# Factors Affecting ICT Diffusion in Australian Construction Organisations – The Storey from the Big End

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**Summary**

Our survey findings confirm that 11 factors influence information and communication technology (ICT) diffusion for experienced ICT users. We offer a model that consists of 4 groups of categories: management (M); individual (I); technology (T); and environment (E). Our conclusions reinforce the importance of a coherent ICT diffusion strategy and supportive environment. This requires substantial investment in training and collegial learning support mechanisms. This paper provides an overview of the work undertaken and an analysis of its implications for the construction industry and we provide useful insights that a wide range of construction industry professionals and contractors may find useful.

## Background

Numerous research studies demonstrate benefits from using ICT. However, in general, the construction industry remains slow in adopting ICT—particularly, for example, when compared to advanced manufacturing industries. One reason often cited by the construction industry is that, by nature, building is both highly complex and fragmented. We believe that understanding factors that influence ICT diffusion could provide an essential mechanism to encourage construction organisations prepare for ICT adoption.

ICT use also provides opportunities to solve coordination problems associated with construction fragmentation (Latham 1994). Construction projects involve many project participants and project stages, such as design, construction, and maintenance etc. During each stage, much construction information is required to be communicated between project participants (Duyshart 1997). Minimising information re-entry and reducing missing essential information being transferred at each project stage is also enhanced by sound use of ICT (Björk 1999). Further, a recent survey of investment in information technology by large engineering contractors demonstrates an increasing trend of the construction industry's use of data management, web application and virtual reality (Songer et al. 2001). In light of this growing interest in ICT up-take to prepare organisations for the future, it is appropriate to focus research upon how adoption and diffusion of ICT applications are undertaken.

## The research project

In late 2001 the Collaborative Research Centre for Construction Innovation commissioned a team of researchers led by RMIT to investigate improved methods of diffusing ICT and improving knowledge management in the construction industry. During 2002, we undertook a survey to investigate factors influencing ICT diffusion from three construction industry organisations: a public sector client, an engineering consultant and a contractor associated with the Cooperative Research Centre in

[1] The research described here was carried out by the Australian Cooperative Research Centre for Construction Innovation

Construction Innovation in Australia. These organisations have demonstrated a high level of maturity in using ICT applications in their construction management processes. Each of the organisations cooperated with us to identify experienced ICT users. This study is part of a wider ICT diffusion research project in which a theoretical framework of ICT diffusion and change management literature was drawn upon to enhance our understanding of ICT diffusion.

The sample that this survey was based upon is drawn therefore, from experienced ICT users. Our aim was to improve ICT diffusion so it made sense for us to focus on existing ICT users. In this regard, our results should not be considered applicable generally across the construction industry were there is a range of ICT user sophistication. That said, many construction small organisations, consultancies and contractors, have been using general purpose software such as office management applications and dedicated applications such as CAD or planning and scheduling for over a decade and for these organisations, this paper may provide useful tips and insights. The total number of survey respondents was 117. There were 35 respondents from the public client organisation (group A), 39 respondents from the construction contractor (group B), and 43 respondents from the engineering consultant (group C).

The survey instrument was developed after undertaking an in-depth review of the business literature relating to innovation diffusion, change management, knowledge management, competitive advantage and information and communication technology. This review gave us an indication of the important questions that should be asked to better understand the drivers and barriers to ICT diffusion. We developed a questionnaire of 75 questions that sought general information such as name etc as well as 64 specific questions about ICT diffusion issues. We tested this on a small sample from the three organisations and modified the instrument to accommodate feedback. We then asked key representatives from each of the three organisations to nominate about 40 people to respond who were already experienced ICT users. We developed the survey to be responded to on-line with automatic updating of the database of responses, several respondents found this inconvenient and emailed their responses for transferring data by a more traditional approach.

The results were analysed using the statistical software package SSPS and we undertook a battery of tests to check that the data was valid for the analytical tools we proposed to use. First, the data from the three different organisations exhibited sufficient coherence and compatibility that they could be consolidated into a single sample for analysis. Even though the individuals had different software application experiences from each organisation and within each organisation, they did share over 70% of a common ICT experience and so the conditions was met to enable the whole sample to be analysed as a group. Second, when we undertook factor analysis we checked that the factors emerging from the data were reliable. Factor analysis takes a large group of suspected variables and distils these into a small number of tightly coherent and internally consistent factor groups. We were then able to test our results by then undertaking in-depth case study research with a focus on groupware ICT applications on contractors to better understand what was going on at the organisational, group and individual level. We did this by including the surveyed contractor and then adding two more major construction companies to our case study research component.

