

A THREE LEVEL APPROACH FOR EXPLORING THE ICT IMPACT ON THE BUILDING DESIGN PROCESS.

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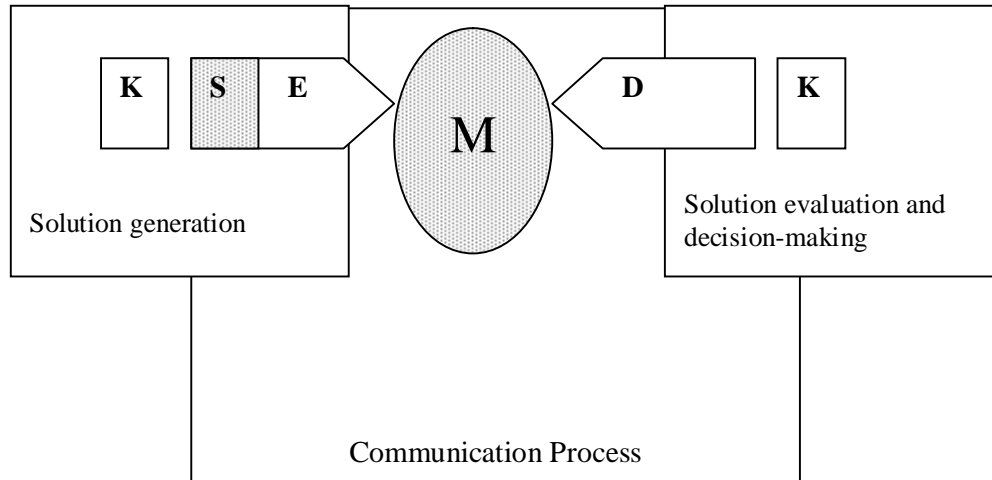
Abstract

The success of a building project is a function of a good design process. Over the years, the impact of ICT has led to dramatic changes within the construction industry. An understanding of how ICT influence on the building design process and the architects' role and contribution within it can be crucial for the building project success. This paper introduces a possible approach of organizing and structuring design process, actions and roles and how ICT impact on them. This approach is based on the definition of three building project levels and how they could contribute to a better overview of how ICT impact on the building design process. The aim of this paper is to illustrate how this approach can be used to explore the impact on a real life project. It concluded by recommending the development of user interface in IT code with various appropriate ICT tools for all stakeholders in building industry for a better productivity.

Introduction

A fundamental pillar of a successful building project is a good design process. The future and development of a good architectural design solution depends on complex and iterative processes on several levels and with different actors. Over the years, the ICT impact has led to dramatic changes within the construction sector average working day, especially the network technologies such as internet and e-mails, and the development of advanced visualization and CAD systems, such as virtual reality and building information models (BIM) have had and will further have an impact on both processes and role definitions (Wikforss, 2003). The participants within the building design process face ICT related benefits and challenges at several levels. The architect has a distinct and important role within the building design process (Gray and Huges,2001). His skills makes him adaptable for several roles from being a design specialist, translating the many project constraints into physical form, to being a design generalist, leading, coordinating and administrating the design process as the building design-or even the project manager. An understanding of how ICT impacts the building design process and the architect's role and contribution within it can be crucial for ensuring building project success, due to quality, time and cost.

This paper introduces a possible approach of organizing and structuring design process actions and roles, and how ICT impact them. This approach is based on the recognition of three levels within a building project. The intention behind this approach is not to force aspects of the complex architectural design into rigid categories; rather it aims to contribute to a better overview of how ICT impact on the building design process in general and on the architect's role and contribution in particular. The paper focuses on four essential aspects of the design process: the generation of design solutions, the communication, and the evaluation of design solutions and the decision-making. These four aspects are highly interdependent and iterative, as figure 1 sees to illustrate. The illustration is among others based on Kalay's description of the communication process (Kalay, 2004).



K = Knowledge, S = Sender, E = Encode, M = Message, D=Decode, R = Receive
Fig. 1. Illustration of the relationship between the four selected architectural design aspects.

