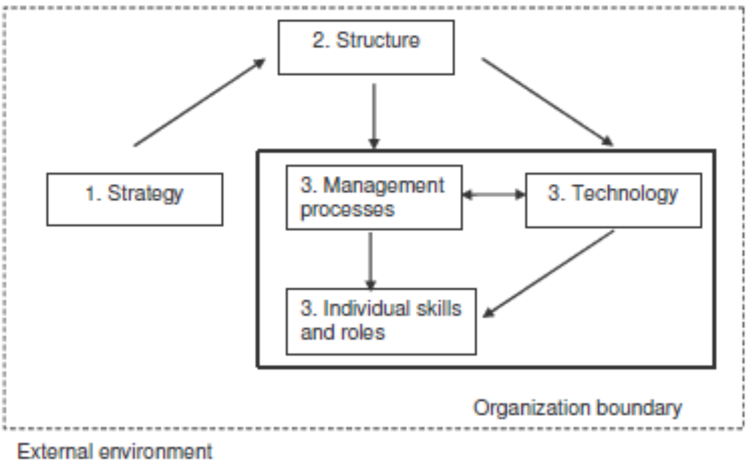

FIG. 3: Traditional path of strategic fit (based on Yetton et al 1994)

Rather than beginning with strategy formulation, Yetton (1994) suggests that the process begins with the tactical and incremental adoption of technology. In turn, that becomes the catalyst for change in individual roles and skills, followed by structural adaptation, and, later, changes in the firm's management processes, which embeds and reinforces organizational learning. The strategic path framework illustrated in Fig. 4 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.

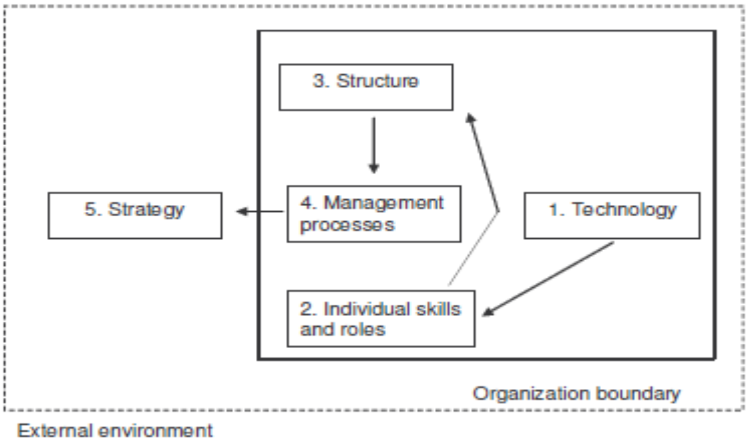

FIG. 4: The path of strategic fit (based on Yetton et al 1994)

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.

In an attempt to modify the IT life cycle by adding a new stage to measure the Information Systems (IS) capability of organisations prior to the commencement of the implementation phase, Alshawi (2007) came up with a list that is more or less similar to Yetton et al. (1994) but better suited for the purpose of this research in a model of four success elements, namely: (1) process, (2) people, (3) work environment, and (4) IT infrastructure. The model focuses on building IS capabilities of organisations and measuring their readiness gap prior to IT investments. As can be seen in Fig. 5, the model describes the readiness of the organisations for IS/IT implementation in terms of the four elements embracing eight attributes. Each of the attributes is described in six levels where each represents a maturity level describing the organisational status in terms of the particular attributes.

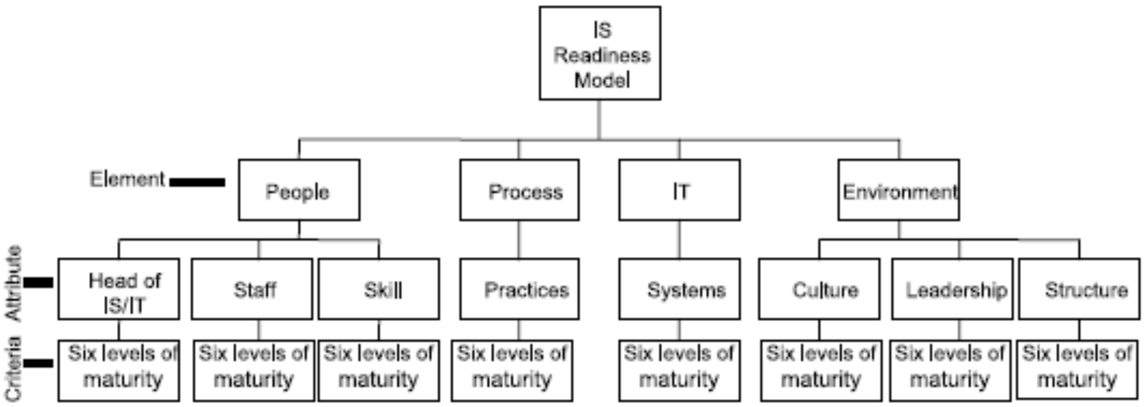

FIG. 5: Structure of the IS readiness model (Alshawi, 2007)

