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COLLABORATION IN DESIGN – JUSTIFICATION, CHARACTERISTICS AND RELATED CONCEPTS

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ABSTRACT

The purpose of this article is to understand the academic landscape on collaboration in design, its characteristics and related concepts for promoting collaboration within in the project based production systems. We aim to answer to the following three questions: How to define collaboration in design and why individuals need to collaborate during design? What characterizes effective collaboration in design? Which concepts support the development of collaboration in design? For shedding light on this subject, a literature review is conducted and applicability to Architecture, Engineering and Construction industry and project delivery are discussed. In this study, it was found that collaboration is a complex phenomenon, which explains the diversity of views and many complimentary concepts in organizational and design literature. Collaboration requires the management of material and knowledge boundaries, in order to develop common goals, processes and product. Lean construction concepts, methods and tools have helped the teams to develop collaborative design and construction practices.

KEYWORDS

Design collaboration, collaboration, boundaries, bridging boundaries, crossing boundaries.

INTRODUCTION

Within the last twenty and more years, the lack of communication and collaboration have been considered as one major issue for underperforming construction industry (Latham

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1994). Since then, overcoming these barriers have been the central issue in the industry and academia, and through these developments collaboration has been instantiated in different forms within the three domains of projects' (Thomsen et al. 2009): commercial terms, organization and operating/production system.

Currently, there are two well established, but competing views of the collaboration in design, which include the constructivist approach (Bucciarelli 2003) and the communication theory (Carlile 2004). Former acknowledges design a as a social process, a dynamic intersection of social and cultural views for developing a common understanding; and the latter stemming from the information theory and mathematics, focused on the efficiency of exchanging information and meaning between two points (dispersed locations, individuals or groups of individuals) (Kvan 2000).

The purpose of this article is to understand the academic landscape on collaboration in design, its characteristics and related concepts for promoting collaboration within in the project based production systems The paper is structured as follows: in the first section of the paper, the definition for collaboration in design together with the justification are given; successively, boundaries and boundary bridging and crossing concepts are discussed to formulate the framework for analyzing existing practices; and finally, an example of the selected practice for promoting collaboration within the construction is reviewed and analyzed based on the developed framework.

DEFINITION AND JUSTIFICATION OF COLLABORATION

In the organizational and design literature, the related levels of working together are viewed as a collaborative continuum, dependent on the degrees of intensity and formality, but also on the sharing and assessing of knowledge through its exploration/creation (divergence) and knowledge integration (convergence) (Dorst 1997; Kleinsmann 2006). Based on these concepts, we have selected the definition proposed by Andreasen et al. (2015) to describe collaboration in design: "…is the process through which actors from different disciplines share their knowledge about the design process and the design itself. This creates shared understanding related to both process and artefact, helps integrate their knowledge, and helps them focus on bigger common objectives—the final product to be designed".

As also stated by Kleinsmann (2006), the three building blocks of collaboration are evident within the definition of collaboration proposed by Andreasen et al. (2015): knowledge creation/exploration and integration between disciplines; communication; and the creation of 'shared' understanding.

JUSTIFICATION - WHY COLLABORATION IN DESIGN?

The need to collaborate has historically emerged from the division of master builder into distinct functional disciplines (Pikas et al. 2015), each operating within their own object world - different paradigms, languages and activity systems (Bucciarelli 2003). In the design process, no single member has all the knowledge and skills needed for the project or information about the current state of every industry, requiring designers and engineers to share knowledge (Bucciarelli 2003).

Pikas et al. (2015) illustrated that all design disciplines are related as they have a common goal in terms of an artefact (common denominator), causing interdependencies

within individuals' design and engineering tasks that must fit together. Thus, in design and engineering, designers from different disciplines must work together for following three reasons (Koskela 2016): Needs arising from the demanding requirements (the purpose/goal of the artefact, when prior solutions do not suffice); needs arising from the design process (the timely delivery of each tasks' outputs); and needs arising from the product being designed (parts must physically fit together to deliver expected functions and behaviors).

RELATED CONCEPTS OF INTERACTION

Besides the collaboration, three other common terms used for describing the sociocultural interaction include communication, cooperation and coordination. However, communication as such is not the separate interaction, but it is the foundation for all of these interactions (Sonnenwald 1996).