The whole research project has taken almost three years elapse time, involved two PhD students who have completed their PhD on aspects of this area. Additionally we had two full time researchers and the equivalent of another full time research with four other people working at varying levels of intensity on the project over that time. The budget for the research project was $400,000 cash with a similar amount of in-kind commitment from our industry and academic research partners.

## Survey Research Results

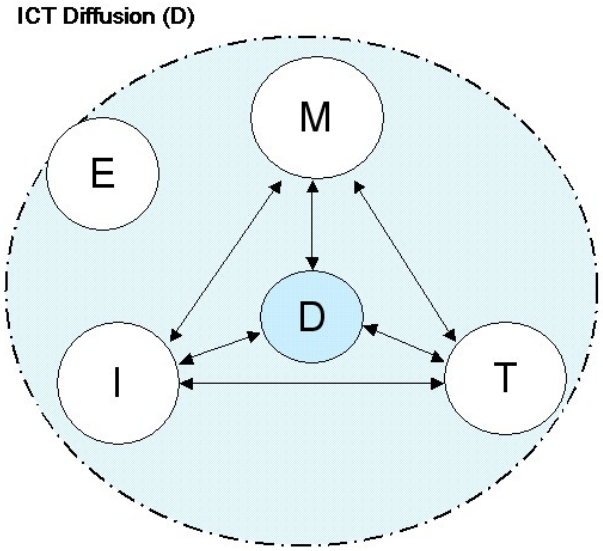
*Table 1 The Factor Analysis of Variables relating to ICT Diffusion*

| Factor | Factors | Group of Variables |
|---|---|---|
| 1 | **Training & learning Support (∝ = 0.9163)** | - Sufficient time to think<br>- Flexibility for learning<br>- Work procedure support<br>- Enough time for training<br>- Technical support<br>- Enough quality of training<br>- Functionality / Ease of use ICT<br>- Easy to observe benefit of using ICT<br>- Trial and experiment ICT<br>- Mentoring Support |
| 2 | **Clear Advantage of Use (∝ = 0.8901)** | - Clear advantage of using ICT for coordinating teams<br>- Clear advantage of using ICT for communication between teams<br>- Clear advantage of using ICT for communication within team<br>- Receive professional credibility<br>- Clear advantage of using ICT for decision-making<br>- Relevance to personal job |
| 3 | **Individual/Personal Characteristics (∝ = 0.8505)** | - Basic skill of using ICT<br>- Personal confident<br>- Enjoy exploring / expose new tools<br>- Personal capability to learn ICT<br>- Mentoring program<br>- Personal commitment |
| 4 | **Technology Characteristics (∝ = 0.8803)** | - Functionality of ICT<br>- Accessibility of ICT<br>- Response rate of ICT |
| 5 | **Supervisor Support (∝ = 0.7326)** | - Supervisor encourage to use<br>- Supervisor openly suggests on improving using ICT<br>- Trust with supervisor on making mistakes<br>- Organisation support sharing ICT experience<br>- Enjoy learning from other |
| 6 | **Open Discussion Environment (∝ = 0.7086)** | - Organisation openly discusses about ICT difficulty (Group)<br>- Person openly discusses about ICT difficulty<br>- Organisation openly suggests on improving using ICT<br>- Organisation commitment (resources) |
| 7 | **Tangible and Intangible Reward (∝ =0.5839)** | - Receive tangible reward<br>- Provide tangible rewards in sharing ICT experience<br>- Provide intangible rewards in sharing ICT experience<br>- Receive intangible reward |
| 8 | **Colleague Help (∝ = 0.7859)** | - Colleagues informally help on using ICT<br>- Colleagues formally help on using ICT |
| 9 | **Positive of using new Technology (∝ = 0.6504)** | - Better than previous<br>- Speed and reliability of ICT<br>- Compatibility with previous system/ work procedures |
| 10 | **Negative Environment (∝ = 0.5852)** | - Feel pressured to be effective in using ICT<br>- Personal anxious |

| | | |
|---|---|---|
| 11 | **Barrier of using ICT** | - Difficult, complex or frustrating to use ICT |

Factor Analysis (Pairwise N= 117) Extraction Method: Principle component analysis
Rotation Method: Varimax Rotation
∝ is represented Cronbach's alpha 0.6 or greater indicates high reliability.

Table 1 provides a summary of the factor analysis. It reveals 11 factors affecting ICT diffusion. These provide a useful cluster than can be seen as naturally falling into four categories or groups of factors. Figure 1 indicates how these fit into management influence factors, factors that relate to the individual's characteristics, technology related factors and factors relating to the work environment.