The model is of a general nature where users can determine the current capability of their organisations in terms of the criteria of the model's attributes. The status of an organisation is measured against the criteria of each attribute. The difference between the current organisational status and the target in terms of all the elements' attributes constitutes the readiness gap.

Although an extensive body of literature exists on the topic of organisation readiness and maturity, it tends to concentrate on big businesses, and the experience of SMEs in this area has gone largely unreported. While there are some notable exceptions (Acar et al., 2005; Abbott et al., 2006; Manley, 2006; Manley, 2008), a significant gap has been identified in the literature on the SME collaborative technologies implementation experience. The insights gained from the managerial perspective results in (Ahmed and Abuelmaatti, 2010), stimulated the data collected from a larger number of SMEs respondents for an end-user perspective, as explained in the methodology. To achieve this aim, the rest of this paper will report on the factors that should be taken into consideration in future implementation of collaborative technologies in SMEs in order to enhance their role in collaboration with large players in the industry.

3. METHODOLOGY AND DATA COLLECTION STRATEGY

This study adopted a deductive approach (Creswell, 2003) which uses the derived factors as identified from the previous section. To achieve this, a survey was undertaken targeted at end-users in SMEs whom used collaborative technologies to play a role in collaboration. The aim of the survey is:

- To explore end users thoughts and experiences regarding the transformation during collaborative technologies implementation;
- To test the companies perception of the underlying factors that SMEs should consider in implementing collaborative technologies;
- To investigate end-users' profile influence on the utilisation of IT.

Sample - the survey was distributed to 120 SMEs' employees of different profile. To reflect the nature of the AEC sector, representatives from the many specialities with useful contribution to projects were selected. Rather than targeting non-collaborative technologies users who may not have relevant experience of collaborative technologies use, only experienced collaborative technologies users were selected from SMEs. The sample used in the survey was drawn from the two interviews with the technology providers. Each was asked to nominate experienced respondents who were users of their technology, only SMEs were selected. Of the 120 questionnaire despatched to the selected sample, 64 were returned. As such, a response rate of 53% was achieved.

Statistical Tests - to aid this investigation, the following statistical tests were carried, where appropriate:

a. Analysis of attributes - Participants' backgrounds were grouped into categories and analysed in percentages, using the SPSS summary of frequency.
b. Analysis of responses - The data collected from the participants' responses contained 1 to 3 categories of ranking. The percentage of frequency in each of these regions were calculated and tabulated using the SPSS summary of frequency.
c. The chi-square x^2 one sample - Tests the significance of the findings. This test is performed to test the Null Hypothesis as to whether the observed frequency of scores are close to the expected frequency of score, i.e., whether participants' responses were given at random or had definite percentage of scoring.
d. Kruskal-Wallis H - Tests whether several independent samples come from the same population, i.e., to test the Null Hypothesis that the participants' responses are dependent of their background.

The following section provides summary of the results generated from theses enquiries.

Questionnaire - the questionnaire consisted of six sections, namely: profile, utilisation of IT, organisational environment, socio-cultural requirements, legal requirements and contractual consequences, barriers and problems. The rest of this paper will report on the findings of this questionnaire.

4. DATA COLLECTION AND ANALYSIS

4.1 Section I – Profile

This section describes the participants' profile, presented in percentages of frequencies, in Table (1), namely: position, level of education, years of experience in the company, years of experience outside the company, age, and IT expertise; whereby a blend of expertise mainly with postgraduate qualifications where the majority are up to 5 years of experience.

Table 1: Profile

Profile		
Position	*Architecture*	42
	Engineering	31
	Construction	27
Level of Education	*Undergraduate*	41
	Postgraduate	59
Years of Experience in Company	*1-5*	78
	6-10	22
	11-15	1
Years of Experience outside Company	*1-5*	27
	6-10	37
	11-15	23
	16-20	13
Age	*25-34*	38
	35-44	48
	45-54	14
	55-65	
IT Expertise	*Novice*	0
	Believer	22
	Expert	78

Therefore this is a fairly representative sample with a blend of expertise, age group and qualifications in order to gather the opinion of end-users in SMEs about the factors that contribute to the implementation of collaborative technologies.