The first outline of the three-level approach is based on the exploration of recent literature and research within the area. The aim of this paper is to illustrate how this approach can be used to explore the ICT impact on a real-life project. This paper and the three-level approach contribute to a framework for further inquiry about the relation between ICT and the architect’s role and contribution within the building design process.

Introducing the Three-Level-Approach

Three levels of operations and actions can eventually be recognized within the building design process. As a first overview of the three levels: the micro-level comprises individual and cognitive processes, based on what is going on in the head of the individual. The meso-level covers the mechanisms within a group and the macro-level comprises the mechanisms on overall organizational or sector level.

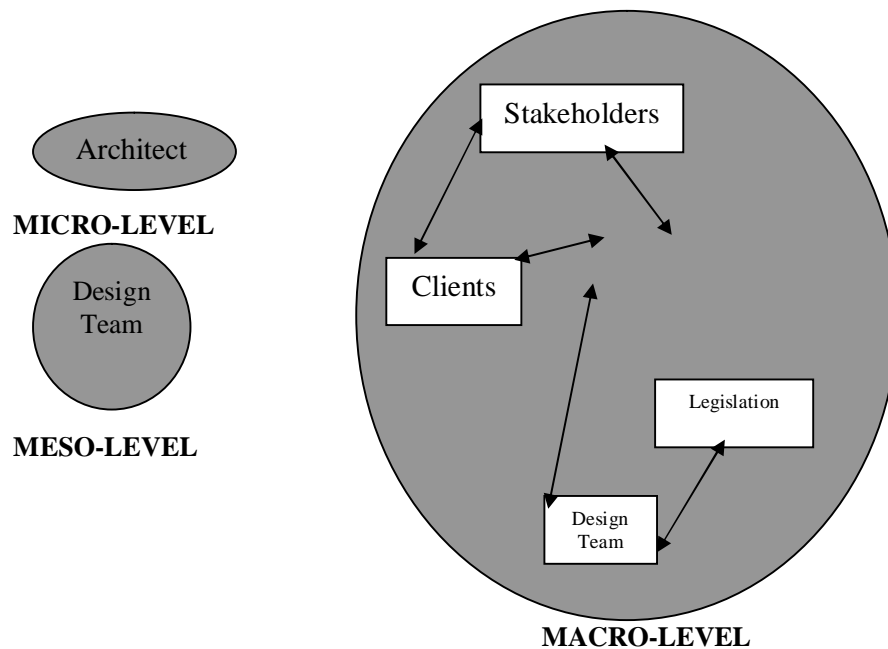


Figure 2: Illustration of the three levels within a building project

Different types of theories, as for instance individual theories (micro-level), group theories (meso-level), and organizational theories (macro-level) can be used to illustrate the processes on the different levels.

Many individuals are involved in a building project each communicating, making decisions and taking actions based on 'something going on in their head'. Each of these individuals is himself a micro-level, as the client, the architect, the mechanical consultant and the manufacturer. However, at the same time, every individual operates within one or several contexts. The client is an individual operating within his own organization (meso-level) and within the overall project context (macro-level). The three-level-approach could thus be applied on different situations with focus on different individuals. The chosen individual can be the filter for defining the other levels. In this case, the chosen individual and the filter is the architect. Thus, in this paper, the micro-level is illustrated by the individual architect generating his ideas, the meso-level by the design team in which the architect interacts and the macro-level by the overall building project context and frame around the design process.

The architect could be seen to have different roles and contributions on the different levels. The creative processes in the head of the individual architect take place on a micro-level. Within a meso-level context or the design team, the architect has to interact with other designers and consultants, as a design specialist and a hierarchical equal participant, or as a design generalist with responsibilities within coordination and leading of the group. On the macro-level, the role and 'visibility' of the architect depends on his function on the two other levels.

In an unpublished paper written for the CIB symposium 'Combining Forces' in June 2005, a literature based on exploring of ICT related benefits and challenges within four essential aspects of the design process: the generation of design solutions, the communication, the evaluation of design solutions and the decision-making, was presented. An ICT impact matrix, based on the three-level approach, was introduced as a frame for summarizing and gaining overview of the theoretical topic explored (Moum, 2005).