Communication has been defined as a formal and transactional process for sharing information. According to Carlile (2004), the communication theory oriented design collaboration concepts emphasize the creation of shared vocabulary in order to reduce uncertainty. The focus is on the direct communication link between participants as information processing units. Communication can take place either synchronously or asynchronously, the former related to the direct and face-to-face communication, and the latter related to the usage information technologies for supporting the communication within the design processes (Emmitt and Ruikar 2013).

Besides the communication, also cooperation has been often used to describe the interactions within the design process. Organizational scientists Smith et al. (1994) defined the cooperation as an activity by which individuals, groups and organizations come together, interact and form relationships for the mutual gain and benefit. According to the Mattessich and Monsey (1992), within cooperation mission and goals of the different organizations are not considered/aligned; interaction and information sharing happen when needed; authority and resources rest within individual organizations; and control is centralized.

The other term often used to describe interaction in the design is the coordination. Crowston (1997) defined coordination as "…the management of dependencies among tasks and/or resources". According to Mattessich and Monsey (1992), coordination is slightly more formal than cooperation and expands it by focusing on the alignment of goals for compatibility; interaction around common project(s) or task(s); common planning of the project communication channels; separate but coordinated authority; some risks , control and leadership are shared; resources and rewards are mutually acknowledged.

According to the Mattessich and Monsey (1992) and Andreasen et al. (2015) within the collaboration all these aspects are more closely coupled, meaning that the common goals and interests are developed; and authority, responsibility, risks, control, leadership, resources and rewards are shared.

DISCUSSION

The need to work together has been caused by the division of labor and specialization, causing boundaries between individuals or groups of individuals, and thus the need for interaction. Levels of interaction have been understood as one continuum defined by the

degrees of intensity, formality, but also as a collective creation, sharing and assessing of design knowledge. These different levels of interaction have been called cooperation, coordination and collaboration, which are distinct, yet complementary concepts. Communication as such is not a separate dimension of interaction, it is required within all three for exchanging information about goals, processes and product. Within the next section, boundaries are defined and concepts for bridging and crossing boundaries are discussed.

COLLABORATIVE BOUNDARIES AND CONCEPTS OF BOUNDARY BRIDGING AND CROSSING

COLLABORATIVE BOUNDARIES

Akkerman and Bakker (2011) provide the following definition for the boundary: "…a sociocultural difference leading to discontinuity in action or interaction. Boundaries simultaneously suggest a sameness and continuity in the sense that within discontinuity two or more sites are relevant to one another in a particular way." Similarly, Star (2010) identifies boundaries as an in-between or middle ground, belonging to the both ("both–and") and at the same time to neither of the two worlds ("neither–nor").

Sonnenwald (1996) described the five types of boundaries, which the boundary spanners try to remove by using different communicative strategies and methods: organizational, discipline, task, personal, and multiple at the same time. What is important within this category of boundaries is the different levels of communicative interactions that are required for delivering designs.

Carlile (2004) proposed fundamentally different category of boundaries, using three concepts of knowledge: difference in the amount and type of knowledge accumulated; dependence between two or more entities that need to take each other into account; and novelty of the circumstances (e.g. new customer needs that generate new requirements). Based on these he proposed three categories of sharing and assessing knowledge across boundaries (Carlile 2004): "Syntactic – Differences and dependencies between actors are known. A common lexicon is developed that is sufficient to share and assess knowledge at a boundary"; "Semantic – Novelty generates some differences and dependencies that are unclear - different interpretations exist. Common meanings are developed to create shared meanings and provide an adequate means of sharing and assessing knowledge at a boundary"; "Pragmatic – Novelty generates different interests between actors that impede their ability to share and assess knowledge. Common interests are developed to transform knowledge and provide an adequate means of sharing and assessing knowledge at a boundary." These are the three different boundaries that need to be managed in order to cooperate, coordinate and collaborate.

Based on the work by Sonnenwald (1996) and Carlile (2004), boundaries can be divided into two the ontological realms, material and knowledge boundaries. The former are caused by the arrangement of individuals into organizations, disciplines, tasks and physical locations; and the latter, by the paradigmatic differences in sociocultural worlds. However, it is important to note that these two do not exist separately but are entangled into the interaction of individuals working together. An example from the design process could be

an architect and engineer from two separate organizations working together on a common project.

Within the organizational and design literature, several concepts have been proposed to bridge and cross boundaries. Four concepts have been central for supporting the continuity across systems/sites: boundary roles and standardized methods for material boundary bridging; and collective learning mechanisms and boundary objects for knowledge boundary crossing.

