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The conditions for successful automated collaboration in construction

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ABSTRACT

A building assignment is a complex task that demands collaborative working if added value is to be achieved for users and society.
The problem today is that the building object is a combination of design results, because the collaborative working is not well organized or well managed as a result of a lack of insight into relevant process variables.
This study used desk research and case study research to identify variables that have an active relationship with collaborative working in design meetings.
The variables that describe a design meeting were established by analyzing 37 meetings during the product and production design phases of a prototype of an industrial, flexible, and demountable building system.
The result of this study is that the variables "Aim of meeting," "Control of meeting," "Participants," "Tools," and "Outcomes" are a suitable set to describe successful collaborative working in design meetings.

1. Introduction

A building assignment is a complex task that demands collaborative working in design meetings if added value is to be achieved for users and society [1]. Wilkinson [2] defined collaboration as:

> A creative *process* undertaken by two or more interested individuals, sharing their collective skills, expertise, understanding and knowledge (*information*) in an atmosphere of openness, honesty, trust, and mutual respect, to jointly deliver the best solution that meets their common goal.

Meetings need to be successful, because:

- In the architecture, engineering and construction (AEC) industry a meeting is an important workplace where diverse professionals design in a collaborative way a public–private partnership (PPP) tender, a building object, or a production process.
- Added value for users and society must primarily be created in adequate prepared and facilitated meetings.
- High level value building information modeling (BIM) needs collaborative working environments [10].
- Participants in construction spend a substantial amount of their time in meetings [3,4].

Lousberg [5] described the goal of meetings thus: "to make transparent the drivers of the stakeholders to each other about their design proposals so that coordination and integration of project parts will be possible."

Emmitt and Gorse [6] distinguished eight types of meetings during the design and construction process, namely client briefing meetings, design review meetings, design team meetings, pre-contract meetings, site-progress meetings, constructor team meetings, hand-over meetings, and feedback meetings. Emmitt and Ruikar [7] also described facilitated workshops which are concerned with establishing and developing interpersonal relationships.

In this paper, the focus is on facilitated face-to-face design meetings in which professionals from different disciplines collaborate in "a closely coupled design process" Kvan in [8]. The participants make transparent their own design thinking, and listen with interest and respect to each other. They are willing to learn from each other, and understand that only in this way a good and integrated result can be achieved [9].

Building information modeling (BIM) and internet-based tools are aids for automated workflows. These 'hardware' aids have an impact on the interactions during product and production design of building objects. Grilo and Jardim-Goncalves [10] distinguish five interaction types along the x-axis: communication, coordination, cooperation, collaboration and channel. Each type of interaction has along the y-axis three values levels: efficiency, differentiation, and value innovation. Collaboration is related with value innovation and described as 3D BIM & Collaborative working environment.

In a course on collaborative design on distance the first author (F.J.M. van Gassel) got the experiences that designers and design managers need special competences to collaborate in design and to organize distributed collaboration processes [9]. These competences have not

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only technology aspects but also knowledge of soft skills of information sharing and knowledge management, professional roles, and commercial context [11].

This knowledge will be obtained in this paper by studying face-to-face design meetings and should also be used by designing and using automated collaborative working environments.

The aim of the present study was to use desk research and case study research to identify variables that influence collaborative working in design meetings.

This paper systematizes an insight into meeting variables that stimulate collaborative work in design meetings, by answering the central question: *Which variables describe collaborative working in design meetings*?

A successful collaborative meeting needs not only a desired outcome but can also create an environment where participants and organizations can learn. A societal imbedding in a macro context of this last mentioned aspect of collaborative working is described in the following two sections.

2. Knowledge, learning, and economic development as context

The most advanced economies increasingly base their competitiveness on the generation and efficient utilization of knowledge for innovation. Increasing emphasis is being put on knowledge and knowledge transfer as development factors, as reflected in, for example, the World Development Report from 1998/99: "This World Development Report proposes that we look at the problems of development in a new way — from the perspective of knowledge" in [12].