The Micro-Level

The micro-level is in this paper illustrated by the architect's individual development of design solutions. According to Lawson (1997), the design process is a simultaneous learning about the nature of the problem and the range of the possible solutions with no clear distinction between problem and solution, analysis, synthesis or evaluation in the design process. The designer juggles with several ideas at the same time without forcing a premature precision or decision. Schon (1991) described the design practice (e.g sketching) as a conversation or reflective dialogue between the designer and the design situation or design issue. The designer conversation with the design situation allows a fluid thinking process without constraints like disturbing accuracy. The designer's conversation with the drawing or what Kalay (2004) calls ideation or an intra-process role of communication are examples of micro processes.



Figure 3: How do ICT impact on Micro-level?

The Meso-Level

The group processes within the design team illustrate actions on the meso-level heavily based on collaboration and communication, taking into account different constraints set for the project which leads to the primary idea develops within a group context into something that can become the conceptual fundamental of the building project.

The importance of collaboration is growing, as globalization and increasingly complex technique and products require more teamwork, and the complexity of the problem becomes unmanageable for one individual. Barrow, (2000) introduces the term Cybernetic Architecture, which he explains as a ‘collective body; body of knowledge and specialty skills found in many individuals. The focus changes from the individual to the collaborative design process and this introduces a challenging dimension in the idea finding process: the interaction between the individual and the group Lawson (1997).

Successful teamwork is among others based on shared understanding. If the group participants have similar background and a common base of experiences, with the opportunity to learn about each other over time, to communicate, share information and to develop a team spirit, this will be ideal conditions to ensure a shared understanding of goals and tasks (Hinds and Weisband, 2003). Within a design team, much of these will not be the case. The actors come from different companies and organizations, have different interests and experiences, have often never worked together before and will perhaps never work together again. However, the project team consisting of specialists with different competencies, as architects and consultants, has a long tradition, especially by middle-sized and large projects. Hence, handling team processes and communication is nothing new for the building process participants. The degree of shared understanding as the basis for a good teamwork can on the one hand be seen to depend on the skills of the manager, such as the facilitating and monitoring of the information exchange and interpretation (Cramton & Orvis, 2003). On the other hand, the informal ‘rules’ of how to structure the building process, partly defined in different professional guideline as the German HOAI (Honorarordnung für Architekten und Ingenieure) or the Norwegian AY (Aritetytelse), contributes to establish routines and an understanding of the work to be done.

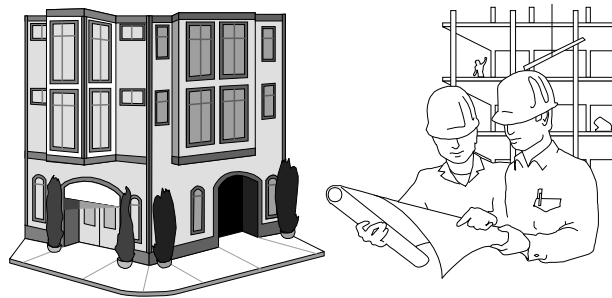


Figure 4: How do ICT impact on meso-level and the architect’s role and contribution within it?

ICT Impact at Meso Level

Decisions made at the early stage of a product development process, the design process, have severe influences on the quality of the product (Cohen, 1995). This is a common phenomenon of projects in any domain including the building sector because design is a decision instrument to express product features and production information (Boveret and BFR, 1994) and (Formoso et al., 1998) .To improve the design process performance, numerous initiatives have been taken including the partnering concept with its focus on stimulating collaboration amongst the stakeholders from the beginning of a project.

Establishing shared value particularly in the context of project related knowledge tends to improve collaboration amongst stakeholders and therefore allow them to make fast and accurate decisions at the early stage of design in order to reduce the potential negative costly impact on the later stages.

Developing a mechanism to manipulate (capture, store, search, retrieve) knowledge generated from experiences has been of interest since the realization that people and knowledge are the

most important strategic resources of an organization (Fruchter, 2002). The fast developing information and communication technology (ICT) tends to expedite the research progress in this area by contributing ICT tools that comprises collaborative features such as co-editing, co-browsing, etc. systems enhanced with technology as such have been used by various professional domains, including the building sector, tempting to manage the existing information base among design team.

