ICT Adoption in the Construction Sector: Education and Training Issues

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Summary

Organisational and human issues have been highlighted, among other issues (ICT infrastructures, legal and contractual, etc.), as key elements in enhancing the competitiveness of the construction sector. More specifically, the importance of human resources has been recognised, especially training and professional development, in order to cultivate a stable workforce. The paper provides a review of the key training needs for the construction sector with particular reference to the uptake and exploitation of new technologies and working practices, presents an action plan to address learning and training needs, and proposes an eight-stage iterative learning and training methodology. The results will be of particular interest to managers in stakeholder organisations of all sizes throughout the sector, plus academic and research bodies intending to continue construction ICT research.

1   Introduction

In a report concerned with enhancing the competitiveness of the construction sector, the Commission of the European Communities (1997) identified the key interrelated elements of competitiveness. Among other factors, the importance of organisational and human issues was highlighted. More specifically, the importance of human resources was recognised, noting the need for training and professional development, as well as effective health and safety measures, in order to develop a stable and well-educated workforce.

With this in mind, the work reported in this paper relates to the development of an action plan for education and training in the construction sector, carried out within the European funded ICCI (IST-2000-33022) cluster project. The general aim of the ICCI cluster was to improve harmonisation and coherency of research and development, and thereby to benefit efficiency in IST projects, assist knowledge transfer to industry, and reduce time to market of exploitation. ICCI acknowledged that deploying and using ICT in construction is nowadays less a matter of cutting edge technology than one of combining technology, organisation, marketing, legal frameworks and social considerations.

2   Context

There are many drivers for change in the construction sector. These include new technological developments, both those that are being developed specifically for the construction sector (such as the developments from the member projects in the ICCI cluster) and other more general developments in ICT, and the diffusion of new working practices such as partnering, knowledge management and the virtual enterprise (VE). By definition, these products of an RTD programme are at the cutting edge of technological development. Thus the prototypes developed

offer companies in the sector a vision of the competitive advantage and other possibilities that the future promises.

2.1 Developments in ICT

It is important to bear in mind that there are many factors which will influence the future characteristics of the construction industry, and that new technologies such as those being developed by RTD projects like ICCI represent only a small proportion of the ICT 'landscape' which will be widely available within the next five to ten years. Some of the current directions in ICT development influencing the construction sector are described elsewhere (Wilson and Rezgui, 2003). There is however a range of technologies which are likely to have an impact on the workplace in general, not just the construction sector, including:

- universal very high bandwidth network;
- portable, powerful personal computers;
- high quality virtual reality facilities at low prices;
- radio/wireless/mobile networking;
- advanced graphics & 3-D displays;
- reliable and flexible software components;
- cheap on-line computing;
- access to vast range of resources worldwide via the network.

2.2 New and emerging working practices

The technologies listed above will enable new working practices such as:

- web based communication infrastructures;
- mobile, flexible and remote working;
- new ways of creating and manipulating visual representations;
- extending the use of simulation /'what if?' analyses.

Further but parallel changes in working practices will come from the dissemination and uptake of good practice processes across the sector, as described in Wilson and Rezgui (2003) e.g.:

- partnering;
- model driven rather than document driven procedures;
- new procurement philosophies;
- "lifecycle thinking" – seamless transition through project phases.

The potential benefits of technical and process innovation in the construction sector can only be realised through individuals at all levels learning and developing new capabilities. Such capabilities will not, in the main, be developed through traditional training courses but through the creation of well-planned learning opportunities in a learning environment. For example, partnering arrangements offer significant benefits to all stakeholders, but these benefits will only be realised fully if individuals such as the supervisors, construction engineers and site workers understand their concepts and implications. This represents an enormous challenge within an organisation and will require an integrated change strategy for learning and training at corporate and at sectoral level.

