

BARRIERS TO ICT UPTAKE IN PROFESSIONAL QUANTITY SURVEYING ORGANISATIONS: AN AUSTRALIAN PERSPECTIVE

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ABSTRACT

The use of Information and Communication Technology (ICT) in the construction industry is viewed as crucial for effective and successful project completion. Moreover, the adoption of appropriate ICT tools increases the likelihood of survival, growth and profitability of the stakeholders of projects and the industry as a whole. Although majority of the Australian Quantity Surveying (QS) profession perceive that greater use of ICT would enhance their performance, they are not adopting ICT in any substantial, cohesive way across the sector. This suggests that there is a need to understand the reasons behind the low adoption thereby identifying the barriers to ICT uptake. Questionnaire survey and non-parametric statistics are employed to study the barriers to, and difficulties of ICT adoption in QS organisations. Cost and time are identified as two strong barriers to the uptake of ICT. Although the age and size of an organisation has no significant influence on ICT uptake, however, it is evident that the level of training and research practice has a significant influence on ICT up-take. It is also found that those organisations that undertake systematic research are more likely to have a plan for integration of ICT into their business.

Keywords: barriers, information communication technology, uptake, quantity surveying.

INFORMATION PERSPECTIVE OF CONSTRUCTION INDUSTRY

Many parties to construction are yet to recognise the information dimension of the Construction Industry (CI). In a modern perspective, built assets are products of intense information exchange - this extends through the design, construction and operation stages of the life cycle. The CI involves many activities that create and consume massive amounts of information, from product data to technical publication, building regulations etc. (Sun et al. 1999). ICT studies in the CI have illustrated that effective handling of such information in the design and construction stages of construction are crucial for effective operations which in turn, produce profitable returns for stakeholders and sustainable construction on a worldwide stage (Li et al., 2000; Love et al., 2000). Due to this complexity there is a growing need to manage and exchange project information effectively, using technology to attain organisational success.

Future success of project organisations are dependent upon on their ability to integrate ICT into their business processes and help the different project stakeholders to improve their performance (Hassan et al., 1999). This highlights the interdependence of supply chain participants, with regard to understanding and fulfilling the business and information requirements of their project partners, (particularly their clients), throughout the project life cycle. Hassan et al. (1999) suggest that consultants working on a project need to have high focus on information sharing through ICT in CAD applications, project planning and communications, while QA systems, facilities management, property systems, database, safety and human resource planning all require a medium level of focus. Further, current project procurement trends are now strongly indicative that organisations (at all levels) not capable of communicating electronically with other project participants will find it increasingly difficult to secure work and will find themselves left out of the communication loop (Smith, 2000). This strongly suggests that if consulting organisations are to be competitive and to satisfy client requirements they have to engage with ICT uptake as a matter of priority.

Despite the information intensive nature of construction projects it is viewed, for a variety of reasons (Smith, 2000; Ugwu et al., 1999) that the CI is slow in the adoption of ICT to manage this information compared to most other industries. However, although detailed research in the field has yet to be undertaken, it is observed that the "leading edge innovators" in the Australian CI are starting to re-engineer their business processes to take advantage of ICT based approaches, adding value for their clients and therefore increasing the value of their business.

ICT UPTAKE IN THE CONSTRUCTION INDUSTRY

The ICT uptake in the CI is, on the one hand encouraged by opportunities, whilst on the other hand discouraged by barriers that also exist in the supporting environment, systems and technologies, and application software (Hannus et al., 1999). Opportunities for ICT engagement are evident in the industry trends, which show that collaborative design and construction, and information sharing culture becoming more prevalent (Ugwu et al., 1999; Sun et al., 1999, Xie et al., 2000). Sun et al. (1999) discuss knowledge-based collaboration in construction information networks, which support collaborative information sharing.

