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COLLABORATION THROUGH SHARED UNDERSTANDING IN EARLY DESIGN STAGE

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ABSTRACT

The complexity of the collaborative design process is related to the nature of the product and the processes, and also involves the social interplay that ultimately generates design. This fundamentally, affects the way people work, in the purposeful action of designing together. Low levels of collaboration are identified especially at early design stages, where the collective design creation is hindered by the lack of ability of the team to build shared understanding, embracing a multitude of expertise in the task. In this context, the research focused on how the concept of shared understanding can potentially support better collaboration at early design stages. This is based on a deeper understanding of collaborative design as a dynamic system of social interplay, in which the process to build shared understanding for concerted actions can be described as a system that combines mediated coupling and coordinated perception, in a context where division of labour exist. Based on a literature review, lean approaches that claim to support shared understanding between project participants are investigated. This paper contributes in discussing how shared understanding, as a process, can be the basis of the collaborative act, and how components of this process can be addressed through lean approaches.

KEYWORDS

Early design, Collaboration, Shared Understanding, Social Dynamic, Complexity

INTRODUCTION

The nature of multidisciplinary early design stage is challenging. Recent studies shown that early design usually present poor integration in the decision-making process between design disciplines (Adamu et al., 2015; Pikas et al., 2015). At this stage, decisions will have significant influence on cost, performance, reliability, safety and environmental impact of a product, accounting for more than ¾ of the final product costs (Hsu & Liu, 2000). This decision-making process involves large amounts of information, which are usually considered imprecise and incomplete (Hsu & Liu, 2000). In this sense, this dynamic nature of information will generally produce a sense of disorganised behaviour within a design

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team (Macmillan et al., 2001). Hence, design teams will spend a lot effort to coordinate individual processes of information processing, involving reasoning and thoughts, in order to reach shared understanding of the problem, mainly managing conflicts based on different interpretations of ideas, concepts and representations (Cross & Cross 1996).

This is particularly challenging for the management of teamwork in design, where an opportunistic exploration on the design space initiated by one member not necessarily is relevant to other members (Cross & Cross, 1996). According to these authors, those tacit iterations are not easy to track, and affect the understanding of design reasoning and decision-making in a group context. More importantly, there is a lack of knowledge concerning the concept of shared understanding in collaborative design (Van de Bossche, 2011). With no underlying theory of shared understanding yet developed, this topic have been superficially addressed on studies on social mind in sociology, and team cognition in psychology, which are based on the concept of understanding.

The discussion on shared understanding must be considered in the realm of social interplay in collaborative design. Specifically in construction the social system is complex, but it is often an overlooked part of the project setting (Bertelsen, 2003). The wicked nature of design has been misinterpreted due to lack of ability of the participants to articulate the holistic nature of the social interplay (Bertelsen, 2003), raising questions as how much the process of shared understanding affects collaboration in design.

This paper discusses how shared understanding, as a process, is in the basis of the collaborative act, and how some components of this process can potentially be addressed through lean approaches. The study is developed based on a synthesis of the literature, building upon definitions of collaboration and shared understanding in design and construction research. To build a model of shared understanding in collaborative design. The conclusions present main concepts and draw attention to some misconceptions that still hinders the process of shared understanding for collaboration.

COLLABORATION IN DESIGN

Schottle et al. (2014) differentiate collaboration and cooperation in terms of interorganizational relationships in the context of Lean Construction. According to them, cooperative actions do not demand a common vision or mission, resulting in independent organizational structures in the project team, which will depend on a project culture based on control and coordination to solve problems independently. On the other hand, according to the same authors, collaboration is built on a common vision with an organizational structure commonly developed by the team in a new project culture based on trust and transparency.

The level of interaction in a construction project will be influenced by the cultural element and will depend on coordination and communication (Schottle et al., 2014). Defining coordination as the planning or organization of different activities, Schottle et al. (2014) argue that coordination is not a separate relationship in a team. However, the authors introduce a prescriptive idea to coordination, as something that would happen before the action, in this case even the relationship, and it is not something that is intrinsic developed/evolved mutually during the task.