MATERIAL BOUNDARY BRIDGING CONCEPTS

Boundary Bridging Roles

Individuals acting in the middle ground have different roles for the purpose of supporting continuity of working together (transition and interaction across different sites) (Akkerman and Bakker 2011). Sonnenwald (1996) defined boundary bridging role as "…communication and information processing behavior between two or more networks or groups" and identified several boundary crossing roles: the internal star (individuals within project/organization/department members occurred more frequently), external star (individuals who had a high frequency of communication external to their project) and gatekeeper (individuals who had a high frequency of interaction both outside and inside their projects). Each of these roles are using different strategies and methods to do the boundary bridging. What is important in Sonnenwald (1996) concept is that the design participants may assume one or more roles within the team communication and collaboration, and these in turn are dependent on the context and content of the design and process.

Standardized Methods

While studying the collaborative working of scientists and novice workers, Star and Griesemer (1989) introduced also another concept, which they named standardization of methods. They characterize methods standardization as follows: "…methods standardization allowed both biologist and collectors to find a common ground in clear, precise, manual tasks." What this says about the interaction is that it is not just redesigning of the organizational structure, but it is the quality of the implementation of methods that help to promote the team working (Majchrzak and Wang 1996). In addition, managers should consider the constraints and possibilities provided by technology, the work processes, the existing organizational culture, and the organization's strategic mission. Interestingly, the standardized methods have often been neglected from the discussions of Star's original contribution (Akkerman and Bakker 2011; Koskela 2015).

KNOWLEDGE BOUNDARY CROSSING CONCEPTS

Learning Mechanisms for Boundary Crossing

Within the design and organizational literature, many different models for learning mechanisms have been proposed. Katzenbach and Smith (2005) defined team as "…a small number of people with complementary skills who are committed to a common purpose, set of performance goals, and approach for which they hold themselves mutually accountable".

For the formation of teams, "shared understanding" is required between individuals. However, what does shared understanding mean? Moller and Tollestrup (2013) concluded that it is not the 'shared understanding' of the team members, but 'sharedness', as meaning making or framing is 100% individual. This means that it is the capacity of re-learning by individual that defines the reflective practitioner (Schön 1984). Thus, designing within teams is about learning and re-learning.

Engeström (2000) proposed a stepwise cycle of horizontal expansive learning, including questioning, analysis, modelling, examining and implementing. A crucial triggering action in the expansive learning process is the conflictual questioning of the existing collective but also individual standard practices (Engeström et al. 1997). Questioning leads to deepened analyses of the design, which in turn means sharper and more articulated questioning. Thus, actions of questioning and analysis are aimed at finding and defining problems and contradictions behind them (Engeström 2000). The third strategic action in expansive learning is modelling, involved already in the formulation of the problem and results of the analysis of contradictions. This process concludes with the actions of examining and implementing the new model in practice (Engeström 2000). In summary, collective learning is a process, requiring continued negotiation and combination of different perspectives and conceptualizations.

Boundary Objects

Star (2010) defined object as a thing, composed of "more or less well-structured stuff" in pragmatist as well as in material sense. She defines object something that people act towards or with, while having a certain intention. This means that boundary objects provide a syntax for the intersecting work of knowledge domains, allowing the exploration of semantic differences and help the joint transformation of knowledge between practice communities (Carlile 2004). Furthermore, boundary objects are central to both the representation of past learning and the construction of new meanings (Carlile 2004).

The form of the boundary object derives from "information and work requirements" (Star 2010). Based on its form, Star and Griesemer (1989) categorized boundary objects into four categories: repositories (ordered piles of objects); ideal type (abstract and conceptual representations); coincident boundaries (common objects which have the same boundaries but different internal contents); and standardized forms (devised as methods of common communication across dispersed work groups). These objects have different capacities to represent the common knowledge (Carlile 2004).

Later, Star (2010) elaborated on boundary objects and identified three basic concepts: interpretive flexibility; the structure of information and work process needs and arrangements; and the dynamic between ill-structure and more tailored uses of the objects. The first means that the same object can be used for different purposes; second how boundary objects provide continuity of doing things together; and thirdly, using boundary object as means for moving between ill- (group) and well-structured (individual) social worlds. Thus, Bowker and Star (2000) defined boundary objects as four-dimensional and complex artefact, being temporal, based in action, and subject to reflection and local tailoring all at once. Boundary objects are dynamic in nature, having different meanings over time.