Further opportunities for ICT engagement lie in the organisational context where a significant benefit of ICT engagement is access to timely, accurate, project-specific information, which is paramount for effective QS operations (Best et al., 1996d). Utilising such technologies will enable the profession to not only attract a larger client base and big projects, but also provide more diversity and value-adding services (Smith, 2000). The potential application of computer-based ICT for the QS profession has been identified as follows: -

- Increased productivity through automated operations (employing digitised measurement, estimating and CAD software)
- Increased productivity through streamlined data entry and data management (object oriented technologies)
- Improved information visualisation techniques to analysis complex data (cost and other data)
- Adoption of web based technologies (e.g. E-legal, e-cost etc.), enabling operation as part of virtual teams
- Shared knowledge management among projects, and,
- Faster communication (transfer data) techniques (e.g. Email, wireless technology etc)

Both past studies and industry experience indicate that project and industry participants should streamline their information and communication practice in order to be competitive. QS organisations cannot ignore this trend if they too are to remain competitive and profitable businesses. Most of the roles and services provided by QS (especially cost planning during the design stage, contract administration and dispute resolution during construction) will be influenced by these developments.

Studies have shown that, although majority of the Australian QS profession perceive that greater use of ICT would enhance their performance, they still are not adopting ICT in any substantial, cohesive way across the profession (Smith, 1998; January, 2001). Although, literature identifies the possible difficulties that they may face in adopting ICT, a systematic empirical study to identify the barriers to ICT uptake has not been evident.

Available literature lacks empirical substantiation of the current status of ICT in professional QS organisations. The results of this study demonstrate the awareness and attitude of the QS profession towards ICT, suggesting directions for their Continuous Professional Development. Moreover, evaluation of the limitations and barriers that obstruct QS firms from ICT uptake can help the profession and its service organisations to devise appropriate strategies to excel into the future.

HYPOTHESIS

The main aim of this paper is to empirically assess the awareness of, and potential barriers to, the uptake of ICT within professional Australian QS organisations. The literature identifies broad factors associated with ICT and related issues. This research studies these issues and barriers in depth by employing a questionnaire survey and rigorous statistical analysis. Hypotheses for this research are

design to test whether QS organisations with different characteristics, view issues related to ICT uptake differently, which would help formulation of focused strategies for effective ICT uptake. Views in the literature and industry suggest that bigger organisations (size) and long established organisations (age) are more positive towards ICT adoption and see the barriers as less of an impedance than smaller, younger organisations. Therefore the first two hypotheses are testing notion that organisational size and age impact upon attitudes to ICT uptake. Meanwhile, change literature indicates that organisations that commit to regular training for employees and engage in structured research and development perceive the barriers to be less of a restriction than organisations that do not engage in training and practice ad-hoc research. Therefore, Hypotheses 3 and 4 test this notion. Following are the hypotheses:

Hypothesis 1

(H0) Organisational size influences the barriers to ICT uptake.

Hypothesis 2

(H0) Organisational age influences the barriers to ICT uptake.

Hypothesis 3

(H0) Organisational training practice influences the barriers to ICT uptake.

Hypothesis 4

(H0) Organisational research practice influences the barriers to ICT uptake.

ISSUES AND BARRIERS TO ICT UPTAKE IN CONSTRUCTION INDUSTRY

Issues related to IT/ICT uptake in construction organisations have been studied by many researchers, including Betts (1995 & 1999), Love et al. (1996 & 1997), Fujitsu Centre & Building Research Centre UNSW (1998), Smith (2000 & 2001), Construction Industry Institute of Australia (2000) and Weisberg (2000). Review of this literature has uncovered a number of potential barriers to the uptake of ICT, across the whole of the CI. These have been conceptually themed for this study.

Therefore, initially the broader conceptual themes related to ICT uptake have been identified and issues and barriers are conceptualised into six major themes, namely:

- 'Strategic/Tactical Direction' – Issues related to business strategies, culture and management commitment to ICT
- 'Time Commitment'- Issues related changing and advancing nature of ICT and time commitment for initial/subsequent development of ICT
- 'Financial Dimension' – Cost and investment perspectives of ICT
- 'Value Perception' – Delivery of ICT and its value to the organisation
- 'Awareness/Knowledge' – The top management's overall awareness of business opportunities from ICT usage and employee's technical understanding, and,
- 'Risk Attitude' - Trust associated with new ICT developments and the attendant risks .