3 Approach

The early work towards the development of an action plan for education and training included the derivation of an initial indication of training needs through synthesis of results from the ICCI consortium, together with a review of the relevant literature regarding training needs in the

construction sector. The next step included exposing this initial indication of training needs to validation and critical analysis by a forum of experts in human resource management and professional development in the construction sector, with a view to specifying the key training needs and devising a strategy to address those needs. This involved the following three activities: Development of task-based scenarios, Validation Workshop, and Development of an Action Plan for Learning and Training. These are described in the following sections.

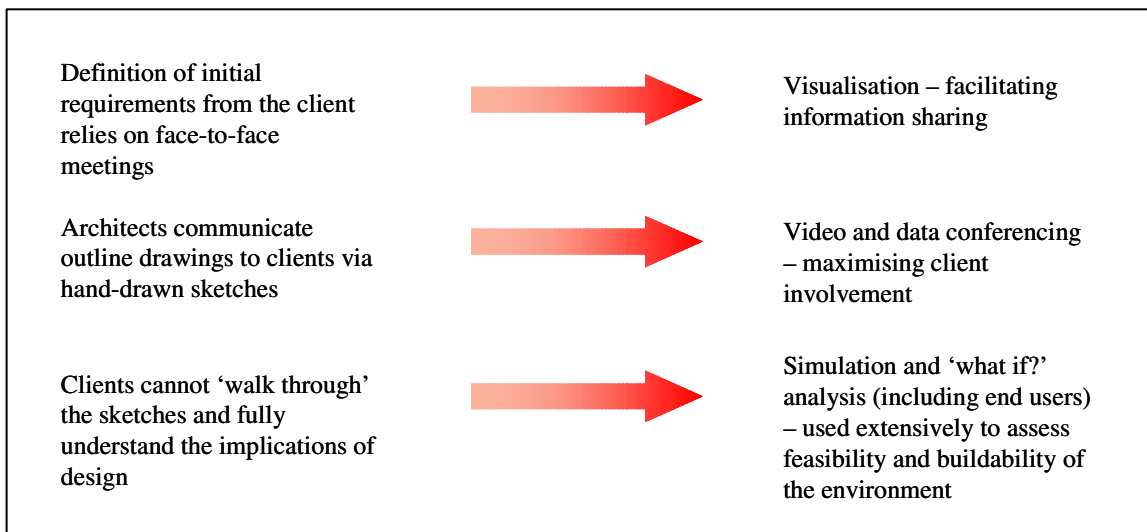## 3.1   Development of task-based scenarios

In order to exploit the potential of newly developed technologies, the construction industry will need to adopt new working practices. This may, in turn, require the development and deployment of new skills. In order for stakeholders to identify any new skill requirements and the associated learning and training needs, they need to be able to envisage the way in which the new technologies will work in practice. The technical demonstrations of advanced ICT developed in the ICCI cluster projects provided the basis for developing a number of future user task scenarios involving new technologies and new working practices. By comparing these scenarios with current tasks, future learning and training needs can be predicted.

