INDUSTRY UPTAKE OF CONSTRUCTION IT INNOVATIONS – KEY ELEMENTS OF A PROACTIVE STRATEGY

Dr Chimay J. Anumba
Department of Civil & Building Engineering, Loughborough University, Loughborough LE11 3TU, UK, c.j.anumba@lboro.ac.uk

ABSTRACT

There is general agreement that the construction industry's uptake of innovations in Construction IT is disappointing, particularly when considered in relation to the huge research effort and expenditure being invested in this field. This is of growing concern to research funding agencies, Construction IT researchers, and some industry practitioners, albeit for very different reasons. This paper examines some of the reasons for this low uptake of Construction IT innovations, drawing on examples of specific technologies and research projects, where appropriate. It emphasizes the need for partnerships and closer working arrangements between the key actors and stakeholders - researchers, funding agencies, software developers, end-users and industry managers. The paper outlines the key elements of a framework within which technology transfer from research to practice will thrive, and highlights some initiatives that will help to address the low uptake of Construction IT innovations.

Keywords: Construction, IT, Innovation, Uptake

1. INTRODUCTION

The construction industry is generally regarded as a conservative industry, set in its ways and reluctant to change. This is certainly true in many respects and has been used to explain the slow uptake of new technologies within the industry. However, many would argue that this line of argument is an over-simplification of the problem and that the industry is prepared to adopt new ideas and technologies where the benefits are demonstrable. In the early days of Computer-Aided Design (CAD), it was evident that while sections of the construction industry enthusiastically adopted systems that reduced the tedium associated with complex, number-crunching analyses, the acceptance of drafting systems was far less enthusiastic. In contrast, other industry sectors (notably mechanical and electrical/electronic engineering) were much quicker to see the benefits of the new technologies and made the necessary investment to transform their business processes. It was generally acknowledged that the investment was much easier to justify in these sectors because, unlike the construction industry which produces unique one-off products, these other sectors could recover the investment over a long production run. The situation has now changed considerably within the construction industry with CAD and Information Technology (IT) systems being deployed by all sectors of the construction supply chain and at nearly all stages in the lifecycle of a constructed facility.

Many reasons have been put forward to explain the increasing uptake of CAD and IT systems within the construction industry. One of the key reasons is the fact that the construction industry has become subject to the same pressures that had forced firms in the manufacturing sector to adopt new approaches to solving their problems. These pressures include (amongst others): the need to deliver more units of construction for lower units of expenditure; the demand by enlightened clients for greater efficiency and value for money; increased

competition; the need to improve quality and ensure client satisfaction; the globalisation of the industry which resulted in geographically distributed project teams; and the increasing requirement for projects to be delivered within tighter time-scales. In order to address adequately these pressures, the construction industry needed to fundamentally re-engineer its business processes. CAD and IT systems were seen as the key enablers for achieving the effecting the changes that were required.

While the industry has come a long way in its adoption of CAD and IT systems, there is still much that needs to be done to address fully the challenges still facing the industry. While researchers enthusiastically seek to develop new tools to address industry problems, they are often frustrated by the nonchalant attitude of industry practitioners towards their latest innovations and products. Before examining in detail some of the reasons for this continuing slow uptake of construction IT innovations, it is pertinent first to discuss the nature and trends in Construction IT research.

2. CONSTRUCTION IT RESEARCH AND UPTAKE TRENDS

Research in Construction IT is regarded as a relatively young field of study, still struggling to define its place within the large family of academic disciplines [Bjork 1998]. Much of the early work was undertaken by enthusiasts striving to find solutions to specific problems in their field of endeavour. These were mainly standalone, pragmatic solutions that addressed effectively the problem at hand but had limited appeal and applicability. In some cases, these were proprietary systems that were not commercially available, thus limiting the number of firms that could take advantage of the functionality that they offered. The advent of commercial systems (based on early research prototypes) that addressed specific problems was instrumental in broadening the appeal of these systems. However, the problem of justifying the cost of these systems remained, with the industry only taking up a system where its advantages over existing conventional approaches could be readily demonstrated.

It was not long before Construction IT researchers realised that the full benefits of CAD and IT systems could only be realised through integrating standalone applications. This led to a lot of research work on the development of interfaces between existing systems. While many of the interfaces developed were very effective between two specific applications, problems were often encountered when it was necessary to link up to three or more applications. The amount of work (and rework) often required in developing the required interfaces was considerable and the benefits marginal in comparison. Nevertheless, the linkages helped to further demonstrate the potential of CAD and IT systems.