These conceptual themes need to be deconstructed into identifiable barriers and logically measurable variables to ensure conceptual validity of this study.

RESEARCH METHODOLOGY

Initial phase of the research methodology reviewed literature rigorously and deconstructed the six themes above into thirteen potential barriers to ICT uptake for construction organisations (Refer Table 2). These thirteen potential barriers are then transformed into twenty-one logical survey variables (Refer Table 4). This means that some of the potential barriers are examined, in the survey, from different perspectives by more than one variable to test the conceptual validity of the findings.

Barriers listed in Table 4 were measured, via a questionnaire, using a Likert scale with each organisation responding to a number of statements (variables). Respondents checked one of five boxes to indicate if they strongly agreed (5), agreed, were neutral, disagreed or strongly disagreed (1). In interpreting the statements, a rating of one (1) on the Likert scale meant that the organisation didn't see it as a barrier and a rating of five (5) means that they saw it as a strong barrier, with a score of three (3) indicating ambivalence. The questionnaire also identified organisational characteristics, to test the hypotheses, by establishing categorical variables.

No	Potential Barriers to ICT Uptake in Construction Industry	Cited from	Survey variable numbers (Ref. Table 4)
Strategic/tactical direction			
1	Lack of documented business strategies for ICT uptake Need to reengineer the organisation with ICT uptake	Fujitsu Center and Building research center UNSW (1998); Construction Industry Institute Australia (2000)	V1
2	Client influence driving the ICT initiative rather Organisational initiative	Fujitsu center and Building research center UNSW (1998); Smith (2000)	V9
3	Senior partner/management resistance to change/experiment ICT	Fujitsu center and Building research center UNSW (1998); Smith (2000)	V12
Time commitment			
4	Difficulty in keeping up to date with advancement and innovations including the time commitment for ICT development	Love et al. (1996)	V3, V10
Financial dimension			
5	Lack of investment capital for ICT uptake due to the low profit margins in the industry	Smith (2000)	V2
6	High cost of ICT investments	Fujitsu Center and Building Research Center UNSW (1998); Construction Industry Institute Australia (2000); Smith (2001)	V6, V7
7	Cost of innovating/learning new technologies	Fujitsu Center and Building Research Center UNSW (1998); Construction Industry Institute Australia (2000); Smith (2000 & 2001); Weisberg (2000)	V13
Value perception			
8	Confusion over the value of ICT investments and fear of over investing (perceiving as not profitable and experiencing not profitable)	Smith, 2000; Construction Industry Institute Australia (2000); Fujitsu Center and Building Research Center UNSW (1998)	V5, V8, V17, V20
9	The benefits of current automation are seen as sufficient	Fujitsu Center and Building Research Center UNSW (1998)	V18, V21
Awareness/knowledge			
10	Lack of awareness of opportunities arising from ICT uptake	Fujitsu Center and Building Research Center UNSW (1998); Smith (2000)	V4, V14
11	Lack of staff training and knowledge about ICT	Fujitsu Center and Building Research Center UNSW (1998); Smith (2001)	V11
Risk attitude			
12	Desire to stick with tried and tested methods	Construction Industry Institute Australia (2000)	V16
13	The belief that there is a high risk involved in up-taking new technologies	Fujitsu Center and Building Research Center UNSW (1998); Construction Industry Institute Australia (2000)	V15, V19

Table 2: Potential barriers to ICT uptake in the construction industry

As the intent is to study Australian professional QS organisations, the target population was identified as organisations that were members of the Australian Institute of Quantity Surveyors (AIQS). This meant that all of the participants of the survey were undisputedly from a professional QS background and were therefore representative of QS profession. The target population comprised the 130 AIQS member organisations located throughout Australia. All members of the target population were invited to participate in this research and out of the 130 questionnaires distributed 58 responses were returned by the due date.

The initial data screening of the responses, using a Box and Whisker plot, reveals that data is not normally distributed and thus non-parametric statistical methods are employed in the analysis. The Mann Witney test, a non-parametric - two independent sample test, has been chosen to test the hypotheses. This test compares the difference in the ICT uptake barriers between two groups identified for each of four organisational characteristics. Table 3- illustrates organisation characteristics and groups. For example the test for the first hypothesis, "The influence of organisational characteristic", 'size of the organisation', on the potential barriers to ICT uptake is tested by comparing the responses between organisations with 'under 5 employees' and organisations 'with 5 or more employees'.

