BARRIERS OR CONSTRAINTS?

A REVIEW OF DEVELOPMENT ISSUES AS THEY APPLY TO CONSTRUCTION IT

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ABSTRACT

The construction industry is widely characterised as conservative in both business practices and construction methods and processes. Companies are seen as reluctant to change existing practices, despite the potential for greater efficiency and time and cost savings offered by technology now available. Supply chains are fragmented, and extensive use of sub-contacting introduces layers of management and a strong degree of autonomy in a wide variety of subgroups within a construction project team.
Many studies have focused on barriers to the uptake of information technology in construction firms, with findings often framed in terms of characteristics of the industry similar to those summarised above.
This paper presents a review of literature related to the introduction of IT in construction. It highlights a number of related issues that indicate that the construction industry might be better seen as cautious, but making progress, rather than resistant.
While there are clearly characteristics of the construction industry that hinder widespread uptake of information technology, this can be seen as only part of the story. The argument for increased application of IT to construction processes is now well established, with identified benefits of improved productivity, financial and environmental sustainability. There are clearly gains to be made from progression in the industry from low-level business applications to construction-specific IT usage, and there are indications that the industry is ready for this to take place.
To conclude the paper, the author questions why these industry characteristics often cited as barriers to innovation are not instead regarded by the proponents and developers of construction IT as constraints or design issues to be factored into the development process.

1. INTRODUCTION

Construction activity is an important contributor to the national economy of most countries, and improved productivity of the sector is widely touted as a key dynamic in boosting the performance of the country as a whole. Application of IT has for some time been hailed as the key to implementing such productivity gains. The fragmentation and inefficiencies in the UK construction industry identified in 1994 by the Latham report (Latham, 1994) triggered a wave of initiatives designed to lead construction in that country into the "information age". This provided impetus for similar initiatives in other countries, and in international collaborations, which have continued in various forms since.

After more than fifteen years of this drive towards more widespread application of IT in the industry, the discussion is surprisingly unchanged (Issa et. al., 2003; Gyampoh-Vidogah et. al., 2003, Peansupap & Walker, 2005). The construction industry is still widely characterised as 'traditional'; conservative in both business practices and construction methods and processes. Companies are seen to be reluctant to change existing practices, despite the potential for greater efficiency and time and cost savings offered by the information technology now available.

This paper confronts some of the assumptions in the literature around this perception of conservatism and unwillingness to progress within the industry, and identifies some optimistic indicators that construction IT is moving forward.

2. WHAT IS "THE CONSTRUCTION INDUSTRY"

From some of the literature on implementation of construction IT, there is an impression of homogeneity in the construction industry. This belies the reality, which ranges from thousands of "one-man band" builders and other trades people, to multi-national, multi-disciplinary consultancies. Depending on how inclusive a scope one takes, construction businesses include not only those active on a site to put a

building together, but the transport companies, primary producers (e.g. cement, stone etc), labour exchanges and other enterprises that contribute to the construction process. This wide variety of businesses has similarly varied needs in terms of IT. To address innovation and expectation across the whole spectrum indiscriminately and to expect a consistency of interest and uptake, would be to invite failure in the IT design process.

A key factor in the development of IT in the construction industry is that of company size and distribution. UK figures show that 79% of companies have less than 5 employees, with only 2% having over 50 employees (Office for National Statistics, 2007). Similarly in the US, recent figures show 59% of companies have less than 5 employees, with only 3% having over 50 employees (US Census Bureau, 2005). Industry distributions in many other countries are likely to follow similar patterns. This is significant, as the literature suggests that the large companies are leading the drive for IT uptake and development. Small and medium enterprises (SMEs) have a much smaller uptake and do not currently see the same benefits and opportunities from the use of IT, beyond a limited range of business applications.

A recent approach has been to address the needs of small enterprises as a particular type of construction organisation. Research in this area (Acar et. al., 2005; Sexton et. al., 2006) has identified that these companies often have more in common with other small businesses, regardless of sector, than with large organisations in the construction industry. Even within the grouping of SMEs in the industry, there are considerable variations between firms in terms of size and purposes, and this must be recognised.