The move towards integrated CAD and IT systems has led to several research themes including integrated data structures, product modelling, development of standards for the representation of product information, data exchange protocols, integration of CAD and project schedules, etc. The numerous benefits possible with the use of integrated systems are increasingly being realised by industry practitioners. Construction IT researchers, having developed integrated systems within individual construction industry disciplines, are now focusing on research work that will result in multi-disciplinary systems integration, as it is here that the greatest potential lies. There is currently significant interest in the development of an integrated project model for construction projects. This is expected to have major impact, particularly if it takes on board the output of the International Alliance for Inter-operability's work on the development of Industry Foundation Classes (IFCs). When available, such a project model will appeal to construction project teams, as the advantages will be demonstrable.

Visualisation is another burgeoning research area which is likely to have an influence in the uptake of Construction IT innovations. It is of utmost importance in multi-disciplinary integration, and many Construction IT researchers are developing tools that can facilitate this. In tandem, there is also work into the development of appropriate information and communication technologies to facilitate collaborative working between members of a project team. These efforts will result in improved functionality and enhance the uptake of CAD and IT systems in industry.

3. REASONS FOR LOW INDUSTRY UPTAKE

The relatively low uptake of Construction IT innovations in the construction industry is of growing concern to research funding bodies, Construction IT researchers, and some industry practitioners albeit for very different reasons. Funding bodies world-wide are keen to justify the millions of dollars that they have invested in Construction IT research by demonstrating to policy-makers that the research undertaken so far is yielding fruit and having a positive impact on industrial performance. Construction IT researchers are often disappointed that many promising research prototypes have not resulted in commercial systems and that much of the output from their research projects end up on the shelf. Some industry practitioners are frustrated that Construction IT innovations do not always address their immediate needs. Whatever the point of view, it is clear that there are several factors at work; these need to be well understood before solutions can be devised.

Some of the main reasons for the low uptake of Construction IT innovations include the conservative culture of the construction industry; poor level of investment in Construction IT; poor dissemination of research results; poor marketing; inadequate user-interfaces; a mismatch between current research and the needs of industry; and the lack of adequate uptake by software developers.

Conservative Culture of the Industry

As mentioned previously, the construction industry has, historically, had inertia to change (particularly in the adoption of technological and process innovations) [Watson & Anumba 1991]. Although the situation has changed somewhat in recent years, construction remains, in comparison to the manufacturing sector, an inefficient, low skill, low technology industry. It is no wonder, therefore, that Construction IT innovations are still viewed with skepticism by many industry managers and practitioners. As younger and more computer-literate practitioners move up the corporate ladder in construction firms, and as the benefits of CAD and IT systems become more evident, this conservatism will diminish.

Poor Investment in Construction IT

While significant sums of money have been invested in Construction IT by research funding bodies in various countries, there is scope for a lot more to be done. The lack of a coherent strategy, in many cases, has led to much duplication, inadequate support for promising new areas, lack of sustained support in some essential areas, and the funding of work of limited industrial impact. In addition, there is very little industry funding for research in Construction IT. Firms are often more interested in funding small, incremental initiatives which may give them a competitive advantage, with very few firms providing any form of support for fundamental, generic work that will benefit the industry as a whole.

Poor Dissemination of Research Results

Another important factor in the low uptake of Construction IT innovations is the poor dissemination of research results. Most academic research results are disseminated through conventional academic outlets – publications in journals and conference proceedings – and so do not adequately reach industry practitioners. Industry practitioners often complain about the dearth of information on what research has already been undertaken and the absence of guidelines on how the results of these projects can be deployed within their own organisations.

Poor Marketing

The poor marketing of Construction IT innovations to practitioners in the construction industry is another reason for the low uptake. Not only has the marketing of these innovations lacked the aggression required in a conservative industry, but also it has often been based on the use of inappropriate and misleading terminology. For example, the use of the term 'expert system' in the marketing of many knowledge-based systems led practitioners to expect 'fool-proof, all-singing, all-dancing' systems. The reality was, of course, very far short of these expectations, and many would-be end-users became disillusioned. Furthermore, the technical jargon often used to describe the functionality and other attributes of CAD and IT systems is incomprehensible to the average practitioner, thereby alienating him/her.