Organisational Character	Size of the organisation	Age of organisation	Training practice of the organisation	Research practice of the organisation
Grouping Variable	- 1 to 4 employees - 5 + employees	- 0 to 20 years - 20 + years	- Training given to employees - No training given to employees	- Scheduled form of research -formal or informal - Ad hoc research

Table 3: Organisational characteristics and grouping variables

ANALYSIS OF RESULTS

Table 4 establishes the central tendency of the potential barriers to ICT uptake for QS organisations. Collectively, themes of 'Strategic/tactical Direction', 'Value Perception', 'Awareness /Knowledge' and 'Risk Attitude' are not seen as barriers. This finding indicates that they feel that they have adequate exposure and the right attitude to ICT issues. However, they regard the 'Financial Dimension' and 'Time Commitment' as significant inhibitors. It is evident that low profit margins (V2), difficulty in finding capital for new ICT ventures (V6), and the time commitment for ICT advancements (V3) are the strong limiting factors for ICT uptake (with a median value of 4).

The attitude of QS organisations in terms of the importance of ICT (V14), adopting new technology (V16) and new organisational procedures with ICT uptake (V1) are not seen barriers. Moreover, they acknowledge the positive returns on ICT investment (V8), and the availability of staff knowledge/skills for such ventures (V11). They do not perceive that past ICT experience (V17, V20), and potential long-term risk associated with ICT investment(V19) as barriers. Literature (Smith, 1998; January, 2001) supports the survey evidence that 'value perception' in respect of ICT is not seen as a barrier to it's uptake.

The respondents were undecided on whether their current ICT was, in fact adequate for their present and future business needs (V18, V21). As a group, they were also unsure of their strategic direction for ICT (V12) and the degree to which their clients' influenced their ICT requirements (V9). Significantly, although they were unsure as to whether their ICT investments could be considered large (V7) and highly risky (V15), they believed that large, costly and risky investments could, indeed be justified (V19, V20).

The availability of capital for initial ICT investments was viewed as an obstruction (V6), however, it was felt that it was less difficult to find capital for upgrading existing ICT (V7), indicating that once embarked upon an ICT direction, finding finance for further development was often easier to justify. In brief, capital and time constraints were felt to obstruct QS organisations being proactive in the ICT domain, a view supported by them being not being categorical about identifying the future direction for their ICT investments(V12).

Var. No.	Variables and Groups	Median	Range	Barrier Indication
Strategic/tactical direction - NB				
V1	The uptake of new ICT does not bring with it the need for new organisation procedures.	2	4	NB
V9	Ultimately it is the client that drives the uptake of ICT.	3	4	N
V12	Our organisation has not identified key ICT uptake stages for the future.	3	3	N
Time commitment -B				
V3	A substantial amount of time is required in order to keep up with ICT advances.	4	3	B
V10	It is difficult to keep up with the current speed of ICT change.	3	4	N
Financial dimensions - B				
V2	Low profit margins restrict the capital available for ICT uptake.	4	4	B
V6	It is often hard to find the required capital to fund new ICT uptake.	4	4	B
V7	The ICT uptake and advances involves a large financial investment.	3	3	N
V13	There is a high cost involved in training staff to be proficient with new ICT.	3	3	N
Value perception - NB				
V5	Investment in ICT need not be a life long investment.	2	3	NB
V8	Investment in ICT is not warranted as the returns often fail to eventuate.	2	4	NB
V17	The uptake of ICT in the past by our organisation has not been beneficial.	2	3	NB
V18	The organisation current ICT usage is seen as sufficient.	3	3	N
V20	In general the cost of ICT uptake is not justified in the long term.	2	3	NB
V21	Current ICT usage by our organisation will allow it to work well into the future without the need for change.	3	4	N
Awareness/knowledge - NB				
V4	Experimenting with new ICT innovations will not allow the organisation to expand and become a leader in the profession.	3	4	N
V11	Staff are currently seen as not having the necessary ICT skills	2	3	NB
V14	ICT is not as crucial to the quantity surveying profession as it is to other professions in the construction industry.	2	4	NB
Risk attitude -NB				
V15	The uptake of new ICT advancements carries with it high risk.	3	4	N
V16	There is no need to change systems and uptake ICT when there are already tried and proven measures in place.	2	4	NB
V19	The risk of up-taking new ICT is not generally justified.	2	3	NB
Note: NB- Not a barrier B- Barrier N- Neutral				

