Building Systems Integration and the Implications for CAD Education

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- Use of computers in British architectural practice.
- The implications of information technology on the structure and working methods of the UK building industry.
- Implications for CAD education

Abstract

The author has been a member of two important U.K. reviews of construction computing (references [1] and [2]). The paper draws on these reports, other U.K. Government Reports and theoretical work on collaborative design undertaken at the University of Strathclyde to present an evaluation of Information Technology use in practice and its implications for education.

Summary of Key Proposals

Building IT 2005 [1]

- IT Strategies should be built on the progress already made by system suppliers, leading users and research and advisory bodies, by linking proven applications in a way that can demonstrate benefits.
- IT should be viewed as an enabler rather than a driver of change.
- Electronic Information exchange guidelines are needed on good practice, access to other networks, copyright, liability, conversion and verification.
- By 2005 clients will have direct access to project data and will expect teams to share this on serial contracts. They will buy services internationally.
- Intelligent agents should be developed to help individuals filter the electronic data which is sent to them or which is available on the Internet.
- If real progress is to be made in maximising the benefits of CAD, complete 3D component libraries, linked with OLE and interoperability standards, are needed.
- More construction documents should use multimedia and electronic publishing, especially user and maintenance manuals.

UK Technology Foresight: Construction [2]

- By 2005 most large clients organisations will use workstations to access design and engineering services.
- By 2010 most building will be designed and detailed in "virtual environments".

Construct IT [3]

- Integrated project communications framework based on a project database.
- Integrated industry-wide information to improve and inform construction projects.
- Specific improvements to the construction process, including better capture and appraisal of client requirements, integration of design and analysis and the supply chain.

Industry Problems

Whilst the above recommendations provide a focus for development, the communication and co-ordination between the divided segments of the construction industry remains the major obstacle to the integrated use of computer based design tools. Developments in building systems software have tended to imitate existing manual procedures and so have remained confined to particular sections of the design team. Such separate development can never resolve the problems of communication between the various individuals and organisations that constitute the project team. To blame the lack of international standards for data transfer is to miss the real problem: a complete re-evaluation of the industry structure is necessary.

Many companies still use IT to automate existing routine tasks (and in some cases consolidate inefficiency). Some tasks are not worth automating as they intensify existing poor practice. If IT is to be effective then business process innovation rather than business process improvement may be needed.

Feature	Improvement	Innovation
Level of change	Incremental	Radical
Starting point	Existing process	Clean slate
Frequency of change	Continuous	One time
Time required	Short	Long
Participation	Bottom-up	Top-down
Typical scope	Narrow, within functions	Broad, cross functional
Risk	Low	High
Primary enabler	Statistical control	IT

Table 1. Business Process Improvement and Innovation.

In summary:

- IT should be viewed as an enabler rather than the driver of change or the guardian of past practice
- IT as an enabler helps transmit, manipulate and display information in rapid and useful ways.
- IT should be viewed as a technology offering opportunities for "doing things better", for doing "better things", and for "doing new things".

Standards

Current standards work has concentrated on defining interface formats to enable data to be exchanged between program modules in the different sectors of the industry. However, the sectors and specialised organisations that currently make up the industry are not well defined - there are no clear lines of demarcation separating the industry into distinct and specialised functions. Indeed, several different categorisations are possible. For example, finance, design, manufacture, construction and operation, could define the construction process. Within this breakdown each sector is likely to have differing ideas of priorities: the developer may be seeking to minimise non-lettable space, the architect will be concerned with aesthetics, the engineers the servicing, and so on. Each of these broad sectors may themselves be subdivided: design may be subdivided into architecture, structures, mechanical, electrical, cost estimating, project management, and so on. Mechanical design may in turn be divided into heating, air conditioning, plumbing, fire protection, etc. This breakdown disguises the fact that all these endeavours are focused on the production of one object - the building. Formally approved standards are not the only relevant ones as many design teams adopt ad hoc "standards" from job to job.

Whole Industry Research

There is a lack of systems which can span the whole of the construction process for specific projects - from clients brief, through design, commissioning the contract, construction, final account, handing over, operation and maintenance. Significant gains may be expected from project-based systems which record and allow exchange of data between the parties involved and provide ready access to project databases for all parties. There are particular opportunities for innovative business process through data transfer. Business process innovation involves using IT to overcome fragmentation and elimination of interfaces leading to major efficiency gains through wider applications of IT. The UK has high construction costs compared to other EU countries and some of the lowest wage costs. The Latham Report [4] advised there should be 30% reduction in cost by 2000. Better collaboration between specialists could deliver it. Efficient capture, transfer and management of information will be seen as a core competence in the construction process. There are, however, legal implications of data ownership, sharing information and resulting liability responsibilities.