In Schottle et al. (2014), the difference between cooperation and collaboration relies on the level of integration of the participants and the organizational structure, which depends on the cultural continuum involving the development of trust and control. In design research, Kvan (2000) defines that the major difference between collaboration and cooperation is the creative aspect of working together that is related with collaboration. Kvan's (2000) definition is based in a different approach, in which is not important to state the intensity of the relationship based on organizational properties, but to recognize the purpose of the interactions. In this case, the question would be what is the purpose of the collective action?

In design, collaboration relates to the achievement of a holistic creative result (Kvan, 2000). In this sense, it demands a higher sense of joint working, and can be thought as joint problem solving, which means to embrace shared goals with the team working to produce shared solutions (Kvan, 2000, Aksenova et al., 2014). Collaboration involves the decomposition of the task; assigning roles and responsibilities; synthesis of information; and discussion and negotiation of shared representation (Qu & Hansen, 2008). Collaboration is also based on a full commitment to a common mission, enhancing the level of trust and compromising the group to higher level of risk sharing (Kvan, 2000). This commitment must be built in the situation context, in a process, which the authority is determined by the collaborative structure (Kvan, 2000), as an emergent property of the system.

One of the major challenges in collaboration is to develop shared understanding, which implies an overlap of understanding among design participants (Maher et al., 1996). Their particular view of the development of possible solutions as well as their understanding of the design problem must be overlapped by a common understanding of the group in the task about what should be achieved (Maher et al. 1996). However, the occurrence of undocumented design decisions and vague design descriptions, which are usually features of early design stages, can certainly lead to misunderstanding and confusion in a collaborative design environment (Maher et al., 1996).

SHARED UNDERSTANDING AS KEY TO COLLABORATION

In design research, the seminal work of Valkenburg (1998) discussed the importance of shared understanding on collaborative design, indicating that without it, decision-making processes will not be supported by all members and later activities in the design process can be hampered by different views of team members on fundamental topics. Hence, the lack of shared understanding causes unnecessary iterative loops (Valkenburg & Dorst, 1998) that can be correlated to the notion of waste in design.

More recently, Kleinsmann (2006) defined shared understanding as a similarity between individual perceptions on the conceptual content of design and the perceptions of how the systems work and who knows what. A more comprehensive definition is proposed by Smart et al. (2009), defining *shared understanding* as "the ability of multiple agents to exploit common bodies of causal knowledge for the purpose of accomplishing common (shared) goals". These authors also describe it "as the ability of multiple agents to coordinate their behaviours with respect to each other in order to support the realization of

common goals or objectives." Seeing understanding as an ability, or "meaning in use" gives strengthen to the viewpoint that understanding is more than knowledge, because it involves reasoned action, thus it is not static, but a dynamic state (Bittner & Leimeister, 2013).

In lean construction, Pasquire (2012) suggest the interoperability between project participants is a form of common understanding. Accordingly, this common held understanding should be managed as flow through the project life cycle. Pasquire (2013) further explores the link between knowledge and understanding in construction, describing the tacit nature of the skills required and the complexity and specificity of the project outcome. Hence, the challenge in knowledge sharing is related to the ambiguity caused by the lack of understanding across the project delivery team.

In this exploration, Pasquire (2013) refers to Simon (1999) work on knowledge ambiguity, and the three characteristics on non-transferable knowledge: tacitness, complexity and specificity. It is interesting how those non-transferable features could be related to the ability of applying knowledge to certain situation. In stating that, the "non-transferable" property of knowledge may indicate a phenomenon of a different nature, cognitively. In this case, arguably the process of understanding.

The problem with the idea of knowledge flow is that it does not consider the evolving and constructive nature of the process of making-sense, which relates to understanding. Furthermore, it does not allow the consideration of the idea of shared understanding as a distributed process, in which individual understandings are complementary and not necessarily the same.