Three scenarios were developed, focusing on three key parts of the construction process where chronic problems have been identified that cause the construction industry excessive amounts of expense and time wasting: client briefing and design, procurement, and facilities management. These were selected as they are critical areas where the construction industry has identified needs for process improvement, and consequently are areas upon which the individual ICCI member projects have focused. (For example, more specifically, client briefing and design featured heavily on the DiverCity project, procurement in the e-Construct project, and facilities management in the OSMOS project).
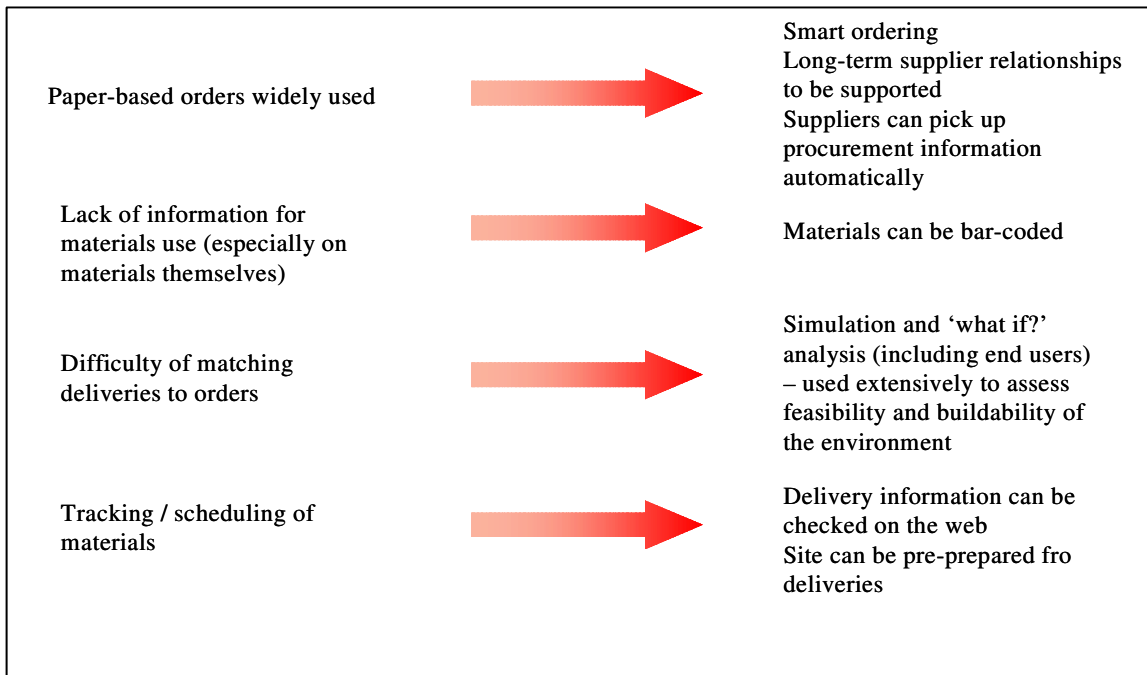
Features of the typical current ways of working are presented alongside the predicted new ways of working for each scenario.

The three scenarios developed were as follows:

Scenario 1 – Client Briefing and Design

Definition of initial requirements from the client relies on face-to-face meetings → Visualisation – facilitating information sharing

Architects communicate outline drawings to clients via hand-drawn sketches → Video and data conferencing – maximising client involvement

Clients cannot 'walk through' the sketches and fully understand the implications of design → Simulation and 'what if?' analysis (including end users) – used extensively to assess feasibility and buildability of the environment

Scenario 2 – Procurement

Paper-based orders widely used	→	Smart ordering Long-term supplier relationships to be supported Suppliers can pick up procurement information automatically
Lack of information for materials use (especially on materials themselves)	→	Materials can be bar-coded
Difficulty of matching deliveries to orders	→	Simulation and 'what if?' analysis (including end users) – used extensively to assess feasibility and buildability of the environment
Tracking / scheduling of materials	→	Delivery information can be checked on the web Site can be pre-prepared fro deliveries