Inadequate User-Interfaces

Many early CAD and IT systems were victims of inadequate user-interfaces which blunted their appeal. In general, the more user-friendly a piece of software is (provided it is of acceptable functionality), the more its acceptability to end-users. Also, the easier it is to use a CAD or IT system, the more efficiently it can be deployed. Several considerations need to be taken into account in the design of user-interfaces for CAD and IT systems [Anumba 1994]. Although some of these considerations are now being addressed in more recent systems, the damage had already been done by earlier systems, as users found themselves spending more time on familiarisation with the software rather than tackling the task at hand. The emergence of enabling IT tools such as multimedia, virtual reality (VR), and voice/motion recognition offers the potential to radically improve the user-interfaces (and hence, the appeal) of new CAD and IT systems for the construction industry.

Mismatch between Innovations and Industry Needs

A reason often given by industry practitioners for the low uptake of Construction IT innovations is the mismatch between some of the systems being developed by researchers and the needs of the construction industry. The existing scenario, in many cases, could be described in terms of a 'technology push' rather than an 'industry pull', with researchers developing systems that exploit computing technology and are illustrative of its potential, but are considered by practitioners to be less appropriate (or simply, less convenient) than existing methods. Researchers tend to concentrate more on what is academically exciting and technologically challenging instead of addressing real industry problems.

Poor Uptake by Software Developers

It must be recognised that Construction IT researchers are not equipped to deliver commercial systems to industry practitioners. That role has to be fulfilled by software developers that have the marketing and technical support infrastructure to achieve and sustain industry uptake of Construction IT innovations. Unfortunately, many software developers are conservative in their approach to new research prototypes based on new technologies. For example, the author and his research team recently developed a knowledge-based system for the engineering management of subsidence cases [Scott 1997], which had very good performance reviews in an industry evaluation. A software developer approached to commercialise the system was impressed with the software but refused to adopt it on the basis that it was based on new technology they did not fully understand. A market survey by an independent Regional Technology Centre has confirmed the market potential of the system (given that the housing subsidence market in the UK amounts to about £200 – 300 million per annum in expenditure) and is currently seeking a suitable joint venture partner for the commercial development of the system.

It should be noted that while the construction industry's uptake of Construction IT innovations has been low, in comparison with other industry sectors, the situation is gradually changing. The afore-mentioned challenges which the industry continues to face have led managers to consider seriously the benefits of using CAD and IT systems to improve their business processes. There are also several demonstrable cases of successful IT usage in construction firms – this is galvanising those that have not yet 'taken the plunge' into action. However, what is desperately needed is a coherent, proactive approach. Some of the key elements of such an approach are described below.

4. TOWARDS A PROACTIVE APPROACH TO INNOVATION UPTAKE

There is an urgent need to improve the uptake of Construction IT innovations, as the construction industry stands to reap significant benefits from these. A multi-faceted and proactive approach is required, as no single solution will suffice. Some of the key elements of this should include: closer partnership between all the stakeholders – researchers, funding bodies, software developers, and industry practitioners; improving the usability of CAD and IT systems; improved research dissemination and marketing; the use of case studies; setting up of Construction IT resource centres for industry; and increased investment in Construction IT research.

Closer Partnership between Stakeholders

It is important that all the stakeholders (researchers, funding agencies, industry practitioners, software developers and other interested parties) work very closely together in the development of CAD and IT systems for the construction industry. This should cover all aspects of system development - from identifying target applications to system implementation and finally, validation and marketing. Without such a partnership, the existing gulf between research and industry application will be perpetuated with the industry unable to reap the full benefits of the available technology. All stakeholders should contribute to ensuring that the right projects are funded to meet the need for long-term strategic research and short-term near-market development work. They should also facilitate the development of appropriate tools by helping to identify target applications and being actively involved in the

system development process. The commitment of software developers is essential to the translation of promising research prototypes into commercial systems.

Improved Usability of Systems

There is also a need to improve the usability of CAD and IT systems, as the most technically proficient systems are only as good as their user-interfaces. The considerations outlined by [Anumba 1994] will be useful in this regard. In particular, the active involvement of end-users from the early stages of the system development process is a key to meeting their requirements and ensuring that they will use the systems when fully developed. Emergent technologies such as multimedia, virtual reality (VR), and voice/motion recognition have a role in improving user-interface design and should be used to good effect in ensuring the usability of Cad and IT systems for the construction industry.