4.2 Section II – Organisational Environment

This section reports on the findings of the questionnaire that examines the existing collaborative environment in the selected SME organisation in order to identify the strengths and weaknesses in the utilisation of collaborative technologies within the selected SMEs.

a. Factors influencing the implementation of ICT

The results of the qualitative study in (Abuelmaatti and Ahmed, 2011) identified a list of factors that influence implementation of ICT in organisations. Table (2) presents the participants' responses about their company's current collaborative technologies implementation initiative.

Table 2: Frequency of scoring to the factors considered for the current implementation of IT

Factors considered by participants	**Response (%)**		
	Not at All	**Fair**	**Fully**
Latest technologies in hardware and networks	5	84	11
Vendor support	10	74	16
Users' technical knowledge and skills	2	63	36
Including in the system design a new design/redesign of work processes	22	47	31
Training to use the collaboration system	2	56	42
Team communications and interactions	69	31	0
Team members participation with management in defining goals, tasks, and creating schedules	24	70	6

The results indicate that the current initiatives have taken into consideration *users' technical knowledge and skills, training to use the collaboration system, Latest technologies in hardware and networks,* and *vendor support. Training to use the collaboration system* scored the highest in terms of factors considered whereas the least consideration went to *team communications and interactions.* The results show improvement in appreciating the importance of *training*. This clearly indicates that SMEs are moving towards the use of IT. However, bringing the team members together is not appreciated clearly manifest in *team communications and interactions* as well as *team members participation with management in defining goals, tasks, and creating schedules*. Therefore, this could be considered as one of the weaknesses for effective implementation.

b. Clarity of existing ICT implementation procedures

Abuelmaatti and Ahmed (2011) emphasized the importance of clarifying the ICT implementation procedures and identified a list of these factors that are shown in Table (3).

Table 3: Frequency of scoring to the clarity of current procedures at explaining what to do in each area

Existing implementation initiatives clarity of	**% Frequency**		
	Very Clear	**Clear**	**Not Clear**
Use of the collaborative technologies features	44	56	0
Manage online relationships	6	72	22
Maintain a non-adversarial environment	27	67	6
Manage online project workflow	14	48	38

These results reveal that the current initiatives clearly explain the *use of collaborative technologies features*, *managing electronic information exchange, conducting online collaboration, and maintaining a non-adversarial environment*, *achieving continuous improvement,* and *identifying and resolving unforeseen issues from the use of collaborative technologies*. Although there was more positive indication in the *use of the collaborative technologies features*, however, *managing online relationship*, and *managing online project workflow* were not clear. This indicates that there are communication and management tools, although guidance is good on the communication side but lacks clarity on the management side. Therefore, this could be considered as one of the weaknesses for effective implementation.

c. Importance of issues to include within guidance for implementation

Similarly, the previous study identified a set of factors that are of great importance for inclusion within the guidance given for the implementation of ICT. Table 4 list these factors and shows the participants responses which indicate that the highest importance is for *defining collaborative technologies responsibilities, ensuring top-level management commitment, common convention, and intellectual property rights*. The importance is less for *flow chart of processes, training provision, enabling buy-in by all parties, establishing trust between all parties, maintaining collaborative technologies security, and collaborative technologies technical support*. *Flow chart of processes* is less than important. Therefore, this indicates the important issues that influence implementation of ICT in organisations to include within guidance for implementation.

Table 4: Frequency of scoring to the importance of including information within guidance for implementation

Importance of including information within guidance on	Response (%)		
	Very Important	Important	Not Important
Strategy for implementing the collaborative technologies	50	45	5
Defining collaborative technologies responsibilities	72	27	2
Training provision	36	62	2
Flow charts of processes	31	67	2
Maintain collaborative technologies security	45	53	2
Collaborative technologies technical support	48	50	2
Intellectual property rights	50	39	11
Common convention	52	48	0
Establishing trust between all parties	36	53	11
Enable buy-in by all parties	45	55	0
Ensure top level management commitment	61	28	11