Scenario 3 –Facilities Management

Lack of as-built information	→	The 'as-built' VR model to be handed over
Maintenance scheduling complex and not integrated into the building process	→	Model-based facilities management Automatic maintenance schedules
Manual regulation of components	→	Regulation of intelligent components
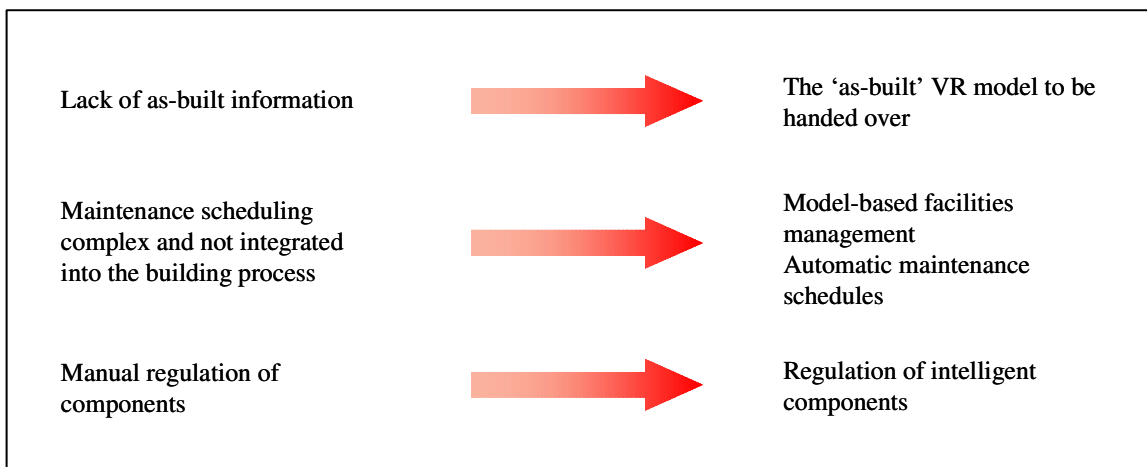
3.2   Validation Workshop and development of an Action Plan

A workshop was organised to which key stakeholders in strategic roles in leading companies in the construction sector were invited. The tasks of the participants were:

- to validate the initial analysis of training needs undertaken by the ICCI research team;
- to validate the future task scenarios derived from the ICCI cluster projects;
- to identify new roles and responsibilities arising from the use of new technologies and new working practices;
- to identify future education and training needs;

The final step was the development of the Action Plan for Learning and Training, informed by the two previous activities and by an analysis of current training provision within the construction sector. Further to this Action Plan, the ICCI Learning and Training Strategy has been formulated, both of which are described below.

4   Findings

4.1   Specification of learning and training needs

Analysis of the future task scenarios reveals two categories of skills requirements: skills essential to operate the technology per se and those skills necessary for the adoption of new ways of working.

4.1.1 Identification of new roles and responsibilities

The industry validation workshops revealed the need for new hybrid roles and new reward structures to support them. In particular, a serious shortage of people with understanding, knowledge and expertise in both IS and the construction sector was identified. This is thought by the industry experts to be primarily because the construction sector tends not to advertise IT posts and instead encourages 'home grown' IT competence. Once individuals become competent, the likelihood is that they will leave for software development and support roles elsewhere for higher levels of remuneration than are available in construction companies.

4.1.2 Analysis and Skills Mapping – between current and new roles

The deliberations of the validation workshops concluded that the real skill requirements for the future are to learn how to use ICT to achieve task objectives more effectively. Thus the focus should be on enhancing task performance and not on learning about specific operating systems or technologies per se. Hence, for example, individuals and their companies are likely to benefit more from learning how to use a spreadsheet with real proficiency than from learning the finer points of object technology.

In a skills mapping exercise, participants also concluded that information management is a core skill. Although managing information is crucial in the construction sector, in general its significance is not understood and the activity is not rewarded. Contractors in particular need to understand that this is central to their role and that the primary benefit of ICT is the enhanced capability it offers for managing information.

An area where expertise was thought to be in especially short supply related to provision of relevant ICT awareness and education. There was perceived to be a dearth of people able to convey relevant skills and understanding and this was regarded as a serious barrier to uptake of advanced ICT.

4.2   Identification of skills gaps

Analysis of the research results indicates skills gaps that can be identified in the construction sector. These skills gaps fall into six categories: General ICT literacy, 'Higher level' ICT operating skills, 'Higher level' specialist ICT skills, New conceptual models, Information & knowledge management, and Change management and culture change.

Effective exploitation and use of new technologies from research projects and other leading-edge ICT developments will obviously require training and support in the use of specific packages and applications. However, in the context of the general developments in ICT listed above, which imply that an increasing proportion of many jobs/tasks in construction will be computer-based, increasing numbers of employees will also require a general level of 'computer literacy' skills, e.g.