Table 4: Professional QS organisations' perception of barriers to ICT uptake

Hypothesis testing yielded some interesting results and insight into QS organisations. The first two hypotheses were rejected, while hypothesis 3 and 4 were accepted.

Hypothesis 1 explored whether the organisational size had any influence in the barriers to ICT uptake in QS organisations. Organisations were put into two groups- those that employed 1-4 employees (n=23) and those employing 5 or more (n=31).

The Mann-Whitney Test did not establish statistically significant results showing any difference in barriers to uptake ICT between the two groups and thus the Null Hypothesis (H_0) was not supported. It followed that there was no evidence to show that organisations of different sizes had significantly different opinions about barriers to ICT uptake.

Hypothesis 2 explored whether organisational age had any influence on the barriers to ICT uptake. Organisations were put into two groups- those that had been established for 0 to 20 years(n=29) and those that had been established for 20+ years (n=29).

The Mann-Whitney Test didn't establish statistically significant results, showing no significant difference in the perceptions of barriers to uptake ICT between the two groups and thus the Null Hypothesis (H_0) was supported.

Organisation character	Grouping variable	Significance	Central tendency and dispersion
Training practice of the organisation	- Training given to employees (37)	V4 Z=-2.041 P< 0.05 V8 Z= -3.397 P< 0.05 V9 Z= -2.847 P< 0.01 V13 Z= -2.518 P< 0.05	Training given MD= 2.5; R=3 No training given MD=3; R=2 MD=2; R=3 MD=2; R=3 MD=3; R=3
	- No training given to employees (20)	V14 Z= -2.221 P< 0.05 V16 Z= -2.038 P< 0.05 V17 Z= -2.052 P< 0.05 V20 Z= -2.882 P<.0.01	MD= 2; R=3 MD= 2; R=3 MD= 2; R=3 MD= 2; R=2 MD=3; R=2

The Mann-Whitney Test established significant results and thus the Null Hypothesis (H_0) - "Organisational training practice influences the barriers to ICT uptake" - was accepted. The eight barriers listed in Table 5 are significantly different for organisations that train employees from those that do not train. Organisations providing training perceived these eight variables as being less of an inhibitor when compared to those that didn't provide training.

- The uptake of ICT innovations would be likely to make them a leader in the profession,
- ICT investments provided returns,
- Clients were not driving their ICT initiatives,
- The cost of training was manageable,
- ICT uptake was crucial for the continuing development of the Quantity Surveying profession,
- Change was required, although tried and proven methods currently existed,
- Past ICT uptake produced beneficial outcomes, and
- ICT investment was justified in the long run.

Hypothesis 4 explored whether the barriers to ICT uptake were influenced by an organisation's research practice. Respondents were formed into two groups- those, which were involved in scheduled research (n=26) and those who conducted ad hoc research (n=29).

Organisation character	Grouping variable	Significance			Central tendency and dispersion		
Research practice of the organisation	- Scheduled form of research (formal or informal) (26)	V1	Z=-2.443,	P< 0.05	Scheduled research	Ad	hoc
	- Ad hoc research (29)	V4	Z=-2.421,	P< 0.05	1 MD= 2; R=2	MD=2; R=4	
		V12	Z=-2.464,	P< 0.01	4 MD= 2; R=3	MD=3; R=2	
		V15	Z=-2.240,	P< 0.05	12 MD= 2; R=3	MD=3; R=2	
					15 MD= 2; R=3	MD=2; R=3	

Table 6: Research practice and barriers to ICT uptake

Organisations that conducted scheduled research were significantly more likely to feel that:

- ICT uptake didn't require a new set of organisational procedures,
- Uptake of ICT innovations were likely to make them a leader in the profession,
- It was crucial to identify the future trends for ICT uptake, and
- ICT was very crucial for the future development of the QS profession.