CAD was originally sold to architects as a productivity tool which would enable small practices to compete effectively against better resourced large practices and the design-construct companies. Currently a two-tier CAD market has developed with small scale systems being sold to individual architectural companies and big networked systems being sold to the large multidisciplinary practices. The

implications of this split are already becoming apparent. The competitive advantage that Information Technology offers a vertically integrated design and construction organisation is so great that the isolated practitioner is forced to operate in increasingly specialised "niche" markets. The larger companies, meanwhile, are forging links with construction companies and developing customised "integrated systems" for design and construction. The official standards will arrive too late to prevent the dominance of the market by those large organisations who have been organised enough to grasp this opportunity.

UK Technology Foresight: Construction [2] identifies the following technical requirements:

- Much greater application of business process to the whole construction project delivery.
- Re-definition of the information needs of clients, designers, suppliers and contractors.
- Re-design of organisational relationships and contractual arrangements to ensure maximum benefit from new technologies including remote working by professionals working from low cost premises.
- Development of co-ordinated and standardised information structure which will support information needs whilst avoiding collapse through information overload.
- Application of IT to the management of the process.
- New and more integrated approach to the training of construction personnel and clients.

Changing Culture and Work Practice

Business Process Engineering defines the overall business process and its key components and then looks for opportunities to improve it before seeking the enabling technologies to support it. Project-based systems which record and allow exchange of data between the parties involved and provide ready access to project databases for all parties are the key to re-engineering the construction process. The major problem in using a common database is Data Sharing. At the moment the different representations in computer applications are independent and, therefore, so are the presentation outputs. The data models underlying each system are disparate and the systems themselves have no clearly defined interfaces. System integration is thus limited and cannot reach a level where benefits accrue. Problems of information co-ordination and real co-ordination of work on site are the costly result. Even with an integrated data model the problem of differing views of the model remains. For example, What is a wall? To the Architect: a functional space divider, the finish of

which is important; Structural engineer: material, strength; HVAC engineer: environmental barrier Acoustic engineer: sound insulation Q.S: material quantities Builder: material procurement and erection Client: cost, time, quality. Application tools will filter and interpret the common information to suit different needs [5].

Integrated Communications

The most sophisticated approach is based on total automation of communication facilities. Different databases based on different hardware and software platforms can be linked in such a way that the communication network is largely invisible to the user. These differing collections of databases are called heterogeneous databases and the technical issues surrounding their co-operative use are called inter-operability. Four key issues arise:

- the architecture of the data necessary for integration
- the technology underlying integration
- the semantics of integration
- integration from the user point of view.

The key requirements of the database itself are:

- Persistency: data exists independent of any program that accesses the data.
- Resilience: the ability of the data to survive and recover from a number of types of specified failure.
- Access control: ensures the correct execution of concurrent transactions, thereby ensuring the integrity of the data.
- Efficiency: necessary because of the large size.

Object Oriented systems are likely to be used and the Object Management Group is developing standards. Even though the technical problems appear solvable a number of practical problems remain:

- Who will own the data stored in a single (i.e. common) database.
- who will be liable for the correctness, updating, etc. of such information.
- Who will maintain the security of the data and when might responsibility transfer.
- Who assures the quality.

IT Training

These points raise a number of issues related to IT training:

- As systems become more sophisticated more training is needed.
- The more IT systems become interactive and capable of processing diverse types of data, the more discipline is needed in the generating and structuring of information.
- The more rapidly IT systems support the integration of different disciplines the more need there is for interdisciplinary training.
- Unless integrated training is carried out is likely that the traditionally divided and disintegrated construction industry will go on using IT tools to exploit divisions rather than to overcome them.
- If training needs are to integrate the work of different disciplines using tools which support simultaneous information processing and exchange, then training methods must meet those needs.
- Training must therefore demonstrate how IT tools support trans-disciplinary working on projects.

Training is necessary at all levels in the industry. Given the state of IT experience generally there is a requirement for extensive CPD (Continuous Professional Development) training. Again the larger practices are taking the lead (Table 2).

Consultants	Partner	Team Leader	Prof Staff	Admin	Site Staff
% firms with any training	69%	66%	78%	27%	15%
Median of staff trained	65%	55%	72%	74%	11%
Median no of days training	3	3.5	5	3	2

Table 2. Levels of IT Training in Large UK Consultancies [6]

Training recommendations:

- Professional Institutions should increasingly structure their CPD requirements in a more integrated fashion.
- Professional CPD and in-service company career development could be linked with postgraduate education.
- Modularisation, distance learning, WWW, make networking and on-line access to various forms of training possible.

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