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Visual management in mid-sized construction design projects

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Abstract

Visual Management has emerged during the past decades within manufacturing and service organizations, as a system that through visualization enables the employees to better understand their role and contribution in relation to both their own organizational values and costumer needs. Visual management is not well known within the construction industry; however, the importance of visualization is well recognized. In construction design, two types of visual means are frequently applied, i.e., 3D models and visual planning. These visual means support communication and mutual understanding during design, but do however not address the management of the project. The aim of this article is to explore how visual means support the design in terms of coordination and how they utilize the potential that exists in a multi-disciplinary design team. For exploring how visual means support the design coordination, we conducted and compared two case studies qualitatively in a construction design setting. Both case studies were followed throughout the entire design process, where the design teams were semi-collocated. More than 15 semi-structured interviews were recorded and transcribed. Both cases were residential in-house projects. Based on our findings we contribute with the following: (1) by using multiple visual means, i.e., visual management, the design teams become more self-going. (2) However, the self-going supported by visual management is primarily related to a collocated setting and active engagement of all actors involved.

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Keywords: construction design; visual management; visual planning; visual representation.

1. Introduction

Construction design is a complex process with multiple actors and often crosses multiple disciplines and organizational boundaries by Bosch and Henriksson (2014). The process of coordinating, sharing of information

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and knowledge between the involved actors is crucial for the success of a project. The theoretical starting point in this research is that knowledge is situated in practice by Beth (2003) or Orlikowski (2002). In a project context, sharing of embedded and practice knowledge and information becomes a challenge, and studies have looked at this from multiple perspectives. A number of concepts have been studied and tested that emphasize the importance of working more close together. Collocation can embrace the complexity of a construction project, eliminate misunderstanding and improve reliability and quality of the final product. Therefore, collocation has found widespread use within the construction industry in terms of the BIG Room concept by Liker (2004), extreme collaboration by Garcia et al. (2004), integrated concurrent engineering by Evbuomwan & Anumba (1998) or Love & Gunasekaran (1998), Integrated Product Delivery methods by Cohen (2010) or Lichtig (2005). These different approaches have however mainly been tested on larger projects, where the design teams have been able to allocate all their time to one single project. The bulk of construction projects are however not that large that this is possible. A variation of the collocation concept that is investigated in this research is therefore a hybrid version, where the design team is semi-collocated. A semi-collocated design team is collocated for one to two days a week, the rest of the time the consultants are working from their home offices. An important element that the collocation supports is the use of different types of visual means.

Studies have discussed the importance of visualization and visual means in the Architectural Engineering and Construction industry (AEC) by Ewenstein and Whyte (2007) or Nicolini (2007) to support and utilize the full potential of all the involved actors know-how, embedded practice and expertise. Visualization within the AEC industry has mainly focused on increasing understanding and transfer of knowledge between the actors involved in the design of the product. Visualization is supported by visual means that are also perceived as visual representations by Ewenstein and Whyte (2007) or Henderson (2007) or Luck (2007) or Nicolini (2007). Common visual representations are sketches, 2D drawings, and 3D Building Information Models (BIM) by Henderson (2007). Another area that lifts up the use of visualization is the lean method of visual planning, which are a collection of tools that visually help coordinate information and activities between the involved actors. Visual planning tools have primarily been applied in the production phase of a construction project by Santos et.al, (1998) or Ballard and Koskela (2009). The tools and concepts mentioned above do however not visualize the management of a project, and visualization in construction has not been connected to self-going of design teams. In other industries the concept of visual management (VM) is discussed as a more holistic approach that helps teams and individuals to be self-going in terms of having a better understanding of their own role and contribution within the larger frame of the project by Liff and Posey (2004) or Eppler and Burkhard (2007) or Jaca, et al., (2013) or Tezel, Koskela and Tzortzopoulos (2009). However, even though the theoretical connection between visual management and construction has been identified by Tezel, Koskela and Tzortzopoulos (2009), few apply visual means to support management in the construction industry.

The aim of this article is to explore how visual means support the design in terms of coordination and abilities to utilize the potential that exist in a semi-collocated design team. To do so the present paper discusses the relevant literature in section 2. In section 3 we explain the qualitative comparative case study method applied for executing this research and in section 4 and 5 we discuss the findings and relate the findings to the literature.