It was evident from the median (Ref Table 6) that organisations practicing ad hoc research didn't perceive any strong barriers (i.e. median >3). However, they were less convinced about its value compared to those who had a commitment to conduct scheduled research.

DISCUSSION

The findings of this research reveal that the profession is aware of ICT and the value that ICT can deliver. However, individual organisations face considerable financial constraints in respect of ICT uptake, especially when making the initial investment. These constraints are caused by a combination of low profit margins and the difficulty in raising/justifying investment capital for such ventures. The low profit margins have been attributed, in large part, to a combination of fee competition and organisational inefficiency. Nevertheless, the literature suggests that ICT engagement can improve productivity and competitiveness on a project, organisational and industry-wide level. Consequently, the uptake of ICT can, to some extent, address both causes of low profit margins – the former will be influenced in long term by achieving competitive advantage and the latter in short term through improved productivity. Therefore, QS organisations need to develop suitable strategies for raising capital for investment on appropriate ICT tools.

Strong commitment from senior partners and managers is essential for long term success, by devising and implementing an appropriate ICT strategy. Specifically, ICT engagement must not be solely a reaction to client demands as it may evolve into inconsistent practice across the organisation - working on different platforms for different clients. They must also devise strategies to encourage ICT integration re-engineering of business practices is implicit in this step. ICT uptake may fail to deliver the desired value if not appropriately integrated into the organisation's practices and culture. Similarly, although initial stage of ICT implementation may take a considerable time, with the use of effective integration, the time spent on subsequent ICT development can be reduced. Providing adequate training to staff and conducting scheduled research into ICT developments is an essential, reflective practice that provides appropriate feedback to decision-makers within the organisation, whilst concurrently ensuring an able, agile staff.

CONCLUSION

The literature review revealed that the CI was increasingly becoming an information-intensive industry and that the efficient management of information was essential for successful project completion while concurrently providing adequate financial returns to the stakeholders. Despite this, the adoption of ICT in construction was observed to be lower than other industries. Meanwhile, the need for consultants, including QS organisations, to engage with ICT was evident and it was suggested that

undue hesitation could eventually result in expulsion from the communication loop. The literature also identified six themes within ICT and thirteen barriers to ICT uptake by construction organisations. These barriers were then measured by twenty-one variables using a survey questionnaire. It was found that QS organisations recognised the potential value that ICT offered to their organisations but viewed the costs associated with new ICT advances, and the time that was required for such innovation as strong barriers to uptake.

The hypotheses that organisational age and size had an influence on the perception of barriers to ICT uptake was not supported statistically. However, the hypotheses that the training and research practices of QS organisations had an influence on those barriers was statistically supported. The findings of this research suggested that they could be overcome by formulating strategies to find both the finance and the time required, resulting in increased profit and competitiveness. Further performance gains could be achieved by using ICT to trigger re-engineering of the business