The idea of team cognition would emerge as an adaptive self-organization of teams (Cooke & Gorman, 2006) in the process to build shared understanding. According to these authors, heterogeneous teams setting, present specific and varied roles, with interdependence, which involves three parts: division of labour; mediated coupling; and coordination, as components of a dynamic interaction between agents performing a task. Under this approach, there is an emphasis on team members' interaction in the task to reach consensus on concerted actions (Cooke & Gorman, 2006).

BUILDING THE SHARED UNDERSTANDING PROCESS

Team interaction in a collaborative task allows us to design a model of the process of building shared understanding, which incorporates three main features: *division of labour*, *coordinated perception* and *mediated coupling* (figure 1).

DIVISION OF LABOUR AND *THE SYMMETRY OF IGNORANCE*

The first feature is a condition for collaboration and relates to the existence of interdependent agents from different specialties (i.e. *division of labour)* involved in the task. This can be correlated to the concept of *symmetry of ignorance* proposed by Rittel (1984) citted on Fischer (2000, 528). Accordingly, when people are engaged in activities, such as collaborative problem solving, they will experience a breakdown (i.e. a piece of lacking knowledge, a misunderstanding about the consequences of some of their assumptions). This condition for collaborative actions is related to the idea of *common ground*, i.e. a set of common values, mutually known facts, and commonly held

presumptions, which is the starting point of social interplay, allowing communication between agents from different backgrounds (Koskela, 2015).

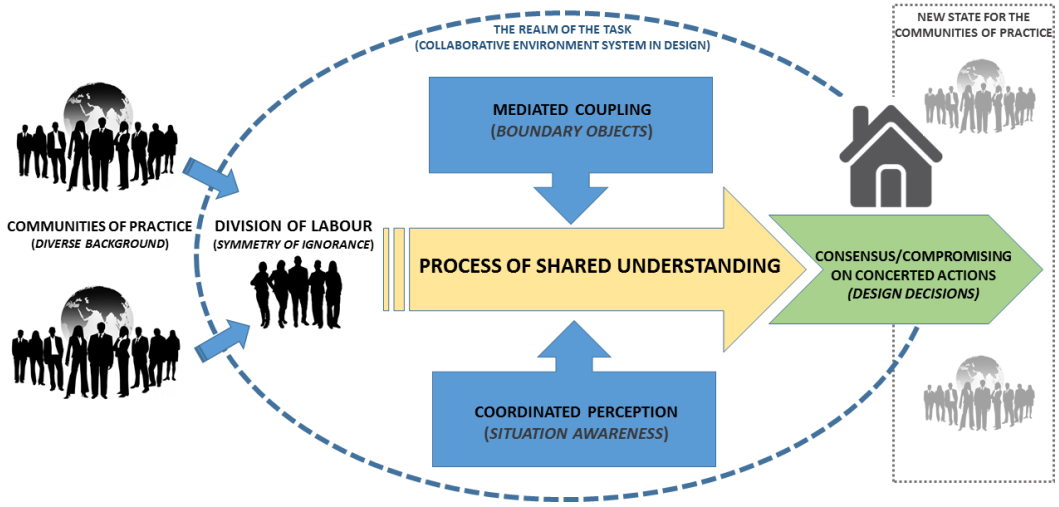

Figure 1: The process of shared understanding in collaborative design.

COORDINATED PERCEPTION AND *SITUATIONAL AWARENESS*

According to Cross & Cross (1996) and Fischer (2000) designers have a limited awareness and understanding of how the work of other designers within the project is relevant to their own design tasks. Therefore, an effective team task depends on the *situational awareness* among team members (Adamu et al, 2015), which is the capacity to perceive and comprehend the characteristics of an environment in a specific set of time and space supporting the realization of predicted futures aligned with a task or project (Endsley, 1995). This is important because it deals with what each worker knows about the understanding and workload of the co-worker, and how is this supported by intercommunication between them (Endsley & Jones, 2001).

MEDIATED COUPLING AND *BOUNDARY OBJECTS*

The process of building shared understanding forces the collision of ideas, and external representations are the means of negotiating shared understanding, in which the objective must be consensus on the meaning of representations (Qu & Hansen, 2008). Accordingly, understanding is achieved through explicit visualizations, comparing high-level overviews of common artefacts. In this sense, the research developed around the concepts of *boundary objects* and *mediating artefacts* (Carlile, 2004) address this component of the collaborative actions. According to Carlile (2004) these shared artefacts and methods provide concrete means of representing different functional interest, consequently facilitating the negotiation and transformation in the collaborative design product.

