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Design team stories
Exploring interdisciplinary use of 3D object models in practice

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ABSTRACT

This paper explores the interdisciplinary use of 3D object models in design team practice by applying a holistic research approach. Based on a qualitative case-study of the ongoing and prestigious building project New Icelandic National Concert- and Congress Center (CCC-project) in Reykjavik, the paper presents five stories about different challenging or beneficial situations from using 3D object models. The implementation of such technology was connected to strategies and guidelines formulated in the Danish public–private R&D program "Digital Construction". A descriptive and multi-level framework for exploring the ICT impact on the architectural design process has been applied to the analyzing and organizing of the case-study data. A narrative story-telling technique is used to capture and communicate the complex case-study findings into five design team stories, which each highlight central issues embedded in the relation between the design team processes and the technology. The following situations are explored: developing complex geometry, achieving shared understanding, handling the painful processes of change, formalizing processes within a dynamic design environment and handling the interface between design and production. The stories show that a number of the challenges perceived by the design team actors were linked to the nature of the architectural design process, particularly to its "hard-to-grasp", iterative and intuitive features. The stories indicate that the interdisciplinary use of 3D object models is affected by the many interdependencies, relations and interfaces embedded in the highly complex and partly unpredictable real world practice. A future challenge would be to better understand, master and balance these relationships — across multiple levels, processes and activities. The presented holistic research approach and the related findings contribute to research which attempts to embrace the complexity of real-life problems and to gain a more comprehensive understanding of real-life problems.

1. Introduction

> "Design is a complex process that continues to grow in complexity because of the dramatic increase in specialist knowledge. There are now many contributors to the design of a project from a wide variety of organizations. This gives rise to design processes that consist of a continual exchange and refinement of information and knowledge. Even the most experienced design teams can fail to manage this complex process and supply information at the wrong time and of the wrong quality to members of the production team." Gray and Hughes ([1], p. 1).

This paper explores the interdisciplinary use of 3D object models by a real life project's design team. In the quotation above, Gray and Huges [1] indicate the challenging task to manage collaboration and design in order to achieve good architectural design solutions and economic successful one-off real estate. The building design teams' efforts are crucially based on a successful interplay between iterative and interdependent processes, actors and actions [2,3]. In her studies of architectural practice, Cuff [4] considers design as a social construction where buildings are collectively conceived. A whole range of predictable and unpredictable issues are impacting the design team members' individual and collective efforts. These issues are placed on many levels, from Architecture–Engineering–Construction (AEC) industry level down to the level of the individual designer. Different trends in the society, as for instance globalization and the increasing focus on sustainability and environmental issues, have contributed to raise the complexity of the design process even more. The interest in integrated practice and collaboration, where specialized participants with different backgrounds, preferences and experiences try to achieve a common goal, is growing within both research and practice [5–8]. At the same time, the productivity status in the AEC-industry as described by Latham in his report from 1994 [9], still gives raise to concerns. A substantial part of the building costs can be related to failures on the building site and to poor interactions

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within and outside the building design team. The implementation of Information and Communication Technologies (ICT), as for instance 3D object models or Building Information Models (BIM), together with the open product model standard IFC (Industry Foundation Classes), is expected to improve this situation through supporting design related work and collaboration [10]. Still, compared to other industries the AEC industry is lagging behind when it comes to the successful implementation and use of ICT [11,12]. In order to encourage and promote the implementation in practice, powerful national and international players in the AEC-industry are combining their forces for stimulating integration in all phases of the buildings' value chain [13–15]. The implementation of ICT is expected to impact on both working processes and role definitions [16–18]. Based on these new trends and movements in the AEC-industry, there is an increasing need for a more comprehensive understanding beyond the purely technology-oriented issues, which until recently have been the main focus of research and development [19,20].

