What did you learn from practice today? Exploring experiences from a Danish R&D effort in digital construction

Anita Moum [a,*], Christian Koch [b], Tore I. Haugen [a]

[a] Department of Architectural Design and Management, Faculty of Architecture and Fine Art, Norwegian University of Science and Technology, Alfred Getz v. 3, NO-7491 Trondheim, Norway
[b] Institute of Business and Technology, Aarhus University, Denmark

ARTICLE INFO

ABSTRACT

The Architecture-Engineering-Construction (AEC) industry has been slow in turning the potential of Information and Communication Technologies into greater efficiency and productivity. This is a phenomenon which can be observed in many countries, and in Denmark this issue has been recognized as a major problem for the further development of the AEC industry. The public–private and nationally funded R&D program 'Digital Construction' was initiated in 2003 to establish a common platform for exchanging digital information and stimulating digital integration in the Danish AEC industry. This paper reports on the lessons learned from developing strategies, demands and guidelines in the 'Digital Construction' program and from adapting one of its 'digital foundations', the '3D Working Method', to the design process of the large-scale building project 'The Icelandic National Concert and Conference Centre'. The explorations are based on a process evaluation of the R&D program and a qualitative case study of the building project. The paper reports on identified factors enabling or hindering the adaptation, as well as on the benefits and challenges experienced from using and exchanging 3D object models according to the '3D Working Method'. The paper concludes that the adaptation has been successful due to the initial ambitions of the project actors. Nevertheless, there are still many challenges to be overcome. The findings indicate that the introduction of the '3D Working Method' to the real-life project depended on the success of balancing an array of the factors identified across the R&D program and the different levels within the building project. Three especially crucial balancing acts are explored; first, the power of the 'implementer' versus the expected risk and benefits of implementation, second, the strategies and guidelines within the program versus the resources for learning and the organizational traditions for using digital tools, and third, the level of ambition versus the skills of the users and the potential of the technology to address real-life practice. Mastering these balancing acts requires a broad understanding of both the project and its context. The findings from qualitative and holistic studies as presented in this paper are valuable for building such understanding, and for further learning and improvement regarding strategies for integrating ICT in architectural and engineering practice.

1. Introduction

Information and Communication Technologies (ICT) are commonly linked to future prosperity and growth in a number of European countries. Nevertheless, compared to other industries, the Architecture-Engineering-Construction (AEC) industry lags behind when it comes to the successful implementation of ICT and in turning the potential of the new technologies into greater efficiency and quality [1,2]. The productivity status in the AEC industry described in the Latham report in 1994 [3], still gives rise to concerns. Several international and national initiatives and consortia working on the integration of ICT into the AEC industry have emerged in recent years [4]. In Denmark, the national R&D program 'Det Digitale Byggeri' (Digital Construction), co-funded by public and private sources, was initiated in 2003 to establish a common platform for exchanging digital information and stimulating digital integration in the Danish AEC industry [5]. While the R&D program came to an end in March 2007, it has been followed by an ongoing implementation effort, which started in 2005. Where Tom Paxton's old song 'What did you learn in school today' refers to the slow and insufficient learning of children, the contemporary AEC industry has to learn at a much faster pace and at a rate beyond the single project's timescales. Learning becomes ubiquitous and large scale R&D programs, as well as real-life practice, are contexts we need to learn from.

Alongside the increasing focus within the AEC industry on implementation of ICT through the establishment of R&D efforts on national and international level, there is a growing interest among several research communities in the experiences gained

* Corresponding author. Tel.: +47 73550568; fax: +47 73595359.
E-mail addresses: anita.moum@ntnu.no, anita.moum@sintef.no (A. Moum), christian@hih.au.dk (C. Koch), tore.haugen@ntnu.no (T.I. Haugen).

from applying new technologies to practice. Howard and Björk [6] are reporting from a qualitative study on experts' views on Building Information Modeling (BIM) and industry deployment. Khanzode et al. [7], Ku et al. [8] and Manning and Messner [9] are dealing with the results from case-based research related to building projects adapting 3D/4D tools and BIM. These are some out of several examples of interesting studies of practice – however, either focusing on the AEC-industry and implementation strategies on general level, or based on experiences made from adapting ICT to single building projects.

