COLLABORATIVE CONCEPT DESIGN AS SOCIO-CONSTRUCTION

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Abstract

This research addresses the problem of lack of integration on decision-making caused by misunderstandings between team members during collaborative concept design. Previous research on collaborative design indicated relevant empirical evidence that current concepts of collaboration in design and construction focus on changing the context and the media, and have not properly addressed the socio-constructive nature of collaboration, failing to allow the development of particular abilities required to engage in collective creative situations. In this research it is argued that while the development of such new context and new media can contribute for integrating organizations, process, communication and coordination, they have limited capacity to support collective reasoning on decision-making, especially during concept design. The research approach is a synthesis of the literature, presenting a new model to study collaboration in concept design. The paper discusses the concept of collaboration in conceptual design, and explains collaboration as a socio-constructive act. Collaboration in design should be considered as dependent on the group ability to engage in self-reflective actions, allowing the group to conduct collective decision-making. Further development will provide ways of measuring this and investigating how a multidisciplinary design team can improve collaboration.

Keywords: *Collaboration, Multidisciplinary Team, