THE IMPACT OF INTERNET ENABLED COMPUTER AIDED DESIGN (ICAD) IN CONSTRUCTION INDUSTRY

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Abstract. The advent of the Internet has opened up and given, particularly, the developing countries and the world in general, a transformation into collective intelligence (Levy, 1998) societies linked to digital communication (Rafi, 2001). Apart from large corporations, the rapid evolution of border-less communication has also synergise between the art and science expertise to form low-cost internet-based networks that have become multi-million dollar companies within a short period of time (e.g. Linux) (Rafi, 2001). In the context of architectural designs and construction industries, the birth of Internet-based CAD (iCAD) solutions has offered a new dimension to architectural practice. The function of CAD has expanded as a tool to communicate and collaborate as well as to better control all phases of the architectural practices. This paper will review the current available iCAD tools and explore the possible utilisation of iCAD in architectural practices. The opportunities for modifying current professional practice standards to best use iCAD will be rationalised as well as the elements in ensuring the effectiveness of iCAD implementation. The final component of the paper will be an evaluation framework to measure the value of iCAD in an architectural practice. The framework will become an early platform for an architectural practice to decide and plan their future in utilising and applying iCAD in the most efficient way.

1. Introduction to iCAD

Computer Aided Design (CAD) tools exist to design construction plans with a dimensional accuracy and clarity. Just as normal CAD, iCAD tools have the entire CAD features with a few value-added features (Day, 2001). The difference is that, unlike normal CAD, iCAD is supported with communications and collaboration tools (which is actually sharing of

knowledge and information) that were previously enabled by additional system called Computer Information Systems (Cornick, 1996). Unfortunately since it was a separated system, the architectural profession has largely ignored it despite professional realisation on clear advantages of the system (Cornick, 1996). The combination of CAD and CIS is empowered with the emergence of new technologies such as the Internet and Networking. The myriad data and information involved will be simultaneously recorded, up-dated and accessible by all the team members all the time, reducing much of the project cost and time cycles (Cohen, 2000). In this sense Internet enabled features are becoming a differentiate factor in architectural practice.

1.1. INTERNET ENABLED FEATURES

Green (2001), in analysing AutoCAD 2000i has divided Internet enabled features according to their centric functions: user-centric functions and collaborative-centric functions.

TABLE 1. Summary of Internet features in AutoCAD 2000i.

Function	Features	Featuring
User Centric	AutoCAD Today	Information access via a live browser connection
	Hyperlink dialog box	Insert hyperlinks into objects
	xref. support	Support for external references and drawing directories
	e-Transmit	Internet/email transmittal of work packages
	i-drop	Importing of drawing content from vendor sites
	Meet Now	Internet based training support
Collaborative/ Customer Centric	Publish to web	Electronic publishing/sharing of drawing files
	e-Plot	Electronic mark-up and draft printing of drawing modification
	Meet Now	Internet-facilitated meetings and conferences

As described in table 1, most of the features identified by Green are the features to enhance the communication and collaboration process via Internet; the closest competitor, ArchiCAD is developing Geometric Description Language (GDL) and Virtual Building as the platform for communication and collaboration, as reviewed by Day (2001) and summarised in Table 2 (the framework of table 1 is used for comparison purpose):

TABLE 2. *Summary of Internet features in ArchiCAD 7.0.*

Function	Features	Featuring
User Centric	GDL Central	GDL objects catalogues via a live browser connection
	Hyperlink dialog box	Insert hyperlinks into GDL objects and drawing objects
	Project Publisher	Internet/email transmittal of work packages
	GDL drag and drop	Importing of GDL objects from GDL Central or vendor sites
Collaborative/ Customer Centric	Object Publisher and Project Viewer	Electronic publishing/sharing of drawing files
	Project Publisher	Draft printing of drawing modification
	Project Mark-up	Electronic mark-up and redlining