ANALYSIS AND DISCUSSION

Collaboration is a recurrent topic in Lean Construction, and approaches/methods/tools have been argued to support collaborative practices. In special, we analyse how some of them could be related to shared understanding in supporting multidisciplinary teams in early design stages. Each of them can be further related to the three main features of the proposed process of shared understanding.

COLLECTIVE PLANNING

In the Last Planner System (LPS), the production units are defined by those who will execute the work, which than feed the system that is built to control the workflow through the coordination of interdependencies in a time frame (Ballard, 2000; Spitler, 2014). Those interdependencies are elucidated in the work breakdown structure, which define planning hierarchies, inducing trade specialists to think of their work in relation to the trades adjacent in location and sequence (Spitler, 2014). The creation of a work breakdown structure is an essential early step to any project (Spitler, 2014), because this alignment could represent "shared understanding", in which a systemic view of the "project" systems needs to be collectively built with the team.

The problem is when the team fail to identify the key systems to coordinate (Spitler, 2014). For example, the Collaborative Design Management (CDM) case presented by Fundli and Drevland (2014) which was based on the LPS, the Start-up meeting seems to be key for establishing the relationship between the agents. The action towards connecting design tasks is related to the process of shared understanding, as it deals with the work breakdown structure. However, there is no clear description/explanation on how this is conducted, nor how this is represented in the phase schedule. In design, especially in early/concept design, the problems are ill-defined and demands the generation of a product and a correspondent production system, where there is no way of dissociating planning from doing. This represents incompatibilities for the use of phase scheduling as a collaborative managerial tool for concept design.

In LPS, coordinated actions are achieved through a complex network of requests and promises that are intimately personal (Ballard and Howell, 2003). This seems to represent a fragility of LPS hindering shared understanding in design. In this situation, the parties do not necessarily need to understand each other, in fact it is matter of believe and trust, which can be related to knowing. This is made clear in the phase schedule, where the focus is on describing specific goals (plans) and handoffs between stakeholders to achieve those goals, without necessarily sharing the reasoning process that support those decisions behind the goals. Furthermore, it could be argued that to build interdependencies in a sequential planning creates "knowledge" about the process but not necessarily "understanding". In this case, team members will know the operations sequence, but not necessarily understand why all that procedures were determined, limiting their ability to collaborate in the decision-making.

CO-LOCATION AND BIG ROOM

Collective coordination and mediating actions towards shared understanding seems to benefit from a shared workspace comprising the continuum space-time, where the

participants find each other involved in the task and the social dynamic to reach consensus on concerted actions. Fundli and Drevland (2014), refer to the role of ICE-meetings and Big Room in making it easier to get clarification on issues. In the process of shared understanding, this actions towards "clarification" are key, and they seem to emerge in situations of collective problem solving (i.e. ICE-meetings), and are enhanced by the co-location factor (i.e. Big Room). Alhava et al. (2015) identified the increased task parallelism, as a benefit from co-location of participants, reducing the latency during design and reducing redesign.

SET-BASED DESIGN

Set-based Design starts with mapping the design spaces to define what decisions need to be made and establishing the available design options (Parrish et al., 2008). The set of alternatives or range of values are identified in this process (Ballard, 2000). According to Ballard (2000), this map of design space will define boundaries, in which all design contributors are free to develop their work. What Ballard (2000) describes seems to be more related to what Kvan (200) means with cooperation. Moreover, using the term "identify", indicates an effort for recognition (analysis) instead of creation (synthesis) in the action of mapping the design space. Considering the uniqueness of the project situation and the actions towards shared understanding it would be necessary to align it to a synthesis approach. The problem is that, it is not clear how the team should manage this action.