To test that the participants' opinion is dependent of their profile, the Kruskal Wallis analysis of variance was carried out. The values indicate that for a level of significance of <0.05 participants' responses are dependent on aspects of their their profile. For a closer examination of the importance of including information within guidance for implementation, the results of the Chi-square Crosstabs analysis of frequencies given by participants with different 'Position' are shown in Table (5). These results show that participants in Architecture gave higher scores to the importance of 'defining responsibilities', than participants in Engineering and Construction. *The discrepancy between these responses becomes smaller for 'training provision', 'flow charts of processes', and 'collaborative technologies technical support'.* The discrepancy in scores between the three positions is noticeably large for 'intellectual property rights'. The scores given by the Architecture participants fall in the very important region, while those given by the Engineering and Construction fall in the important region. *The discrepancy between these responses becomes smaller for 'trust', 'commitment', and 'buy-in'.*

Table 6 shows that participants with a postgraduate qualification gave higher scores for the importance of 'enabling trust between all parties' and 'enabling buy-in by all parties' for the implementation, than those with an undergraduate qualification. *The results indicate that participants are mostly in favour of 'enabling trust between all parties' and 'enabling buy-in by all parties' which demonstrate an interrelated nature.* This indicates that establishing trust between all parties and enabling buy-in by all parties may deter the older generation and the highly educated from using the technology. As such, trust and buy in are important factors for accelerating the shift to the use of ICT and should be considered within guidance for implementation.

Table 5: Chi-square Crosstabs analysis of frequencies for the importance of including information within guidance for implementation in relation to their Position

Importance of including information within guidance on	**Kruskal Wallis Analysis of Variance**	**Position**	**Very Important**	**Clear**	**Not Important**
Defining general collaborative technologies responsibilities	.000	*Architecture*	26	1	0
		Engineering	11	6	0
		Construction	9	10	1
Training provision	.000	*Architecture*	11	16	0
		Engineering	11	6	0
		Construction	1	18	1
Flow charts of processes	.000	*Architecture*	16	11	0
		Engineering	3	14	0
		Construction	1	18	1
Collaborative technologies technical support	.001	*Architecture*	16	11	0
		Engineering	12	5	0
		Construction	3	16	1
Intellectual property rights	.015	*Architecture*	17	10	0
		Engineering	9	7	1
		Construction	6	8	6
Establishing trust between all parties	.000	*Architecture*	7	19	1
		Engineering	2	9	6
		Construction	14	6	0
Enabling buy-in by all parties	.001	*Architecture*	8	19	27
		Engineering	5	12	17
		Construction	16	4	20
Ensure top level management commitment	.001	*Architecture*	10	10	7
		Engineering	14	3	0
		Construction	15	5	0

Table 6: Chi-square Crosstabs analysis of frequencies of participants for the importance of including information within guidance for implementation in relation to their qualification

Importance of including information within guidance on	Kruskal Wallis Analysis of Variance	Qualification	Very Important	Clear	Not Important
Establishing trust between all parties	.006	*Undergraduate*	6	13	7
		Postgraduate	17	21	0
Enabling buy-in by all parties	.015	*Undergraduate*	7	16	0
		Postgraduate	22	19	0

Table 7 shows the results of Chi-square crosstabs analysis in relation to experience, indicating that there is significant difference in the distribution of frequencies presenting the discrepancy of scores among the more experienced participants' opinion and the less experienced.

Table 7: Chi-square Crosstabs analysis of frequencies of participants for the importance of including information within guidance for implementation in relation to their Experience outside of company

Importance of including information within guidance on	Kruskal Wallis Analysis of Variance	Experience Outside of Company	Very Important	Clear	Not Important
Strategy for using the collaborative technologies	.018	*1-10*	22	19	0
		11-20	10	10	3
Defining general collaborative technologies responsibilities	.000	*1-10*	35	6	0
		11-20	11	11	1
Training provision	.004	*1-10*	20	21	0
		11-20	3	19	1
Flow charts of processes	.001	*1-10*	20	21	0
		11-20	0	22	1
Maintaining collaborative technologies security	.003	*1-10*	21	19	1
		11-20	8	15	0
Collaborative technologies technical support	.001	*1-10*	26	15	0
		11-20	5	17	1
Intellectual property rights	.001	*1-10*	24	17	0
		11-20	8	8	7
Common convention	.002	*1-10*	18	23	18
		11-20	15	8	15
Ensure top level management commitment	.052	*1-10*	21	13	7
		11-20	18	5	0

These results indicate that, although all scores fall in the important region, the less experienced gave higher scores than those given by the experts. Although the experienced more outside the company form only 36% of the sample, they gave higher scores falling in the very important region for 'defining general collaborative technologies responsibilities', 'common convention' and 'ensure top level management commitment'. Although the results of the Chi-square test show that 'enabling buy-in by all parties' and 'common convention' were given at random, further analysis shows that participants' experience may be a factor that influenced these decisions. Conclusions drawn from the previous section also indicated that postgraduate degree holders value 'establishing trust between all parties' and 'enabling buy-in by all parties' more than those with undergraduate qualifications which demonstrates an interrelated nature with 'defining general collaborative technologies coordinators responsibilities' and 'ensuring top level management commitment'.