- selecting the most appropriate applications;
- setting up own workspace;
- personalising/customising applications;
- managing many-to-many communications;

- using data exchange;
- encryption – to use how and when;
- object manipulation;
- using VR technology;

Some, but not all, of these skills are currently covered by training courses and packages such as the European Computer Driving Licence (ECDL – www.ecdl.com), CLAITT etc.   Training courses to deliver these skills tend to be vocational and/or voluntary (i.e. undertaken for reasons of continuing personal development) and therefore at present there are evident skills gaps. However, ICT is now an integral part of the minimum curriculum in virtually all European countries. In March 2000, a survey carried out by the EU funded European Schoolnet project (http://www.eun.org/) reported on a number of national strategies. In Denmark ICT has to be integrated in all subjects from grade 1 to 12 where relevant. In Finland the curricula also require that all pupils in comprehensive schools shall acquire basic ICT skills, integrated in a variety of subjects. Media literacy shall become part of general Finnish education by the year 2004. Luxembourg has a "PC-Driving-Licence" for all students at the secondary school entry level. In the UK the national curriculum for all pupils aged 5-16 includes ICT now (in secondary school as a special subject) and the aim is to give most school leavers a good understanding of ICT.

Such initiatives should help to ensure that this skill gap is closed for new entrants to the const-ruction sector over the next 5-10 years, but there will remain skills gaps in this area for large numbers of existing employees. Participants at the validation workshop felt that internal (construction-company specific) training schemes and programmes currently gave insufficient priority to ICT related issues, with the result that existing operations staff are not fully trained in ICT. There was also perceived to be a shortage of trainers within the industry, so that more 'training of trainers' was also required to deliver the training that is needed.

Furthermore it was felt by participants that, while there needs to be a general basic level of ICT literacy for all employees in the sector, a construction-sector specific version of general ICT literacy training such as the ECDL would be useful.

There is a perception within the construction sector that senior management tend to be lacking in awareness of the available/forthcoming technologies and of the potential benefits of these technologies for process improvement and competitive advantage. Decision-making with regard to ICT investment and exploitation was perceived by participants to be influenced almost exclusively by the desire for lowering costs (reinforced by current approaches to contract letting in which 'lowest cost wins'), rather than value, and therefore activities are required which are targeted specifically at improving senior management awareness and education about ICT at a variety of levels.

Workshop participants also expressed the view that there will also be greater requirements for trained technical staff with ICT support skills, such as programming, network development and maintenance, website development and maintenance skills, database administrator skills, etc., to support the increased use of and dependency upon ICT both in the fixed workplace and for mobile workers and project sites.

The industry will also require individuals with skills in systems design and development to produce bespoke solutions. To deliver high quality, user-centred and effective systems, these individuals need to be trained in current best practice e.g. in Soft Systems methods, user-centred design approaches, and ergonomics/human factors.

Participants at the workshop felt that currently the most effective support came from individuals who had both high levels of ICT skills and construction-sector specific experience. Examples were cited to support this statement but it was noted that the sector currently has difficulty in

retaining individuals who do successfully acquire and exploit these 'hybrid' skills, in the face of higher pay and better employment conditions in other employment sectors.

Skill requirements for operating advanced ICT are identified as the ability to conduct the following functions:

- choose the relevant application
- set up own workspace and personalise the desktop etc.
- manage many-to-many communications
- use data exchange
- apply encryption appropriately
- use object manipulation
- use VR technology

4.3   Synthesis of training needs
The following figure summarises the key points from the research, indicating the individuals targeted for the identified categories of needs, potential mechanisms for the delivery of the required training, and important remarks.