**Management (M)**
F1: Professional Development and Technical Support
F5: Supervisor and Organisational Support
F7: Supporting Tangible and Intangible Reward

**Individual (I)**
F2: Clear Benefits of Use
F3: Supporting Individual/Personal Characteristics
F9: Positive Feelings Towards ICT use
F10: Negative Emotions Towards ICT use

**Technology (T)**
F4: Supporting Technology Characteristics
F11: Frustration with ICT use

**Environment (E)**
F6: Supporting Open Discussion Environment
F8: Supporting Colleagues Help

Figure 1 The ICT Diffusion Model

Figure 1 provides an interpretation of the data results. We saw cross-linking relationships between factors. For example management has the role and capacity to facilitate professional development and technical support, supervisor and organisational support and create a system whereby tangible and intangible rewards are given for the level of knowledge sharing that leads to ICT users seeing benefit from their cooperation in helping to diffuse knowledge about ICT applications. There were issues of technical support both positive and negative that the data suggested had an impact upon ICT diffusion. Finally, the work environment had an influence through supporting open discussion of problems with getting to grips with the ICT application or and the manner in which colleagues supported and helped each other.

Table 2 illustrates the mean value of the responses from the survey. A five point measurement scale was used with 1 = very low and 5 = very high. The Environmental factors with a mean score of almost 4 (high) indicate that this is very important for ICT diffusion. This makes sense because you need an open environment in which people are free to ask for help and uninhibited in sharing concerns as well as knowledge. Similarly colleagues supporting each other provide a vital element in creating a supportive work environment. The next highest scored factor group was individual characteristics and while the group mean was a little lower that the

environmental group, it was still high (close to a value of 4) with several factors being just over 4 (high). These make it clear that people use ICT applications to make their daily lives easier to cope with. They will not warm to an ICT tool unless it provides real perceivable benefits. The applications must also support the person's characteristics such as email or intranet applications becoming a tool that ICT users expect as part of their general array of working tools to perform their job.

Figure 2 – Factor Mean Scores (1= very low; 5 = very high)

| Factor Description | Means Score | Rounded Means |
|---|---|---|
| **Individual (I) Factors** | | **3.8** |
| F3: Supporting Individual/Personal Characteristics | **4.145** | 4.2 |
| F2: Clear Benefits of ICT Use | **4.105** | 4.1 |
| F9: Positive Feelings towards ICT Use | 3.623 | 3.6 |
| F10: Negative Emotions towards ICT Use [1] | 1.780 | 1.8 |
| **Environment (E) Factors** | | **3.9** |
| F6: Supporting Open Discussion Environment | 3.928 | 3.9 |
| F8: Supporting Colleague Help | 3.895 | 3.9 |
| **Management (M) Factors** | | **3.2** |
| F5: Supervisor and Organisational Support | **3.808** | 3.8 |
| F1: Professional Development and Technical Support | 3.277 | 3.3 |
| F7: Supporting Tangible and Intangible Reward | 2.423 | 2.4 |
| **Technology (T) Factor** | | **3.5** |
| F4: Supporting Technology Characteristics | **3.703** | 3.7 |
| F11: Frustration with ICT Use [1] | 1.690 | 1.7 |

[1]*Negative factors, therefore a low value implies high emotions towards ICT applications*

Technology factors, although of importance were perceived as not high but still greater than average. This may reflect the experience of the sample group surveyed. They probably have the computer literacy to be able to overcome some of the more mundane problems that often occur with computer use such as knowing how to open email attachments, how to move from one application to another and understand simple problems if they arise and thus who to seek help from and what questions to ask. Management Factors were also generally around average but the supervisor and organisational support might have been categorised as an environment group factor as it related to getting help when required. This factor had a means score of almost high.

**Implications For the Construction Industry**

The above clearly indicates that if the construction industry will in general take on board the advantages and benefits of ICT then its leaders must be able to create the work environment that supports people sharing knowledge about how to most effectively use ICT applications. The survey highlights the personal drive that motivates people to effectively use this technology, their personal benefits are highly important to them. This can be enhanced by ensuring that technology support is in place to help people when they need it and the management and leadership style must also support the creation of an open work environment where people feel free to ask 'dumb' questions and voice concern about technology or other problems that hinder

their getting benefit from ICT. While this may appear to merely state common sense, it is surprising how many organisations generally fail to budget sufficient resources for ICT support both in terms of help-centres but in providing the organisational slack that permits people the time to stop and help colleagues when requested. Finally, ICT has changed the power balance within organisations between managers and those doing knowledge work. The focus is now on empowering and enabling people, not checking and monitoring that work is done in a particular way. It is also about leadership that inspires and transforms a workplace through supporting individual and supervisor skills and abilities to share knowledge.

The construction industry has always tended to be team-oriented recognising that expert power and ability to get things done usually is more respected than formal position or authority. The key lesson to be learned from this survey, at least for experienced ICT users, is that smart management will invest in the workplace environment and support mechanisms rather than expect more hardware and software application expenditure to automatically provide a competitive advantage.

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