Problem Definition and ICT Solution

The early stage of a building project is usually referred to as activities that start from client briefing to conceptual design and are inherently iterative. Data and information generated at this stage such as briefing notes and sketches are mainly informal and not well structured but important to reflect the tacit design knowledge and possibly documented as design rationale. Such weakly structured information is not less important than the structured one such as the final drawings and reports that are generated at the end of every meeting. Likewise the tacit and explicit knowledge (Nonaka and Takeuchi, 1995). It is an uneasy task to integrate both the weakly –and–well–structured information from the perspective of traditional knowledge management (Fensel et al 2002).

The building industry is very project-oriented in nature and it is organized on actor streams wherein actors are involved in several projects at the same time (Zarli et al, 2002). Actors involved in the same project are sometimes thousand miles apart and practicing different working methods in accordance with their respective roles. In addition, most projects can be characterized as virtual organizations that are only established for the duration of a contract with temporary and often short-term business relationships (Zarli et al., 2002). All of these factors have created the dilemma upon the building sector that extra resources are required respectively to manage each project. Consequently, the project related machine stored knowledge would no longer be contained in one centralized repository but distributed in heterogeneous databases that belong to different individuals, discipline groups, project teams and organizations. Even though the concurrent ICT enables the formation of virtual project team that can work across geographical and time constraints through virtual workspaces integrating the heterogeneous information sources particularly ones that contain weakly structured information remain an uneasy task in the building sector. The widely use of low-level technologies mostly adhering to hyperlinks and keywords search (Ding et al., 2003) and lack of Meta level data structures (Christianson, 1998) is the main reason behind this non-integrating phenomenon.

The Macro-Level

The design team is a part of an overall context, the macro-level. The building project comprises many organizations, representing different interests. The client organization, the users, the building authorities and the contractors are some of the actors, which establish the overall building project frame and the constraints and requirements influencing the design process. Decisions are made on all three levels. The architect will on the micro-level make his decisions about which design solutions are worth being put on the paper. But on the macro-level the client will be responsible for the crucial decisions regarding which proposed concept should be developed further.

There are several challenges due to decision-making within the field of architecture. The building design process is in addition to the measurable, quantitative and conscious based on the qualitative, intuitive and tacit (Kiviniemi, 2004), (Lawson, 1997). Explicit knowledge can be articulated and is thus accessible to others while tacit knowledge cannot be articulated (Griffith et al., 2003). Wittgenstein's language game theory is one illustration of this problem area (Lundequist,1992). The crucial question within evaluation of design solutions is how to measure or judge the qualitative, tacit and intuitive aspects? "Is it possible to say that one design is better than another and, if so, by how much?" (Lawson, 1997), p.62. The client's understanding of the qualitative aspects depends essentially on the communicative skills of the architect and the design team.

Failed communication can cause conflicts and misunderstandings, negatively influencing the building project if not recognized and solved at an early stage. As illustrated in figure 1, the sending and receiving of a message (e.g design solution) depends on the competence, knowledge and previous experiences of the participants in the communication process. The architect must encode the design solution in the form of some symbolic language, which is then transmitted, through a suitable medium (e.g paper drawing scale 1:100), to the client, which must decode the design solution to understand it. Both the client and the architect decode and encode information based on their knowledge, or

frame of reference Kalay, (2005). If the client does not know the symbolic meaning, or what level of abstraction used, he will not understand what the architect or the design team tries to communicate.

These were some theoretical key points related to each of the three levels, which seem to inherit different challenges and difficulties to be handled. Processes and actions on all three levels could be seen to impact on the successful design process and the generation and development of good design ideas.