Improved Dissemination and Marketing of Research Results

It is imperative that Construction IT researchers move from traditional academic research dissemination and exploitation routes to more industry-focused means. This should be based on a more aggressive strategy involving the conduct of demonstration workshops; the provision of 'demo' disks; securing of the endorsement of major firms (including, where appropriate, both consultants and contractors), key industry organisations (such as, in the UK, the Building Research Establishment, BRE, and the Construction Industry Research and Information Association, CIRIA), and professional bodies (such as the Institution of Civil Engineers, The Institution of Structural Engineers, the Royal Institution of British Architects, the Royal Institution of Chartered Surveyors, and the Chartered Institute of Building; as well as widespread dissemination through publications and presentations, and advertising. Use should also be made of the Internet, which could host a number of demonstration systems that industry practitioners can experiment with at their convenience. The systems themselves should be marketed as tools to aid the engineer in the execution of particular functions, without the unnecessary use of technical jargon and/or acronyms.

Use of Case Studies

Case studies of industry usage of CAD and IT systems have a major role to play in increasing industry uptake of Construction IT innovations. Practitioners are more likely to appreciate the merits of a system when its practical use in industry is properly documented, with full details of the problem being tackled, the background to the choice of a given system, the problems encountered in the use of the system, the benefits of using the system, and lessons learned. In workshop or seminar settings, they are more likely to believe other practitioners extolling the virtues of a given system than a researcher. Documentation of case studies of CAD and IT usage in industry is therefore urgently needed.

Setting up of Resource Centres

There is significant benefit in having Construction IT resource centres, which provide a forum for industry practitioners and researchers to exchange ideas on the development and use of CAD and IT systems in the construction industry. Practitioners with specific needs can also contact the centre to explore the availability of CAD and IT tools (or personnel) that may be able to help. The need for such centres is increasingly being recognised with several countries setting up national centres (e.g. The Construct IT Centre of Excellence in the UK). It is hoped

that, with time, such centres will be able to provide authoritative advice on aspects of Construction IT, as well as publish best practice guidelines on the effective deployment of CAD and IT systems within the construction industry.

Increased Investment in Construction IT

Both the quantity and quality of Construction IT research supported need to be increased if the uptake of Construction IT innovations is to improve. The close partnership between stakeholders mentioned earlier is vital in this regard. Funding bodies need to increase the amount of money available for Construction IT research as it is difficult, under the present dispensation, to undertake sustained fundamental research over a period of time, or to develop excellent research prototypes that software developers can commercialise. Recent efforts in Sweden (the IT-Bygg programme) and Finland (the VERA programme) are commendable in this regard. The industry also needs to increase the level of investment as the current token sums and 'staff time' invested are grossly inadequate. Where projects are too expensive for individual firms, they can go into partnership with other firms or make use of professional bodies and other industry groupings such as the Construction Clients Forum (CCF), the Association of Consulting Engineers (ACE) and the Major Contractors Group (MCG) in the UK.

5. SUMMARY AND CONCLUSIONS

Clearly, the construction industry's uptake of Construction IT innovations leaves much to be desired. There are several factors which contribute to this including the conservative culture of the industry, poor investment in Construction IT, poor dissemination of research results, poor marketing, inadequate user-interfaces of systems, mismatch between Construction IT innovations and industry need and poor uptake of promising research prototypes by software developers. The situation is changing for the better but much more still needs to be done. In particular, the construction industry needs to adopt a more proactive approach. The key elements of such an approach include close partnership between all stakeholders (i.e. research funding bodies, Construction IT researchers, industry practitioners, software developers, and other interested parties), improved dissemination and marketing of research results, the use of case studies, the setting up of Construction IT resource centres and increased investment in Construction IT by both industry and funding agencies. There is no doubt that the construction industry will adopt CAD and IT systems that have a demonstrably positive impact on their business processes. Researchers need to bear this in mind in seeking to increase the industry's uptake of their research results.

REFERENCES

Anumba C. J. (1994): 'Considerations in User-Interface Design for Knowledge-Based Systems', *Artificial Intelligence and Object-Oriented Approaches for Structural Engineering*, Topping B. H. V. & Papadrakakis M. (Eds.), Civil-Comp Press, Edinburgh, pp 47-51.

Bjork B. C. (1998): 'Information Technology in Construction: Domain Definition and Research Issues', *International Journal of Computer-Integrated Design and Construction* (in press).

Scott D. (1997): 'An Intelligent Approach to the Engineering Management of Housing Subsidence Cases', *PhD Thesis*, University of Teesside, March.

Watson A. S. & Anumba C. J. (1991): 'The Need for an Integrated 2D/3D CAD System in Structural Engineering', *Computers and Structures*, Vol. 41, No. 6, pp 1175-1182.