Another area of diversity in the industry is the distinction between the office and site activities of a company or project. Even within a single company, performance in terms of IT may vary widely. Given the temporary nature of project site offices, it can be a difficult task to establish a workplace with an IT environment comparable to those in a permanent office (Tah & Carr, 2001).

3. IDENTIFIED BARRIERS

Many studies have identified barriers to the uptake of information technology in construction firms. Stewart et. al. (2004) summarised these into three levels of barriers: industry, organisational, and project. Another way to categorise these barriers is to view them as culture or organisation based, where the barrier results from the way people work within the construction industry; and technological barriers, which result from shortcomings in the technology and its development process.

Almost all of the barriers identified by Stewart et. al. (2004) may be characterised as cultural/organisational barriers. However, it is notable that contrary to the characterisation of the industry as conservative and slow to change, respondents in that study did not consider conservatism and fear of change to be significant issues in limiting IT implementation. The most significant organisational issue identified was the limited time and money available for investment in IT, particularly for small and medium enterprises. This highlights the significant challenge that the diversity within the industry, outlined in the previous section, introduces to IT implementation.

When these multiple organisations of various sizes and specialisations come together to form a project team, layers of management are introduced. Supply chains are fragmented, with participants retaining a strong degree of autonomy and independence. The project-focused nature of the industry means that each project team is relatively short-lived. The effort involved in putting IT into practice within a project - development and implementation, training staff in how to use it, and monitoring and adjusting the processes involved - represents a huge investment in time and cost in an industry which operates on already close margins and high risk levels.

Because of the project focus, and resulting from the shared risk of projects between participants in the project team, there is often no clear beneficiary from advancement in IT. The benefits accrue to the project as a whole, but the advantages to any one participant are not as easily quantified. In addition, the savings resulting from IT usage are difficult to specify, as they manifest in terms of time savings, reduced waste, etc (Tah & Carr 2001) which may also result from a variety of other factors.
This difficulty in identifying company-specific benefits contributes to another sticking point in advancing the IT development of the industry – use of IT occurs primarily at project level, and most of the drivers for development and innovation result from project-focused needs, but it is at company level, and particularly in the small companies, that increased uptake needs to occur for the industry to continue to grow and develop in IT use (Sexton et. al., 2006).

On the technology side, the lack of interoperability between many IT tools has been identified as a barrier. The "one-off" nature of much of the industry's work, and fragmentation and reforming of project teams and temporary organisations has hampered the development of industry standard systems, and has prompted the creation of many task-specific tools that have a limited market and so are often subject to a less thorough development process. A European project in 2000 identified over 4000 items of construction-related software (Amor et al., 2000). This quantity acts to limit the amount of conformity between tools, and means that although industry standards exist, many companies use non-standard applications that are not able to exchange data.

Even where successful tools have been created for a company or project and put into action, limitations in other aspects of IT implementation or technologies act to limit the achievements possible with the new tool (Alshawi & Faraj, 2002). There has been a considerable level of ongoing development, adaptation and specialisation required to ensure tools continue to meet the requirements of individual companies and projects, which again contributes to diversity in applications that may have started out as standard but have become increasingly bespoke.

Bandwidth has been a technological barrier, particularly acting as a hindrance in document exchange. While large companies with broadband access have increasingly adopted electronic document transfer and internet-based project portals in their operations, the speed and unreliability of dial-up have been limiting factors for smaller companies who run systems with dial-up access to the internet. Even for companies using broadband, the large size of CAD files and transfer formats such as IFC still mean that this type of transfer is not instantaneous.

Limitations in mobile computing and flexible computing impose other technological barriers. Establishment of temporary site offices is essential if IT is to be used throughout the construction process. While the computers and other equipment needed to meet construction requirements may have been around for some time (Bowden 2002), users of new technology are still experiencing difficulties with equipment that does not perform properly in the demanding environment of a construction site (Svidt & Cristiansson, 2006).

That barriers exist to more advanced and more widespread use of IT in the construction industry is indisputable. Many of these barriers stem from the nature of the construction industry, and as such are difficult to overcome. Technological barriers are less intractable, with development in IT both within the construction industry and in the wider IT context serving to reduce their impact.