This paper explores the interdisciplinary use of 3D object models in architectural design practice by applying a holistic research approach. The explorations are based on the understanding of the design process as a complex conglomerate of predictable and unpredictable interactions, interrelations and interdependencies. This understanding relates to observations of the design practice made by for instance Cuff [4], Kalay [21], Lawson [2] and Schön [22]. By using a qualitative, descriptive and multi-level framework and a story-telling technique, the paper attempts to reveal and communicate central aspects, relationships and interdependencies embedded in the encounter between technology and the architectural design process. The paper presents five design team stories about different challenging or beneficial situations from using 3D object models in the new Icelandic National Concert and Congress Centre (CCC-project) in Reykjavik. The stories are highlighting the role of technology in the architects' and engineers' work and interactions, and the enablers and barriers which affected the design team's interdisciplinary use of the technology. The stories are based on the findings of a PhD project conducted in the period of 2004–2008 with the title "Exploring relations between the architectural design process and ICT — learning from practitioners' stories" [23]. The main objective of this PhD project was to contribute more knowledge on the current situation in practice by investigating relations between the architectural design process and ICT in real-life projects. An important issue was here to gain knowledge about practice by unlocking knowledge embedded in practice.

The paper is structured as follows. After a short section about the research strategies and methods used, the CCC-project and the background for implementation and use of the 3D object models is briefly introduced. In the main part of the paper, the five design team stories are told, each including a summary and a short discussion. Finally the paper provides a short conclusive discussion of the main findings and the application of the holistic research approach.

2. Research strategy and method

The holistic research approach has been developed to appreciate some of the complexity embedded in the practice of architectural design. The main idea behind the approach mirrors the architects' holistic handling of problem identification and solving, and their ability to synthesize and coordinate bits and parts into a whole without detailed knowledge about each of these. The approach is based on two elements; a descriptive framework and the use of a story-telling technique.

2.1. The descriptive multi-level framework

The descriptive multi-level framework intends to support the achievement of a better overview and understanding of the implementation and use of ICT in real-life projects. The framework is grounded on two dimensions of design practice. First, there is the process dimension. The framework focuses particularly on four central design process aspects; the generation of design solutions, the communication of design solutions, the evaluation of design solutions and decision-making. Second, the framework is based on the level-dimension, where three levels representing different social constructions in a building project are suggested; a macro-level (overall project), a meso-level (the design team) and a micro-level (the individual practitioner) (Fig. 1). These three levels are again embedded in the context of the AEC industry, in this paper represented by the national R&D program 'Digital Construction'. The development of the framework is based on reviews of relevant literature and research, as well as on observations of practice.

Based on the main framework elements, different tools and models have been introduced to provide an overview of the factors affecting the implementation and use of ICT. These tools are operationalizing the relations between the architectural design process and ICT. The ICT impact matrix (Table 1) has been used as a tool for organizing and analyzing the qualitative case-study findings from the CCC-project.

The matrix provides an overview of key benefits and challenges from the interdisciplinary use of 3D object models in the architectural design process, related to all four design aspects and all three levels. The multi-level factor model (Fig. 5) provides an overview of the identified enablers and barriers affecting the implementation and use of 3D object models in the architectural design process. The framework and its tools have evolved and improved throughout its application on several real-life projects, and it has been presented at several workshops, seminars and conferences. A thorough description of the framework can be found in Moum [24].

2.2. Data gathering

The case-study data have been gathered from several evidence sources, a strategy recommended by Yin [25] to ensure the construct validity of the qualitative study. The findings presented here are generated from twenty semi-structured and open-ended interviews [26] conducted in 2006–2007 with eleven practitioners' 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

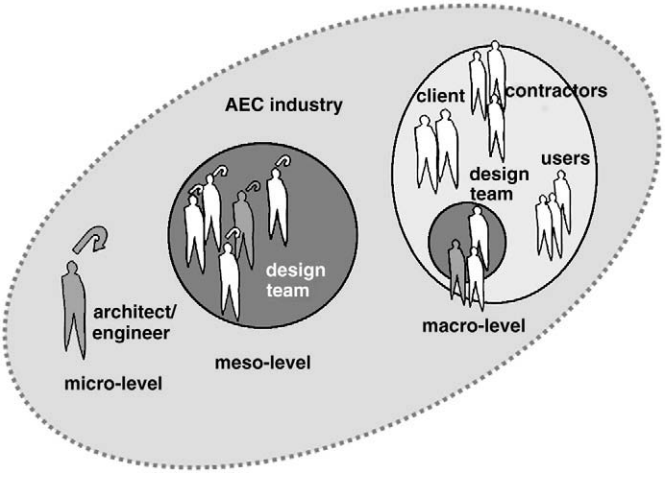

Fig. 1. The three hierarchical project levels, embedded in the AEC industry context.