2. Theoretical departure

The main starting point of our study is based on a focus on knowledge as situated in practice by Orlikowski (2002). Knowledge is often embedded in practice as well as in actions. Literature discusses that in design projects in which members have embedded practices, know-how and different organizational cultures it becomes more difficult to share knowledge and information within the project by Bosch-Sijtsema and Henriksson (2014). Learning by doing or learning by observing can be supported by visual means. From studies on visual illustrations we know that the human brain is faster in processing visual illustrations than text and spoken language, and is capable of handling more visual information than non-visual information by Greif (1991) or Barry (2005). For sharing knowledge and practices, the use of visual means has been studied from different perspectives and supports learning, sharing of knowledge, as well as the development of new work practices by Boland et al. (2007) or Henderson (1991) or

Nicolini (2007). Visual means are already applied in the construction industry in terms of visual representations as well as visual planning methods. Many of these visual means are enabled by physical presence, i.e., collocation. Especially in construction design, the use of collocated design teams in which all actors including the client are participating, has become more popular by i.e., Garcia et al., (2004) or Liker (2004). The collocation of the design team (either in a hybrid form or full-time) supports face-to-face interaction, facilitating both formal and informal communication and increases the chances to discover problems and solutions in line with the client's requirements Garcia et al. (2004). The physical presence supports the use of the following visual means as representations.

Visual means are often perceived as visual representations that support the visualization of a construction through 2D or 3D boundary objects by Ewenstein and Whyte (2007) or Henderson (2007) or Luck (2007) or Nicolini (2007). These representations can be drawings or even 3D digital representations. Especially, the use of 3D models, i.e., Building Information Models (BIM), is increasingly applied during design in the AEC industry. Visual representations are known to support the transfer of information and knowledge within a construction design project. The different types of representations like drawings, BIM, and sketches are important in the process of aligning all involved actors in a construction design, and support discussions by using the visual objects as a starting point.

Another approach that is known for using visualization is visual planning. Visual planning tools support coordination between different activities, commitments and obligations in a visual manner. Visual Planning is a visual method for collaborative project planning. With the help of visual planning tools that typically consist of white boards and post-it notes, the different actors visualize their respective processes, including needs and deliverables. Visual planning originates from lean methods, and has primarily been applied in the production phase of a construction project by Santos et al. (1998) or Ballard and Koskela (2009). Only few studies lift up the use of visual planning during design, i.e., pull planning by Ballard (1999). Visual planning in design, visualizes dependencies in terms of activities, contributions and knowledge between all actors involved. This visualization of the needs enforce that questions are raised early in the process as compared to a conventional project, which give the design team a better chance to handle a certain problem in line with the clients needs and wishes by Ballard (1999).

The use of visual means has been more common in other industries. The term visual management is applied in manufacturing as a holistic system supporting visualization information to help teams and individuals to gain a better understanding of their role and contribution within the larger frame of a project by Liff and Posey (2004) or Eppler and Burkhard (2007) or Jaca, Viles, Jurburg and Tanco (2013) or Tezel, Koskela and Tzortzopoulos (2009). Through such a system, knowledge and information can no longer be treated as an asset, but information becomes available for everybody by Greif (1991) or Liff and Posey (2004) or Galsworth (2005). This creates transparency as well as motivation among the employees in order to understand behind lying reasons for activities.

3. Setting and method

The study performed a comparative qualitative case study by Easterby-Smith et al. (2014), in order to explore how different visual means are applied within construction design, to support the team in terms of coordination and abilities to utilize the potential that exist in a semi-collocated design team. The study includes two qualitative case studies of two ongoing design projects, where the researcher took the role of a complete participant observer by Adler and Adler (1994). A complete participant observer implies that the researcher was an active member of the project and was known to all involved partners during the projects and everybody was aware of the researchers role in these two projects. Both cases were in-house residential housing projects. The two cases were selected based on their similarities regarding work method (hybrid collocation), size, geographical location and design manager. Both projects were followed throughout the entire design process and more than 15 semi-structured interviews were recorded and transcribed with key members of the two projects. Furthermore, continuous observations > 100 hours, collection of secondary data in terms of protocols, feedback questionnaires and involvement of informal communication with both design teams were carried out. The study was conducted at one of the largest contractor companies in the Nordic EU-countries. The company has 18.500 employees and is engaged in the construction of housing, residential, roads etc. The company has a well-established culture of testing and implementing new methods, which is the main reason for selecting this company. Case study A consisted of a team of 6 -13 members,

Case study B had a design team of 8 - 12 members. Both teams had the following disciplines represented at every collocated session: client, architect, structural engineering, heating, ventilating and air conditioning (HVAC), electricity, project manager (subcontractors, Virtual Design and Construction (VDC) coordinator, fire, cost estimation, and site manager were also present but not on a regular basis).