4. DEVELOPMENT PROCESS

While there are clearly characteristics of the construction industry that hinder widespread uptake of information technology, this can be seen as only part of the story. Where there is a demonstrated advantage, with a supported process of application and implementation, the industry has shown it is open to change in how IT is applied to both business and site activities.

There has been a considerable increase in use of information and communication technology at the office level in construction companies. For example, the construction industry was one of the early adopters of mobile phone technology, and continues to pursue further applications of mobile communication such as video phones, as well as wider application of mobile computing.

Successful use of IT in construction, as in any industry, depends on alignment between the business processes and the IT intended to support it. A mismatch in this alignment will result in rejection of the IT by the people using the system (Adriaanse et. al., 2004). While there are many shades of change possible between them, the two polar approaches to this are clear: either to use existing behaviour as the model for how the IT processes should be developed; or to change the existing processes so that the IT determines the practice.

The literature suggests that the most successful uptake of IT results from implementations that tend towards the former of these two paths. The tight margins and high risk already present in construction projects means that companies are loath to introduce more risk. Process re-engineering is a very risky approach, in terms of both time and cost, with the end result an unknown. Stepwise change represents a much smaller upfront investment, in terms of cost, time and overall risk management.

CAD is one example of how this progressive uptake has proved successful. Initially, the change to CAD was a computerisation of existing activity. There was little or no change to the business, reducing the risk of moving to this use of IT. Draughtspeople were trained for CAD in a similar way as they developed manual draughting skills, in a training organisation outside the hiring company. The process for the company involved some outlay, in terms of equipment purchase, but little in training and time. Once this first step of computerised draughting had been accepted, the way was opened for the incremental of additional processes developed from that. The current movement away from CAD as a document production tool and towards the development of 3D CAD building models can be seen as part of this gradual progress. This signifies a considerable change in the way users will develop or model a building, integrating design with product details and other modelling and visualisation tools, but it has taken place gradually over time. Users have accepted new ways of working as a side effect of the technology, rather than being forced to confront change as a result of the change in technology.

This process of incremental change also serves to develop partnerships between the many organisations and interests involved in a construction project. Fernie et. al. (2006) identifies the divisions that can grow within partnerships if change is imposed rather than progressing incrementally. The extensive partnerships and inter-organisational processes in the construction industry are unavoidable, so development and implementation of IT needs to be cognizant of this effect.

Change can often be risky and thus daunting to businesses, both for managers and employees. A gradual approach to change, integrating current practice into new processes, is a successful model that allows low risk adaptation to new ways of working, and assists companies in building partnerships rather than threatening them.

5. BEYOND THE BARRIERS

The current environment in the industry is shifting towards increased adoption of IT and a wider acceptance of its use across the industry. While this change may be slow to filter down to the many micro-companies in construction, a number of factors are important in driving a swing towards IT.

Education is a significant factor in accelerating change, with young people entering the industry more comfortable with technology. This has brought a considerable shift in attitudes towards IT. For the current generation of workers entering the workforce, IT is no longer seen as a threat or a change. They expect to see and use it in their work environment, as it has become an established part of their education and home life. For companies, this reduces the risk of introducing advanced IT, as the culture change and general acceptance of IT have taken place outside of their circle of influence. The organisation can then focus more on the specific application, and the technology and processes involved.

Clients, particularly government clients, are increasingly requiring companies to move beyond generic business use of IT into the use of domain specific tools as part of the construction design and management process. This is providing impetus for even the small companies to identify appropriate IT and shift towards a more integrated approach across the supply chain (Brewer et. al., 2005). Strategic partnerships and “favoured supplier” relationships are reinforcing this move, where companies seek to become part of projects or ongoing partnerships by aligning their IT use with that of the dominant companies. As more companies use advanced IT in their operations, other companies have to adopt similar practices to work with them, compete with them, or simply to maintain their market position. This is leading towards the point where a company has to adopt a certain level of technology to participate in the industry.

Improvements in technology are also contributing to greater acceptance of IT in the industry. Increases in capabilities and reductions in price of computing equipment make establishing a project site office less of a hurdle. Improvements in telecommunications, most notably the widespread access to broadband, also assist this process. The development of industry standards for information exchange is perhaps not a strictly technological change, but this a change in the way IT is being addressed across a range of industry sectors (Amor et. al., 2001). Increased momentum in the development and application of these standards will overcome the significant and widely identified barrier of lack of interoperability in industry tools.