Kenneth Boulding, founding father of evolutionary economics, expressed it in the following way:

> … as we have seen, all processes of production involve the direction of energy by some know-how structure toward the selection, transportation, and transformation of materials into the product… It is not "labor" that produces a commodity or product as Marx and indeed Adam Smith and Ricardo thought, but human knowledge and know-how, operating through institutions which enable this know-how to capture energy and rearrange materials [13].

Evolutionary economics implies that the dynamics of knowledge – that is, how knowledge is created, distributed, utilized, and destroyed – ought to be at the core of development theory. Achieving the interactions and synergies a country requires to advance toward an economy that is based on the production of knowledge-intensive goods and services, necessitates the inscription of this action in a society that presents high levels of structure and cohesion, and whose social capital offers the functional organization, coordination, and social integration capacities [14].

López and Johnson developed the idea that learning – in the broad sense of creating, distributing, and utilizing knowledge – is one of the driving forces behind social and economic change. They affirmed that knowledge has to be associated with learning, and learning with innovation, and posited that the term "a learning economy" is more adequate to characterize the current phase of socioeconomic development than "the knowledge-based economy" [15]. This is because all economies are based on knowledge, but not all economies are learning economies, since the term presupposes a certain speed of change in the knowledge base.

Fig. 2. Modeling a meeting as a black box.

The concept of "learning economy" refers to an economy that is characterized by the ability to learn, internalize, and build on what is learned, so that new competences can be adapted or created. It is an economy where the rate of new knowledge and skill creation has increased, and also where the rate of obsolescence is evident, and thus the need for change has increased [16].

A combination of technological developments, institutional change, and globalization has led to an acceleration of technical and economic change, a situation that presents firms with important and constant challenges in maintaining their competitiveness in their respective sectors.

An interesting development that tends to make learning more instrumental is the growing attention paid to "learning organizations" [17]. The basic idea is that the way an organization is structured and the routines that are followed have a major effect on the rate of learning that takes place. The appropriate institutional structures may improve knowledge production in terms of competence building based on daily activities.

3. Consequences for the firm and its organization

We have entered a new era that is characterized by rapid change and the need to learn (and forget) rapidly in all economic activities. National economies and firms must therefore modify their organizational structure to fit and succeed in the new context.

The ability of firms and individuals to learn rapidly and acquire new competences as they are confronted with new types of problems, may be even more important for their economic success than their access to a given knowledge base. In the learning economy, new knowledge is being created at a rapid and probably increasing rate. At the same time, the quantity of relevant knowledge is being reduced, as knowledge becomes obsolete increasing quickly. This often implies "de-learning" old competences that could otherwise delay or block the development of new ones.

The way that work is organized in a firm can facilitate or hinder the transfer of knowledge and the learning processes within it. Innovation systems work through the introduction of knowledge into the economy (and into society at large), which requires active learning by individuals

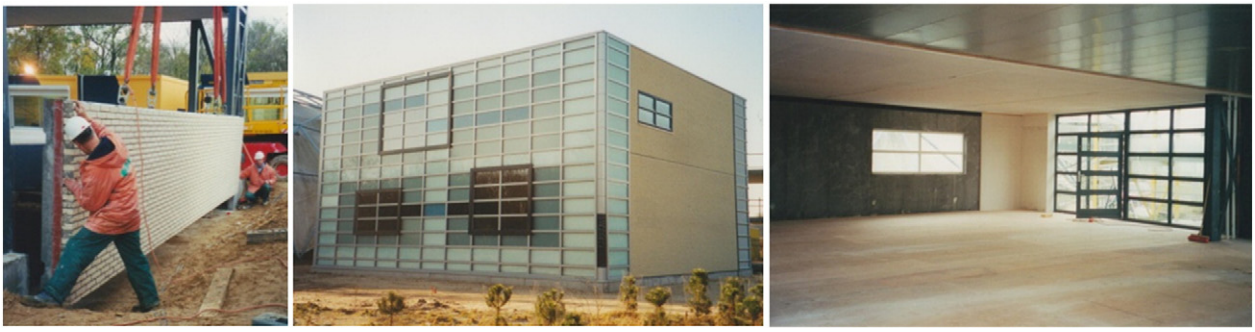

Fig. 1. Mockup of the IFD Today research project.