Both cases designed residential houses in the Gothenburg area in Sweden and we followed the projects during their design and detailed design phase. In the design phase the overall design system is settled and in the detailed design phase the detailed drawings for production are produced. In these phases, the involved actors collaborate collocated as an integrated project team for one day a week.

4. Findings

This section presents the following: 1) The use of visual means, 2) How visual means provide the design team with the possibility to be self-going and 3) Lack of transparency and competence hinders self-going of design teams.

4.1 Use of visual tools

During the collocated working time the projects use a number of visual means, see Fig. 1. In the first collocated session the projects have a kick-off meeting, in which the client and project manager (PM) discuss the project. During this meeting the project teams of both case A as well as B, jointly produced a visual time plan by using pull planning. The other sessions followed a fixed agenda in which several visual tools were applied.

Each collocated session began with a review of the protocol followed by a review of the *visual time schedule*, which is self-coordinated among the design group. In the time schedule discussions, all deliverables were confirmed, mandatory explanations for delay are discussed and new deliverables are negotiated, the impact of the delay is considered by everyone, and additional changes are made in order to still be able to comply with the final deadline.

The second step is the "*to and from*" matrix that shows visually who has questions and who needs to answer them in the project (only applied in project A). In project A, this tool clearly showed the visual transparency of this tool, in the form that the work routines and workload of one actor became clearly visible to another actor: "*Obviously it does have an effect on me that I see that X gets so stressed, I mean, I admittedly start to think okay what is it that we absolutely must do now and what can wait.* "

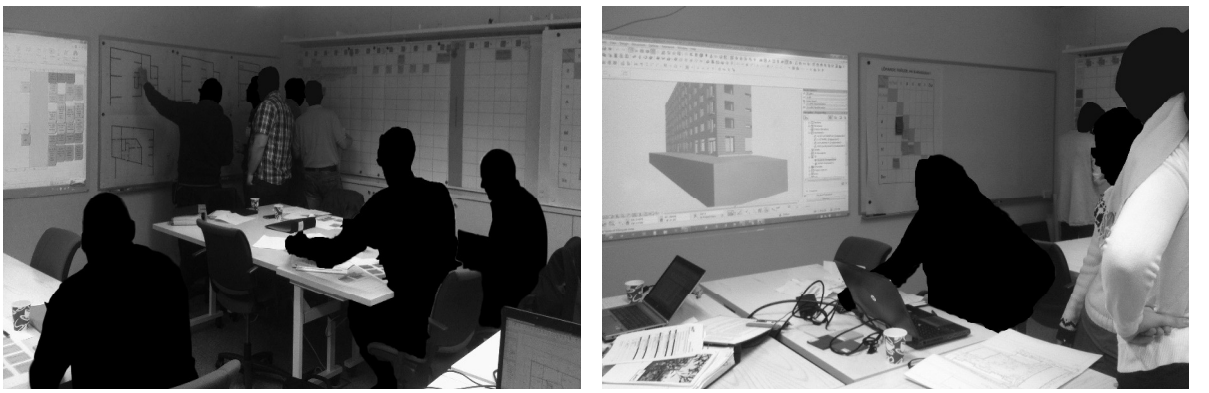

Fig. 1: (a-b) Design teams' use of multiple visual means during their collocated sessions

These three activities combined took usually between half an hour and a little more than an hour. After this, the team began their coordination work, where they continuously applied the decision list, A3's and the BIM models or

print-outs from the BIM model. The "decision list" is a live document where all decisions (by whom and when) are transparent. All decisions made that impact the overall progression of the project were documented on the visible decision list. The "A3" is a visual tool representing parts of discussions that take place, i.e., all sketches and screen dumps from the BIM model. For example, in both projects we observed that sketches of design solutions made by multiple actors were posted on the wall section dedicated for A3, so that those who were not directly involved in the particular discussion, would be able to access what had been discussed and what was concluded. From session to session the PM is digitalizing both the A3 and the decision list and attaches them to the protocol.