Identified Training Needs:	Target for Training:	Potential Delivery Mechanisms:	Remarks:
General ICT literacy	Existing/new entrants, suppliers, customers; Senior managers	General education, in-house training/learning; Awareness raising	Within next decade, greater ICT priority; ICT developments
'Higher level' ICT operating skills	Project managers Project administration and support staff	In-house; ICT manufacturer/supplier provided; Tertiary edu.	Should desirably be construction-sector focused
'Higher level' specialist ICT skills	ICT developers/support staff; Specialists (CAD designers, architects)	Tertiary education; ICT manufacturer/supplier provided; in-house	Should desirably be construction-sector focused
New conceptual models	Existing employees; New entrants	Demonstrators/models of good practice; trials, simulations; CPD	Information/knowledge cascaded through org.; construction focused
Information & knowledge management	Existing employees; New entrants	In-house; Tertiary edu.; Demonstrators/models of good practice; CPD	Formal/taught skills, learning/developing & applying good practice
Change management and culture change	Management and senior management	Awareness raising; Training by specialists; Tertiary edu.; CPD	Specialist input procured to supply or develop within

Figure 1: Synthesis of training needs

5   Action plan: towards a learning sector
The training needs of the construction sector, and indeed those that would arise from implementation of the products and services developed within the ICCI member projects go far beyond HCI issues and the particularities of specific applications. The literature regarding training in construction (CICA, 2000; CRISP Consultancy Commission, 2000; DfEE, 2000) clearly shows that it is of strategic importance, and that the creation of not merely learning organisations, but a 'learning sector' is required.

Analysis of the results presented above indicated that the key points required in the creation of an action plan for accelerated learning fall into two major categories. Firstly there is a need to promote 'technology pull'. This will be achieved via the following four activities:

- Recognising that low cost high bandwidth, email and mobile phones are now powerful drivers for enhanced communication and data transmission. People throughout the industry want the benefits these relatively cheap and accessible technologies are seen to be offering.
- Achieving attitude and behavioural change through acknowledging and addressing fears: reluctance of decision-makers in organisations to respond to the increasing 'pull' appears to stem from fear of individuals who are not themselves confident with using the technologies others are demanding.
- Encouraging people 'to work smarter not harder'. This can be achieved in most organisations through identifying people who are interested in finding better ways of doing things and giving them opportunities to explore options and to introduce new methods and systems on a carefully monitored trial basis, as a preliminary to wider roll-out.
- Showcasing the benefits and commercial advantages of ICT to encourage 'pull' from contractors (peer pressure or performance comparisons with peers is particularly powerful, especially where competitors can be seen to be gaining significant advantage from using electronic means to conduct business processes.)

Secondly, there is a clear need to develop new models for ICT training, which are far more human and culture oriented than merely concentrating on the technology alone:

- Give priority to promoting ICT awareness and education amongst senior people
- Implement a culture change programme driven from the top that will create an environment in which new graduates can use and apply their ICT competence and proficiency to individual and commercial advantage.
- Promote awareness of soft systems methods – especially as a technique for effective user-centred requirements capture.
- Train customers and suppliers in three areas:
  1. basic functions of ICT
  2. construction-related skills
  3. advanced skills
- Develop relevant demonstrators to showcase the benefits of ICT to the sector.
- Address the frequently posed question "What's in it for me?"
- Improve quality of information management:
  - Promote awareness of the high costs of poor information management.
  - Encourage analysis of existing information, how it moves, how it is validated, how it is stored and disposed.
  - Encourage effective use of data (with the aim of doing things right first time)
  - Create understanding that the primary benefits of IT are in improved management of information.

6 The ICCI Learning and training strategy

As discussed above, the emergent problems in learning and training in the construction sector are due not only to a lack of technological training but also to a lack of familiarity with new methods of working. An eight-stage iterative learning and training methodology is proposed, which is illustrated in the following figure, and further detailed below.
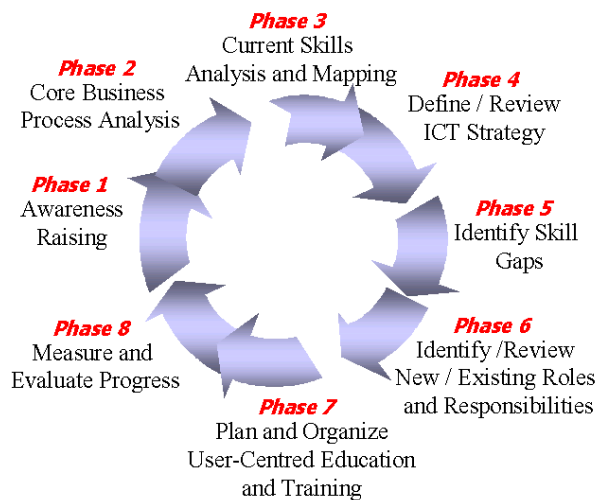
Figure 2: Proposed ICCI Learning and training methodology