REFERENCES

- AIQS (2002), *What is AIQS*, <http://www.aiqs.com.au>
- Atkin, B. (1990) *Information Management of Construction Projects*, TW Crow Associates, Sydney
- Best, R. et al. (1996a) *Information Technology and Quantity Surveying – Industry Comparisons*, The Building Economist, September 1996 pp 22-25
- Best, R. et al. (1996b) *Information Technology and the QS Profession – Educational Implications*, The Building Economist, June, 1996 pp 20-25
- Best, R. et al. (1996c), *Information Technology and Quantity Surveying*, The Building Economist, March 1996 pp 27-29
- Best, R. et al. (1996d) *Information Technology and Quantity Surveying – Where Do We Go From Here?*, The Building Economist, December 1996 pp 20-22
- Betts, M. (1995) *Technology planning frameworks to guide national IT policy in construction. Automation in Construction*, Elsevier Science, pp251-266
- Betts, M. (1999) *Strategic Management of IT in Construction*, Blackwell Science
- Cole, J. (1990) *The Profession of Quantity Surveying Towards 2000*, The Building Economist, December 1996 pp 20-22
- Construction Industry Institute Australia (2000), *Improving the uptake of Information Technology in the Industry*, Construction Industry Institute of Australia Information Technology Task Force
- Cyril, S. (1994) *The Future Use of IT Within the Surveying Profession*, Cyril Sweet & Partners, London
- Donovan, J. (1994) *Business Re-engineering with Information Technology*, PTR Prentice Hall
- Fujitsu Centre & Building Research Centre UNSW (1998) *Information Technology in the Building and Construction Industry: Current Status and Future Directions*, Fujitsu Centre Australian Graduate School of Management & Building Research Centre
- Gleick, J. (1999) *Faster the Accelerator of Just About Everything*, Vintage Books
- Hannus, M. et al. (1999) ICT tools for improving the competitiveness of the LSE industry, *Engineering, Construction and Architectural Management*, 6(1), 30-37.
- Hassan, T. M. et al. (1999) Emerging clients' need for Large Scale Engineering Projects, *Engineering, Construction and Architectural Management*, 6(1), 21-29.
- Hutt, R. (2000) *Managing, Motivating and Training in the Information Age*, Construction IT 2000 Conference, April, Sydney
- January, M. (2001) *Information Technology in the Construction Industry*, The Building Economist, March 2001 pp 18-24
- Li H et al. (2000), A preliminary investigation into the relationship between the use of IT/IS and the productivity of professional consulting firms in construction, The International Journal of Construction Information Technology, Vol 8 No 1 pp 15-27
- Love P. et al. (2000), An Empirical analysis of IT/IS evaluation in construction, The International Journal of Construction Information Technology, Vol 8 No 2 pp 21-38
- Love, P. et al. (1996), *The use of Information Technology by Australian Contractors*, The Chartered Building Professional, June pp 14-18
- Love, P. et al. (1997) *Process Re-engineering; a review of enablers*, International Journal of Production Economics, 50(2/3), pp 183-197

- Love, P. et al. (Not stated) *The Application of Information Technology by Australian Contractors: Toward Process Re-engineering*, <http://web.bham.ac.uk/d.j.crook/lom/iglc4/tucker/tucker.htm>
- Mohomad S. et al. (1999), Quantifying the time and cost associated with the request for information (RFI) process in construction, The International Journal of Construction Information Technology, Vol 7 No 1 pp 35-50
- Murray, M. (2002) *A Brief overview of ICT tools available to render the construction process more productive*, University of Witwatersrand Johannesburg
- Murray, M. et al. (2001), *The Integrated Use of Information and Communication Technology in the Construction Industry*, Proceedings, CIB-W78 International Conference, pp 39-1 to 39-13
- Sharpe, R. (1995) *IT in Construction Engineering*, CSIRO, Victoria
- Smith, P. (1998) *IT and Quantity Surveying – The Australian Perspective*, Construction Economics Unit University of Technology Sydney, Australia
- Smith, P. (2000) *Information Technology and the QS Practice*, Construction Economics Unit, University of Technology Sydney, Australia
- Smith, P. (2001) *Information Technology and the QS Practice*, The Australian Journal of Construction Economics and Building, Volume 1, Issue 1, August p 1 –21
- Sun M. et al. (1999), Intelligent agent based collaborative construction information network, The International Journal of Construction Information Technology, Vol 7 No 2 pp 35-46
- Ugwu et al. (1999), Agent-Base decisions support for collaborative design and project management, The International Journal of Construction Information Technology, Vol 7 No 2 pp 1-18
- Vidogah G. R. et al. (1999), Cutting construction costs: EDMS as an administrative and communication tool, The International Journal of Construction Information Technology, Vol 7 No 2 pp 59-72
- Weisberg (2000), *In Building Design The Young Need the Old and Vice Versa*, Chartered Building Professional, March
- Xie X et al. (2000), 'A survey of communication issues in construction design', Proceedings of 16th Annual conference of ARCOM , Glasgow, pp 771-780.