DISCUSSION

It is the division of labor and specialization that have caused the material and knowledge boundaries between individuals or groups of individuals, who have their own paradigms, languages and activity systems. Consequently, for supporting the continuity of collaborative working at the boundaries requires: individuals filling in boundary crossing roles; standardized methods to promote the quality of teams working; learning and re-learning at the boundaries; and usage of mediating boundary objects.

For the purpose of this article, two categories of boundaries are disentangled and an initial analytical framework is proposed as shown in the Table 8. Moving on the vertical axis, between and within organizations, disciplines, tasks and individuals, requires persons filling in boundary crossing roles and standardized methods to define and communicate common vocabulary, meaning or interests; and moving on horizontal axis requires using collective learning and usage of boundary artefacts. One can use the framework to ask for example following questions: How to manage 1) Organization and syntactic boundaries, 2) Organization and semantic boundaries and so on.

Table 8. Collaborative design framework.

Boundaries		**Syntactic**	**Semantic**	**Pragmatic**
Collective	Organizations	**Goal:** Common vocabulary (syntax) to reduce uncertainty **Temporal:** Formally structure	**Goal:** Common meaning **Temporal:** Processes for developing a shared meaning	**Goal:** Common interests and goals to work towards **Temporal:** Processes for defining
	Disciplines			
	Tasks			
Individual	Personal			

Managing material boundaries: Boundary Crossing Roles and Standardized methods

Managing knowledge boundaries: Learning Mechanisms (questioning, analysis, modelling, examining and implementing) and Boundary Objects

REVIEW OF LEAN CONSTRUCTION PRACTICES

From the above it is clear that collaboration in design is described by different levels of the interaction, named cooperation, coordination and collaboration. Moving between these different states and levels of interaction requires bridging the material boundaries and crossing the knowledge boundaries. What is important to note is that collaboration is a continuous process. Within following, we shortly review some of the key lean construction (LC) practices for the bridging and crossing of boundaries, which need to be analyzed more in-depth within the future research.

Boundary Bridging Concepts in Lean Construction

In LC, several different concepts and methods have been proposed to bridge the material boundaries. Few include the co-location within the 'big room', for bringing individuals physically closer to each other in order to shorten the communication pathways (Dave et al. 2015); the last planner system as a standardized operating system for collective

planning, execution and improvement of the production system (Ballard 2000); and the leads of the cross-functional teams to do boundary bridging by communicating and coordinating information and work between different clusters and within clusters (Do et al. 2015).

Boundary Crossing Concepts in Lean Construction

Some of the boundary crossing concepts in LC include: choosing by advantages, which is a process comprising of the set of methods for argumentative, collaborative and holistic decision making (Suhr 1999); value stream mapping as a visual tool for documenting and visualizing all the steps in the workflow that add value or do not add value to the final deliverable from the perspective of the customer (Rother and Shook 2003); an A3 report with a structured layout providing a methodology for the initiation, development, sharing, and documentation of ideas, problems and information within organizational setting (Sobek II and Smalley 2011); and building information modelling (BIM), which according to the stage of the project progress can have different meanings, it can act process facilitator but also as a representation of collective knowledge (simply a model) (Eastman et al. 2011). Thus several of these concepts act as boundary objects and learning mechanisms at the same time.

CONCLUSIONS

Collaboration is a complex phenomenon and many partially or fully overlapping concepts have been proposed. It is a process of creating/exploring, sharing and integration of knowledge, requiring the management of material and knowledge boundaries in order to develop common goals, processes and product. Bridging the material boundaries requires individuals filling in the boundary bridging roles and standardized methods of working together. Crossing the knowledge boundaries requires collective learning by means of debating, negotiating and combining of different perspectives and conceptualizations of vocabulary, meaning and interests. In lean construction many concepts, methods and tools have been developed to promote collaboration within the design and construction process. Some of these include co-location, ‘big room’, last planner system, and the leads of the cross-functional teams for boundary bridging; and choosing by advantages, value stream mapping, A3 report and building information modelling for boundary crossing. The scope of this research is limited as only a handful of concepts related to collaboration were discussed. For example, we have omitted to discuss the activity system theory, grounding and mediating artefacts, to name a few. Furthermore, several questions remain that need to be addressed in the future research: Which other concepts of collaboration in design exist; how to measure collaboration in terms of understanding the most influential factors of success; how collaboration influences the design process outcome; and finally, is collaboration always needed?

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