The following is a brief expansion of the phases within the methodology:

Phase 1 – Awareness raising: This first phase is continuous throughout the whole lifecycle. Its purpose is to promote education and training awareness to company staff, including senior managers and decision-makers, and to develop a shared vision and commitment to a learning organisation culture.

Phase 2 – Core business process analysis: Any business process improvement initiative, including education and training, should build on a comprehensive understanding of both inter- and intra-organisation aspects. The key objectives of this stage are to understand the current company strategy, the organisational structure and culture, and the systems currently in use.

Phase 3 – Current skills analysis and mapping: The purpose of this phase is to provide a general picture of the capabilities and ICT literacy of the company staff, which will reveal indications regarding the level of maturity of the business processes described in the previous stage.

Phase 4 – Define / review ICT strategy: Most construction organisations tend to use ICT in an ad-hoc way. An ICT strategy should promote a culture supportive of a learning organisation. The purpose of this task is either to define an ICT strategy or to review the existing one in the light of ICT advances, and ensure that the education and learning dimension are fully supported and integrated.

Phase 5 – Identify skills gaps: There is a growing tendency for business processes to be partially or fully supported by ICT, yet there are obvious skill gaps in the sector due in part to a lack of education and training support within most organisations. This task will build on Phases 2, 3, and 4 to identify skill gaps within the organisation.

Phase 6 – Identify/review new/existing roles and responsibilities: There is an increasing need in construction to have new roles and reward structures. It is important to understand the skills required to perform a role and to ensure that individuals in charge receive the right training to perform their duties.

Phase 7 – Plan and organise user-centred education and training: Learning is an individual-istic characteristic, and people think and act as a result of what they have learned. There is a need to encourage people to work 'smarter, not harder'. This can be achieved in most organi-sations through identifying people who are interested in finding better ways of doing things and

giving them opportunities to explore options and to introduce new methods and systems on a carefully monitored trial basis, as a preliminary to wider roll-out.

Phase 8 – Measure and evaluate progress: The purpose of this phase is to put in place mechanisms to review the efficiency and effectiveness of the user-centred programme of training and education, and measure achieved business benefits. In order for an organisation to perform an evaluation process, success factors must be clearly defined.

7   Conclusion

The work carried out regarding human and organisational issues in the ICCI project allowed the research reported in this paper to be realised. The research indicates that the problems the construction sector faces with respect to training and education, still require attention, and indeed with continued development of advanced ICT will continue to do so. Through the process described in the paper, the ICCI team was able to validate the potential new working practices enabled by ICT, with key actors involved on a day-to-day basis in the industry.

In order to take advantage of the future vision enabled by the technologies being developed there are clear requirements for skills not only in terms of the technology but also the 'human' skills necessary for the adoption of new ways of working. Central to this is a strong need for new hybrid roles and new reward structures to support them, especially as the sector has difficulty in retaining individuals who do successfully acquire and exploit these 'hybrid' skills, in the face of higher pay and better employment conditions in other employment sectors.

In developing an action plan for accelerated learning and training there needs to be a promotion of technology 'pull', and development of far more human and culture oriented new models for ICT training. The authors feel that the ICCI learning and training methodology adequately addresses such human issues, and also the very real need for the 'training of trainers', but there is still a real need to continue the research carried out in the ICCI cluster project, preferably in projects taking a positive 'action research' approach with far greater practitioner involvement and evaluation.

8   References

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