1.2. INTERNET COLLABORATION TECHNOLOGY

Besides the new iCAD features, there are a few Internet collaboration technologies that have been developed and are available on-line, with the intentions to surface the iCAD benefits and match them with the real-world architectural problems. The technologies are not part of the iCAD, but are part of the infrastructure that supports collaboration via Internet; Exchange (Virtual Marketplace), Extranets (Project Collaboration Network), Internet Portals, Vertical Portals (Vortals), [5]Video Conferencing and [6]Application Service Provider. Application Service Provider (ASP) is the most comprehensive technology that supports collaboration and communication via Internet (Laiserin, 2001). The integrated project database capability offered by ASP is the most promising solution for the architectural practice, as they face the changes in their roles (which will be discussed in change of architect roles) since it virtually integrates the Computer Information System (CIS) into iCAD.

2. Applications and Impacts of iCAD

This section will describe the application of iCAD in architectural practice (with focus to the less explored area), and explain the changes and impacts of the iCAD application. Five layers have been identified in the analysis (i.e. in reference to architectural practice phases) namely Program/Brief, Design Development, Working Drawing, Contract Document, and Construction.

2.1. PROGRAM/ BRIEF PHASE

The current usage of CAD in the brief phase is minimal due to the uncertainty of the project being continued into the next phase. There is opportunity to use iCAD at this phase especially in identifying client/market's requirements and the information in justifying a design intention/rationales. Growing numbers of clients may have their own computer-based system to support their businesses. They would appear to have adequately described their business operations and activities in order for architects to directly translate them into a briefing for building/spaces. Geographic Information System (GIS) can be manipulated in providing the spatial and descriptive information on the site and it's surroundings. The public interest and government regulation will be implemented at the earliest stage of a design/construction process.

2.2. DESIGN DEVELOPMENT PHASE

The use of information in this phase is unquestionable. The ubiquitous information and data in the Internet might be the most well-known Internet benefit. The sharing of information and knowledge exchange will speed up the design cycle (e.g. information on new material and construction technique) The advent of information/knowledge management will help architect to concentrate in design with less resistance. The design feedback/approval from the government, statutory bodies, client and even the community will be much faster and more accurate. The process of conceptualisation, visualisation and expression will be an interactive process. In a boarder sense, architects will not just achieve a better design with the use of iCAD, but will also enable them to contribute to the expanding collection of data, information and knowledge.

2.3. WORKING DRAWING PHASE

The use of iCAD in the working drawing phase is able to reduce the time and cost of multiple drawing production, printing and delivery. The new features, such as inserting hyperlinks are promising improvement in the quality of information in terms of accuracy and authoritativeness. For the other consultants, their decision-making and calculation will be more accurate since most of the information required by them is linked to the object in the drawing (even for the case of new material and new construction method). This is supported with the new Internet technology which makes collaboration is much easier.

2.4. CONTRACT DOCUMENT PHASE

The use of iCAD will simplify the bidding and procurement paper trail (i.e. tender can be offered, managed and received via Internet). The project management planning such as material, human resource and machine availability can be justified earlier. There is opportunity for the supplier and manufacturer to project the market demand beforehand. These facilities will help architects and clients to reduce the variation order and possibilities of project delay.

2.5. CONSTRUCTION PHASE

The most promising Internet technology at this phase might be the capabilities to monitor project from distance. A few cameras will be located at the construction site. Any changes that are varied from the tender document can be recorded and all the parties involve can be alerted simultaneously, the instruction from the architect and other consultant can be validated instantly. The integration of iCAD with project management software (currently available in web-based) will help a lot in improving the construction site quality of work.

3. New Roles for Architectural Practice

According to Architect Code of Professional Conduct, there are a few special skills of a professional architect, which are capabilities to create, design, plan, manage and supervise construction project (PAM, 1996). The use of iCAD is calling for a new communication and collaboration skills, which were not mentioned since it is considered as the common skills in any business area. This section will try to describe a few views on the new roles of architectural practice.