Table 8 results show that the older age group gave higher scores to the '*defining general collaborative technologies responsibilities*', '*intellectual property rights*', '*common convention*', and '*ensuring top level management commitment*'. Similarly, higher scores are given by the older participants to the importance of '*defining general collaborative technologies responsibilities*' '*intellectual property rights*', '*common convention'* and '*ensuring top level management commitment'*. Conclusions drawn from the previous sections also indicated that postgraduate degree holders and the more experienced value 'establishing trust between all parties', 'enable buy-in by all parties', 'defining general collaborative technologies responsibilities' and 'ensuring top level management commitment' which demonstrates an interrelated nature with the older age group scores. This may be due to the interaction between the three attributes, i.e. qualification, years of experience and age.

Table 8: Chi-square Crosstabs analysis of frequencies of participants for the importance of including information within guidance for implementation in relation to their Age

Importance of including information within guidance on	**Kruskal Wallis Analysis of Variance**	**Age**	**Very Important**	**Clear**	**Not Important**
Defining general collaborative technologies responsibilities	.009	*25-34*	20	4	0
		35-44	17	13	1
		45-54	9	0	0
Intellectual property rights	.001	*25-34*	11	13	0
		35-44	19	12	0
		45-54	2	0	7
Common convention	.033	*25-34*	9	15	0
		35-44	16	15	0
		45-54	8	1	0
Ensure top level management commitment	.008	*25-34*	11	6	7
		35-44	19	12	0
		45-54	9	0	0

Table 9 shows a summary of the distribution of scores given by the experts and the believers. These results indicate that, although all scores fall in the important region, experts gave higher scores than those given by the believers. Although experts form only 22% of the sample, they gave higher scores falling in the very important region.

Table 9: Chi-square Crosstabs analysis of frequencies of participants for the importance of including information within guidance for implementation in relation to their Rate with regards to IT

Importance of including information within guidance on	Kruskal Wallis Analysis of Variance	Rate	Very Important	Clear	Not Important
Defining collaborative technologies responsibilities	.000	*Believer*	43	6	1
		Expert	3	11	0
Flow charts of processes	.043	*Believer*	19	30	1
		Expert	1	13	0
Intellectual property rights	.008	*Believer*	31	12	7
		Expert	1	13	0
Common convention	.011	*Believer*	30	20	50
		Expert	3	11	14

Although ‘Common convention’ scores were given at random, however, participants' responses to the importance of ‘defining general collaborative technologies responsibilities’, ‘flow charts of processes’ and ‘intellectual property rights’ were not given at random and were dependent on the participants' rate with regards to IT.

5. DISCUSSION AND CONCLUSION

This paper looked into the factors that enable collaboration between large organisation and SMEs. It presented a literature review and survey results on the implementation of collaborative technologies in the AEC sector. Related theoretical concepts have been reviewed and the key areas to focus on during implementation have been highlighted. In order to map the current practice of SMEs implementations and their success level in the United Kingdom, the results of a survey research have been presented.

Although an extensive body of literature exists on the topic of organisation readiness and maturity, it tends to concentrate on big businesses, and the experience of SMEs in this area has gone largely unreported. The results of the survey show improvement in appreciating the importance of training. This clearly indicates that SMEs are moving towards the use of IT. However, bringing the team members together is not appreciated which is considered as one of the weaknesses for effective implementation. The results indicate that there are communication and management tools, although guidance is good on the communication side but lacks clarity on the management side. Therefore, this could be considered as another weaknesses for effective implementation.

For SMEs to enhance successful collaboration, the study found a list of elements to focus on during the collaborative technologies implementation to include within guidance for implementation, namely: defining collaborative technologies responsibilities, ensuring top-level management commitment, common convention, and intellectual property rights. The importance is less for flow chart of processes, training provision, enabling buy-in by all parties, establishing trust between all parties, maintaining collaborative technologies security, and collaborative technologies technical support.

Based on these findings, further research will be carried out in order to assess their level of importance. Indeed, the partial findings indicate that a more in-depth research study is warranted to truly understand the implementation of technologies in AEC for the industry to move forward.