Many of the factors identified in the literature as barriers are themselves in a state of change. Shifts in the way the industry operates, improvements in the available technology, and changes in society as a whole

are all contributing to a reduction in importance of some of the issues that have been traditionally seen as obstructing greater uptake of IT in the construction industry.

6. BRIEFING FOR BARRIERS

Many of the factors that have been widely identified as barriers to the introduction of IT into the construction industry could be viewed as key design factors to be considered as part of a development brief. For example, the implementation process is almost always identified as a barrier to the uptake of unsuccessful IT projects, despite there being a widely recognised best-practice process for achieving uptake (Stewart, 2004). Shifting the focus from barriers to brief requires a recognition that part of the design process is designing for not simply a system that 'can' meet the requirements but one that can be put in place to do so.

Another barrier can be overcome through recognition that there is not a single 'client' for an IT product. By taking a cross-functional view in the brief, there is a greater likelihood that developers are able to fulfil the requirements not just of the primary user of the tool but of the many other parties who will interact either with the tool itself or the information output from the tool. As discussed above, adherence to and support for industry standards will also serve to reduce the discrepancies in information exchange for the multiple users.

Parallel to the incorporation of these barriers as design factors in the brief, is the need for IT developers to take greater responsibility for achieving successful adoption of the tools created. A relationship between developer and user(s) is necessary as part of the development process, particularly for non-standard IT applications (Svidt & Christianson, 2006, White et. al., 2002). The dynamic nature of the industry means that the use of an application may evolve across the course of a project, or change between projects and project teams. For any application to achieve long term success in this environment, the development process needs to be regarded as evolutionary rather than one-off.

Understanding industry constraints and requirements is a further onus on both the developer and industry researchers. Industry benchmarking exercises such as the IT-barometer (Samuelson 2008) provide for greater understanding of the constraints and limitations present in the industry, and thus allow factors such as limited IT-usage by sectors within the industry, or areas of planned investment to be considered as elements of the brief, instead of as barriers to be encountered later during implementation. Process modelling is another area where improved information will lead to better briefing and thus a more responsive IT development. If an activity or process is to be supported by the development of specific IT tools, scrutiny of the interactions and procedures involved will allow the systems developed to align more closely with practice.

In redefining many of these traditional barriers as factors for consideration in the development brief for new IT applications, the focus is shifted from perceived shortcomings of the construction industry. Given that many of these are fundamental elements in the way the industry operates, it seems more realistic to approach IT development with an awareness of the constraints that exist. This in turn requires IT developers to recognise and incorporate these constraints into their work.

7. CONCLUSIONS

Many barriers have been identified that limit the successful implementation of IT in construction. A number of these barriers stem from the demographics of the construction industry. Many participants in the industry are micro businesses that do not realise the advantages that larger specialised companies can. A recent research focus on the needs of small and medium sized enterprises is helping to tailor development to the needs of smaller companies, and the inter-organisational nature of construction projects is also acting to include SMEs in advanced applications of construction IT.

Incremental change appears to be a successful approach in the industry in avoiding many of the barriers. The multi-party, short-term, high-risk endeavours that are construction projects have too much at stake to add further risk through introducing new processes and new IT tools. Incremental development allows gradual change and potentially leads to acceptance of more advanced applications once initial changes prove advantageous.

While there are still limitations to how construction companies and project teams accept and apply IT, many of the technological barriers are losing their significance. Moves in IT and telecommunications are improving access, reducing costs and increasing interoperability. Some of the cultural and organisational barriers are also decreasing in importance. Changes in attitudes and expectations surrounding IT in society as a whole are being reflected in construction, with greater personal experience changing the way employees approach IT in the workplace.

Many of the remaining barriers are intrinsic in the way the construction industry functions. In these instances, there is a need for these to be considered as part of the IT development process. If these characteristics are regarded as part of the question, if the constraints are incorporated as part of the brief, the IT tools that result will have a greater potential for contributing to the construction processes they are intended to serve. IT developers need to work with and for the construction industry, from an understanding of the needs and challenges it faces.

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