3.1. CHANGE OF ARCHITECT ROLES

In international scenarios, American Institute of Architect (AIA) in their Governance Policies, set out a vision in which practitioners will increasingly be called upon to manage complex set of interwoven professional relationship (Laiserin, 2001). They also envisage architect to assume a central role of facilitator and integrator of the knowledge and disciplines needed. Royal Institute of British Architect (RIBA) in the Guidance Notes for School of Architecture on Examinations in Professional Practice (1998) has emphasised the importance of communication and collaboration in architectural practice as being outlined in the syllabus. From the knowledge

economy (k-economy) point of view, architects are becoming knowledge managers where knowledge management is considered as new skill, which has to be mastered by them. In order to play this new role, architect has to be able to facilitate collaborative working members of a construction project team and allows consistent integration of all project data as well as greater data integrity. The adoption of iCAD might be utilised to equip architectural practice in facing the new challenges as a knowledge manager since most of the new iCAD features deal with CIS.

3.2. NEED FOR CHANGES IN ARCHITECTURAL PRACTICE SYSTEM

More than ever, architectural practices face the challenge of improving business processes to produce the results internal and external consumers want. The next stumbling block towards maximum manipulation of iCAD is might be not the technology, but rather the willingness of architectural practice to review the procedures by which they do work and willingness to revise existing procedures as well as allocation for Information Technology development (Cohen, 2000). There are three identified elements that need extra attention from architectural practice in order to ensure the system works properly namely Participant, Information and Technology. It should be noted that the concentration should be on how work is being done using iCAD rather than the technology itself, and the balance between the respective elements. The whole system of architectural practice business process and the construction industry environment might need to be reviewed to achieve full potential of iCAD, including the preparation of an evaluation framework to assist them in preparing for the changes.

4. Evaluation Framework

The evaluation framework is primarily developed to find balance according to the need of each practice. The need is determined by the strategic mission of a practice. The gap between the strategic mission and the actual practice's competencies can be identified as a strategic gap that needs to be faced by a practice. There should be a link between the architectural practice elements with the practice structure as well as with the environment. Strategic Structure is representing the new form of architectural practice where all the alignments will meet and the strategic gap will be filled (figure 1).
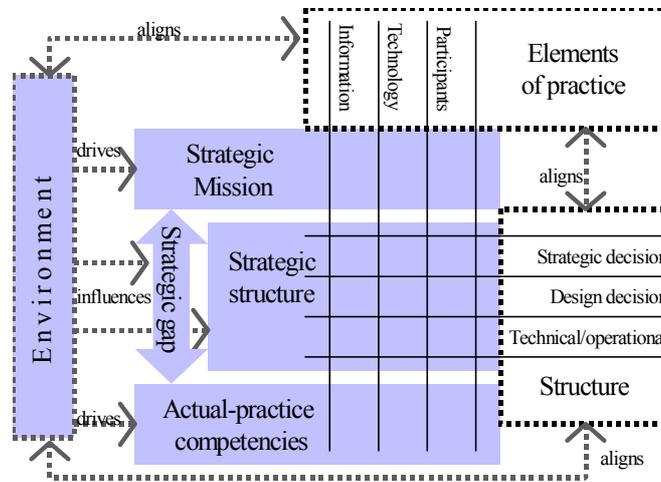
Figure 1. Defining and aligning the strategic mission with the actual-practice's elements.

The process will provide feedback and new synthesis (due to the dynamic of knowledge and technology). The use of iCAD will help architectural practice to go through the process since iCAD is capable to receive, record, store and help architects to manage the information. Architectural practice as well as construction industry should manipulate the information in order to remain innovative in facing the ever-changing business environment.

5. Conclusion

The introduction of iCAD has a great impact on the construction industry. Architectural practices have to revise their roles as a knowledge manager primarily to gain new knowledge and skills. The utilisation of iCAD is part of the tools and powerful for the architects in realising their new role since iCAD as virtually embedded in CIS. There are also calls for architects to continuously revise their strategic mission, skills, technology and knowledge to remain competitive in the industry. The evaluation framework will help architectural practice to set-up a learning-organisation and iCAD once again will become an essential tool in enabling architectural practice to face the wave of changes.

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