Each project participant must understand what is asked, articulating the levels of detail and accuracy required to define alternatives, taking into account the values and constraints that emerge from each member (Parrish et al., 2008). Those breakdown in communication highlights how important is to properly define the set in mapping the design space to articulate the input from the team (Parrish et al., 2008), which can be related to the process of *mediated coupling* presented earlier.

In Set-based design, Ballard (2000) also suggest integrating by intersection, which means to look for solutions within the intersections of sets, where the interface dimensions, for example, need to be based on shared values. The actions to work on the intersections, which means between boundaries, is a fundamental one in collaboration (i.e. "boundary objects"). At this point, is crucial to be able to engage in the Mediated Coupling process, in which the agents develop a combined representation to support negotiation and shared understanding.

Analysing the examples presented in Parrish et al. (2008), the different backgrounds of participants may affect some basic presumptions made on defining and working on the nature of abstract concepts in design, such as "*skin weight*", which consequently affects the understanding of the levels of detail and accuracy required by the other party in that design phase. In this situation, the emergent behaviour observed was that the affected party asked for clarification, in which the interdependent factors for decision-making were collectively understood through a breakdown, which can be related to the discussion on the *symmetry of ignorance.*

CHOOSING BY ADVANTAGES

Choosing By Advantages is a decision-making system that considers advantages of alternatives and supports comparisons based on these advantages (Suhr, 1999 citted in Parrish & Tommelein, 2009, 509). In comparing alternatives, participants will establish factors, which are dependent on their ability to discern unique advantages of the alternatives (Parrish & Tommelein, 2009). Factors are determined by a list of attributes, which must reflect facts wherever possible, postponing value judgment, making the process more transparent and defensible (Parrish & Tommelein, 2009). In CBA, arguments are built upon data that is relevant to a particular decision, providing stronger support and less ambiguity (Arroyo et al., 2014). This is an important feature of CBA, but it needs to consider the nature of knowledge and understanding. Providing the data/information that can be based in some knowledge structure, does not necessarily guarantee understanding. Since, understanding will be related to actions of synthesis, as an ability to make a proper decision. In this case, the use of logical reasoning, to describe and summarize the advantages of alternatives (Arroyo et al., 2014), may be examples of the use of causal knowledge and could be related to actions towards shared understanding.

At certain point, the group need to set the importance scale, defining the paramount advantage and assigning a degree of importance to advantages based on the multiple perspectives of the participants (Parrish & Tommelein, 2009). This could indicates a self-organized process of the team to support the coordinated perception of the project participants towards shared understanding on design decisions.

CONCLUSION

To better understand collaboration in design, there is a need to improve the theoretical foundations of shared understanding, which means to understand the dynamics of the social interplay to achieve consensus in concerted actions. We assume the definition of shared understanding as an ability to be collectively developed, contextually, in the realm of the project, which will be under the influence of many aspects of social interaction emerging to support team cognition (i.e., division of labour, coordinated perception and mediated coupling). More specifically, the process will involve two parallel abilities: one related to collective action for sense-making; and the second related to the collective coordination of interdependent perceptions between team members.

There seems to exist a problem of an epistemological nature, in which “knowledge” is considered as transferable. In this case, the general use of the term “ambiguity” is based on an idea of “sharing knowledge” and suggest an attempt to reach “common understanding”. This interpretation supports the idea of a unique organisational knowledge (as a “thing”), which exists outside individuals mind. However, this is contrasting with the nature of project situations and consequent actions, as it was addressed in the paper (i.e. specific, complex and tacticness). Since, the need to share understanding is based on a situation of working together, a proposed solution to the paradox demands to rethink the nature of knowledge, in alignment with the idea of social construction of “knowledge”, as a collective cognitive achievement, that cannot be dissociated from the situated action. In that sense, it can be argued that knowledge does not exist (or more precisely, could not be

measured) prior or without the ability to articulate it as an action to understand as specific situation.

A preliminary analysis shows that Set-based Design, Choosing By Advantages and Co-location have the potential to address parts of this process engaging project participants in situations in which they need to build shared understanding. However, it is still necessary to investigate how this process happens in depth and how management strategies could be adopted to improve collaboration through higher shared understanding in early design stages.

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