Many discussions in both projects happened around 2D sketches, several different actors gathered around these sketches, draw on these, and discuss them together in different settings. "*It more became that we were discussing things based on 2D print-outs, and then maybe the architect would have the 3D model open on his laptop."*

Furthermore, in both cases, the 3D model is applied in the team in (i) on people's own laptop and (ii) during a clash detection shown by a VDC coordinator. The VDC coordinator is an external person to the project who takes care of clash detection among the different disciplines' models. The discussion that happens with and around the model is coordination and clash detection oriented; only in a few cases, especially in project A, the model is the basis for a discussion. In project A, the 3D models was a starting point for discussion, but was combined with 2D drawings in order to gain full understanding for all actors involved.

4.2 Visual means provide teams with the possibility to be self-going

The data collected indicates that the visual means are enabled by collocation to a larger extent than more conventional run projects. The visual means provide the integrated design team to be self-maintained and progress independently without external vigor. The client mentioned during an interview that it was possible for anybody to perform the time schedule: "*I remember one day when the PM had sick kids and called me like 15 min before the meeting "..oh I have sick kids can you take the meeting today" And I became like… - would it have been a conventional project, I would definitely not have been able to do it, but here I mean we went through the time schedule with the post- it notes with questions like what do you need finalized today and so on. I mean it was like just checking off everything. So I was actually capable of running the meeting. I think that it is a very positive side effect that the project is proceeding even though someone might get sick*."

People also mentioned that they felt more responsible for participating in the project because it became clearer what everybody's task was and how different elements were connected and depended on each other. An example of project B is mentioned below concerning the visual time schedule: "*With those post-it's, it becomes very clear how things are connected and you don't want to be the person who makes it all fall to the ground, so you make sure to have done the things on your post-it notes. So I'm extremely impressed*."

Others mentioned that the use of visual means helped to gain more understanding of the tasks of other actors in the project. "*It is first after having been a part of a project studio that I have really understood what and how much work an architect has to do – I have not really understood why things took so much time – but now I understand! I mean all kinds of details, from like how you draw an electrical wire to objects lists – I gained a much better understanding for the other disciplines*."

The PM also mentions clearly that the use of visual means are only tools, but it is very much depending on the team members how they collaborate. *"I mean it is not like that there is nothing happening during such a day, it is very much depending on oneself what you get out of a day. Obviously, you need to have your own agenda so that you progress in your own work and in the interest of the project."*

The use of visual means provides the teams with more options to steer their own work and the project is less dependent on one project manager.

4.3 Lack of transparency and competence hinders self-going of design teams

The data collected also indicates that information regarding the project economy is disconnected from the collocated sessions. Visual means support the coordination of the design team, in terms of understanding and being

informed about different solutions and decisions. However, the use of the above-described visual means primarily work in a collocated setting. When important actors of the design process are not present during the design sessions, they cannot take part in the discussion or the visual communication and from the interviews and observations it has become clear that this impacts the process.

In project (B), the design team decided to make a design deviation from the platforms that residential housing projects normally follow. Everybody in the collocated design sessions understood why this deviation decision was made and what the impact would be on the design. The design deviation was clearly visible in the visual means applied by the teams, i.e. decision list, A3, time schedule and to-and-from matrix. However, this deviation was not secured with the finance department for cost estimation, who not actively took part in the sessions. Several interviewees have mentioned that transparency into economical information and participation from construction during design could diminish rework of the design. "*Lack of attendance from purchasing and people from construction has had an effect. Both regarding the technical construction and the project economy they have not 100% understood the impact of the deviation from the standard solution, and have therefore continued to plan and calculate as if it was a standard solution - and then it came as a surprise that the design was not a standard solution for them (*cost estimation and production*). All other project members knew about the design solution... but those two important parts of construction and finance had not understood or were not aware."*

It was also mentioned that the process of how the economic aspects of the project are handled during design are unclear to the involved actors in the project studio. The client of the design project mentioned the following: *"I do not know how the finance manager and the PM are communicating, but the communication that I have with finance is only about finances of the project. How the actual product in taking form is with the PM. But it is obvious that the finances and the design of the product are strongly connected. So actually I think he (*finance*) should be a part of the collocated meetings to secure that the project is not becoming economically unviable.*

Additionally, it was mentioned that the project team currently does not hold the competences to handle the financial aspects of a project. "*Right now the project managers that we have are not fully updated or capable of handling the financial questions; they do not know anything about which detail costs more than the other etc. … I think the project manager shall have this competence, but that is not the case today and we have a long journey ahead of us before they gain that."*

Even though the visual means support the design teams in being self-maintained and to a large extend self-going. The design team is unable to be fully self-going based on detained information and lack of participation of influential actors.