6. REFERENCES

Abbott, C., Jeong, K. and Allen, S. (2006). “The economic motivation for innovation in small construction companies”, Construction Innovation, 6(3): 187-96

Ahmed, V & Abuelmaatti, A 2011 "The Use of Collaborative Technologies within SMEs in Construction: Case Study Approach', in: 'Cases on E-Readiness and Information Systems Management in Organizations: Tools for Maximizing Strategic Alignment, IGI Global, New York, USA.

Alshawi, M. (2007) Rethinking IT in Construction and Engineering: Organisational Readiness. London: Taylor & Francis.

Aranda-Mena, R. Wakefield, Interoperability of building information - myth of reality? in: Scherer, Martinez (Eds.), eWork and eBusiness in Architecture, Engineering and Construction, 2006, pp. 127–133, London.

Barker, K. (2012) SME Spotlight: BIM Special, http://www.bimtaskgroup.org/wp-content/uploads/2012/07/SME-Spotlight_030033_CN_210612.pdf, accessed on 29/07/2012

Cabinet Office (2011) Government Construction Strategy, http://www.cabinetoffice.gov.uk/sites/default/files/resources/Government-Construction-Strategy.pdf, accessed on 22/12/2011

Creswell, J. W. (2003). Research Design: Qualitative, Quantitative, and Mixed Methods, Approaches, Sage, Thousand Oaks, California.

E-Business W@tch. (2007) ICT and e-Business in the Construction Industry, Sector Report No. 7, European Commission

Egan, Sir J. (2002) Accelerating Change, London: Department of the Environment, Transport and the Regions.

Gladwell, M. (2001). The Tipping Point. London Abacus.

Anumba, C. J., Pan, J., Issa, R. R. A. and Mutis, I. (2008) Collaborative project information management in a semanticweb environment”, Engineering, Construction and Architectu ral Management, 15(1) 78 – 94

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

Manley, K. (2006a) “Frameworks for understanding interactive innovation processes”, The International Journal of Entrepreneurship and Innovation, 4(1): 25-36.

Manley, K. (2006b), “The innovation competence of repeat public sector clients in the Australian construction industry”, Construction Management and Economics, 24(2): 1295-304.

Manley, K. (2008), “Implementation of innovation by manufacturers subcontracting to construction projects”, Engineering, Construction and Architectural Management, 15(3): 230-45.

Manley, K. (2006a) “Frameworks for understanding interactive innovation processes”, The International Journal of Entrepreneurship and Innovation, 4(1): 25-36.

Manley, K. (2006b), “The innovation competence of repeat public sector clients in the Australian construction industry”, Construction Management and Economics, 24(2): 1295-304.

Manley, K. (2008), “Implementation of innovation by manufacturers subcontracting to construction projects”, Engineering, Construction and Architectural Management, 15(3): 230-45.

McKinsey (2005). Does IT Improve Performance? Chart Focus Newsletter, Member Edn, The Mckinsey Quarterly.

Nitithamyong, P. and Skibniewski, M.J. (2007), Key success/failure factors and their impacts on system performance of web-based project management systems in construction, ITcon, Vol. 12, 39 – 59.

Philip, D. (2012). BIM is here and now, http://www.cnplus.co.uk/hot-topics/sme/bim-is-here-and-now/8632019.article, accessed on 29/07/2012

Rezgui, Y. (2011) “Past, present and future of information and knowledge sharing in the construction industry: Towards semantic service-based e-construction?”, Computer-Aided Design journal, 43:502-515

Scott Morton, M. S. (1991) ‘Introduction’, in MS Scott Morton (ed.), The corporation of the 1990: Information technology and organisational transformation, Oxford University Press, New York.

Sun, M., & Aouad, G., 2000, ‘Integration Technologies to Support Organisational Changes in the Construction Industry’, 7th ISPE International Conference on Concurrent Engineering, Lyon, France, 17-20 July, pp. 596-604.

Whyte, J., Lindkvist, C., & Hassan Ibrahim, N. (2011). Value to Clients through Data Hand-Over: A Pilot Study: Summary Report to Institution of Civil Engineers (ICE) Information Systems (IS) Panel.

Wilkinson, P. (2005) Construction Collaboration Technologies: The Extranet Evolution, Spon Press, London

Yetton, P. W., Johnston, K. D. and Craig, J. F. (1994,) ‘Computer-aided architecture: A case study of IT and strategic change’, Sloan Management review, 35(4):57-67.