What are the factors affecting the implementation and use of ICT in practice, while considering both the R&D activities on international or national AEC-level, as well as the experiences made in real-life projects? This paper presents the findings from an overarching and holistic exploration of the strategies, demands and guidelines formulated in the 'Digital Construction' program, and the lessons learned from applying one of the program's digital foundations, the '3D Working Method', to a real-life project – the new Icelandic National Concert and Conference Centre in Reykjavik (CCC project) (Fig. 1). The paper explores enablers and barriers from the national R&D program level down to the individual architect or engineer involved in the real-life project, as well as the benefits and challenges experienced from using and exchanging 3D object models according to the '3D Working Method'. The focus is particularly on non-technological factors. Research dealing with ICT related to the AEC industry has been dominated by a focus on the development and improvement of the new tools, or on technology-related issues of implementing these in practice [10]. More research is needed on the impact of non-technological and human factors – an issue which has increasingly gained the attention of researchers [11–13], as well as of the evaluators and developers of the 'Digital Construction' program. The paper is furthermore based on the understanding of the design process as a complex conglomerate of predictable and unpredictable interactions, interrelations and interdependencies between actors and their actions. This understanding relates to observations of the design practice made by for instance Cuff [14], Lawson [15] and Schön [16]. The knowledge generated from holistic and overarching studies as presented in this paper could be valuable for establishing future strategies and guidelines for ICT integration, and for improving the further implementation and use of new technologies in real-life projects.

After a brief description of the methodological issues, some examples of international and national initiatives for integrating ICT in the AEC industry are provided as background for the further exploration of the Danish context. The first part of the exploration deals with the structures, visions and strategies developed within 'Digital Construction' and specifically within the '3D Working Method' part of the program. In the second part, the focus is on the CCC project, and on the design team actors' adoption of the '3D Working Method' in six activities related to 3D object-based modeling. The final discussion interweaves the findings from the program and the building project with the main lessons learnt from adapting the '3D Working Method' to real-life practice.

2. Methods

To explore the complex, iterative and unpredictable arena of the AEC industry and architectural and engineering practice, we need an approach that enables broad and holistic insight into the topic. The exploration of the 'Digital Construction' program is based on the results from a qualitative process evaluation which has followed the development of the program over a period of about 4 years by an independent evaluation panel, where two of this paper's authors have played a major role. Seeing the Danish 'Digital Construction' program from a process evaluation point of view gives us the possibility to evaluate the dynamic development of the program [17–19]. Initiated by EBST (The National Agency for Enterprise and Construction, a Danish public agency under the Ministry of Economics and Business), which is the host of the program, the evaluation started in the winter of 2004. Since the program was launched in late 2003 and ran up to the summer of 2007, the process evaluation has been documented in four intervention and status notes on the program's progress, in addition to a final report [20,21]. The process evaluation is based on an array of methods; interviews, participant observations and desk research. Forty-nine interviews have been conducted, comprising biannual interviews with project managers from EBST and project managers representing the various active development consortia within the program, the surrounding learning network and so on.

The exploration of the experiences of implementing 'Digital Construction' in the CCC project, build on the findings from a qualitative case study which has been carried out as a part of a Ph.D. project with the title 'Exploring relations between the architectural design process and ICT – Learning from practitioners' stories' (completed in the summer of 2008). The empirical data have been collected from several evidence sources, a strategy recommended by Yin [22] to ensure the construct validity of the qualitative study. The findings presented in this paper are generated from twenty semi-structured and open-ended interviews [23] conducted in 2006-2007 with eleven architects and engineers involved in building design and project management. To gain broad insight into the studied project beyond the subjective world of the single respondent, project actors have been selected who represent different backgrounds, experiences and points of view. Further sources of evidence are; passive observations of three different kinds of design meetings, 'guided tours' on computers with the users of the 3D tools, observations of the workplace of the design team as well as investigations of project material. The brief glimpses into other national and international initiatives for integrating ICT in the AEC industry are based on open-ended interviews with key actors involved, as well as on desk research.

A descriptive and holistic framework developed for gaining a better overview and understanding of the implementation and use of ICT in real-life projects has been applied as an instrument
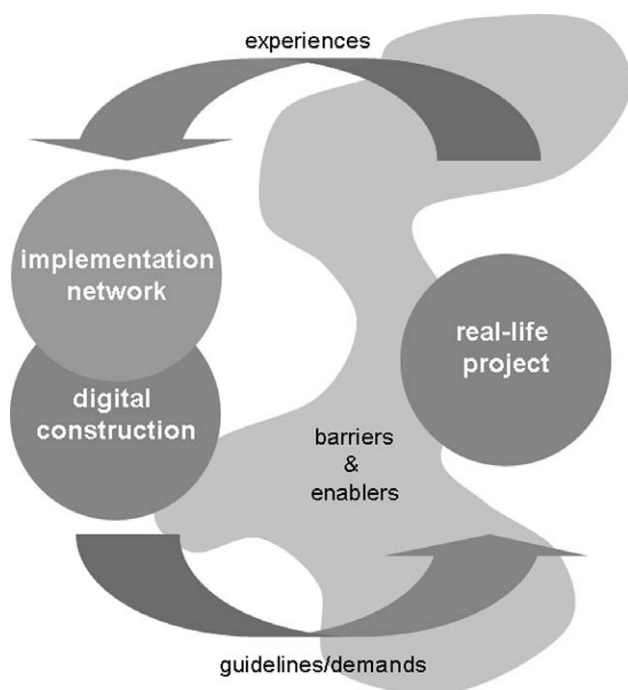

Fig. 1. Exploring the relationship between the R&D program and a real life project.