5. Discussion

The paper studied how visual means support the design in terms of coordination and abilities to utilize the potential that exist in a semi-collocated construction design team. Based on two comparative case studies we contribute with the following: (1) by using multiple visual means, i.e., visual management, the design teams become more self-going. (2) However, the self-going with the help of visual management is primarily related to a collocated setting and active engagement of all actors involved. These two contributions are discussed in more detail below.

5.1 Visual means support self-going teams

Visualization has been an important concept in literature in terms of representation of objects and artifacts that can support communication, mutual understanding as well as discussions by Ewenstein and Whyte (2007) or Henderson, (2007) or Luck (2007) or Nicolini (2007). Especially in construction design the use of sketches and drawings (Henderson, 2007) as well as 3D modeling by Ewenstein and Whyte (2007) has been studied. Especially, in the literature discussing collocated design through extreme collaboration by Garcia et al. (2007), big rooms by Liker, (2004) or even concurrent engineering methods by Evbuomwan and Anumba (1998) also apply multiple visual means as well as lean thinking to gain a more shared understanding between different actors, and to support discussion as well as joint decision-making. These studies discuss the benefits of these approaches as well as how visualization can increase understanding and knowledge transfer, but focus less on how visual means can support

design teams in becoming more self-going. From our findings and observations we noticed that actors involved in the collocated design sessions perceived that they, to a greater extend, were able to steer the design process, gained a better understanding of the whole process and different roles and activities of the other actors, and finally felt ensured to manage the design process jointly. The use of visual tools and methods helped the actors to gain a transparent overview of the whole project, the different discussions that were taking place as well as all decisions that were made and the argumentation behind these decisions. The combination of visual means as well as the collocation and lean methods improved the self-going of teams, such a combination can be perceived as a form of '*visual management*'. Visual management has hardly been studied in the construction industry, but in other fields, it has been a combination of multiple means supporting self-going of teams as well as a better understanding of one's own role and contribution by Liff and Posey (2004) or Eppler and Burkhard (2007) or Tezel, Koskela and Tzortzopoulos (2009).

5.2 Visual Management's dependency on collocation and active engagement

Even though we found that teams became more self-going with help of visual management, other observations clearly argued for a collocated environment as well as active engagement of all actors involved. Without having a collocated setting in which members worked jointly on design issues and problems, it became more difficult to share the visual representations, post-it notes and other visual means. Even though the activities, decisions, and discussions were captured digitally, this did not automatically mean that members actively engaged with the visual material once they were outside the collocated sessions. Especially, actors who are important for the project, but did not participate actively in the process, were not inclined to study the digital representations of the design sessions, and were therefore not aware of decisions made during the problem solving and collocated design sessions. Therefore, next to having the opportunity to share information visually, either in a collocated or digital manner, also the engagement of the involved actors of the design team is prominent. Other studies on extreme collaboration by Garcia et al. (2004) and big room by Liker (2004) have also found the importance of active engagement of all actors as well as the importance of all relevant actors participating in the design sessions.

The way of obtaining visual information either face-to-face or digitally with a visual component is also mentioned in literature as important when using information technology (IT), especially in construction projects as mentioned by Alin et al. (2013) and Whyte and Lobo (2010). Members who are not actively engaged, but whose role and competence are important for the progress of the design therefore hinder the self-going of the whole design team. Sharing visual information and knowledge, becomes difficult to execute when members are not engaged to participate or when it becomes difficult to have the possibility to take in visual attributes. Visual management in construction would need to comprise a system of methods and approaches to support the self-going of the team, sharing of visual information and knowledge in multiple ways as well as stimulate and motivate actors to collaborate.

6. Conclusion

Based on our findings we contribute with the following: (1) by using multiple visual means, i.e., visual management, the design teams become more self-going. (2) However, the self-going with the help of visual management is primarily related to a collocated setting and active engagement of all actors involved.

Since this study has only been based on two case studies, future research will focus more on the implications of visual means, visual management as well as on the impact of self-going in design teams. Furthermore, the consequences of a more self-going design team for traditional routines, roles and structures is another theme that becomes important to lift up. Finally, the findings lift up that it is important in what way visual information is shared within the team, either collocated or in a digital version.

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