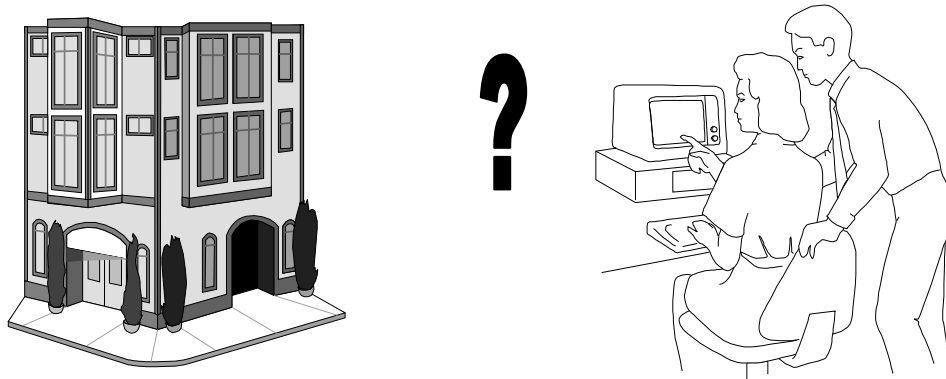


Figure 5: How do ICT impact on macro-level and the architect's role and contribution within it?

Semantic Web in the Building Sector-A Pedestal of ICT Impact at Macro-Level

To maintain its competitiveness, the building sector must progress in parallel with the e-commerce sector to face the challenges of paradigm shift with respect to the use of the innovative ICT as well as the strategy of ontologies. To date, the favourable collaboration ICT tools in the building sector are the project extranets (project websites), workflow management tools and groupware application for collaborative working.

Project extranet builds on client-server and web browser technology to enable distributed project team members to share, view and comment on project-relevant information. This tool is still widely implemented though limitations from its purely document-centric characteristic and limited workflow support have been identified. To overcome the limitations of project extranet is somehow necessary to accommodate the increase of information generated throughout the building life, in particular in the early creative design phase wherein fragmented design knowledge capture is of importance. The use of diverse professional languages impairs communication amongst stakeholders while provoking them to the possibilities of misunderstanding. After being aware of the potential impact, the building sector has taken numerous initiatives to broaden the horizon of communication capabilities that are supported by the Internet, and therefore lead to a change of paradigm.

“In this aspect several EC funded projects have been conducted to provide the building sector a stepping-stone on the path of paradigm-shift. For example, Diversity, which is a project that aims at supporting and enhancing concurrent engineering practices through allowing teams based in different geographical location to collaboratively design, test and validate shared virtual prototypes (Christiansson et al., 2002), and e-Construct, a project with the aim to improve internet-based communication in e-Commerce and e-Business, in the context of communication across national and organization barriers. Solutions for transferring and sharing knowledge across ICT systems are therefore the focus of e-Construct. To achieve the objective, a common communication-oriented language, namely the XML has been defined based on Extensible Mark-up Language (XML) with building construction meaning aimed at e-Commerce transactions (Construct, 2001). E-COGNOS, which aims at offering a generic, modular and open solution for knowledge management in the context of collaboration between actors in a construction project (e-COGNOS, 2001) started in year 2001. To summarize, the insights of these examples imply that there is an evolution tendency from the document-centric Internet to a meaning centric Semantic Web. This shift in focus may meet the

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requirement of knowledge management practices in the building sector, which is mostly informal and people-centered wherein abstract concept and meaning are of interest.

Conclusion

The three-level approach is a conceptual system that aims at enhancing collaboration amongst key stakeholders in order to improve the efficiency and effectiveness of the early design process of a building project via the use of Semantic Web. Shared value build between project stakeholders supports the decision-making process, which is crucial particularly at the early design stage. Common workspace and information sources form the basis for conducting collaborative activities, and thus play a vital role in establishing shared values. The functionalities of the above-discussed Semantic Web based knowledge management system are apparently contributable to this goal. The developing prototype system provides a more user-friendly environment as all sorts of information can be annotated.

Recommendation

The following recommendations are made:

- i. In view of the dilemma of knowledge management that the building sector is facing, a lightweight ontology based prototype system must be developed by Architectural firms and other stakeholders in building industry.
- ii. The need to develop user interface in IT-CODE for composing more complex query in design process. The IT-CODE with various appropriate ICT tools linked will enable the creation of semi-structured information such as sketches, client requirements in digital format. IT-CODE provides a virtual meeting environment that is Internet accessible and will allow the meeting context to be recorded and efficiently reusable to provide the users with knowledge of the decision intent and rationale. The knowledge management prototype system plays the role of managing semi-structured information that is neglected by most of the conventional archive mechanism.

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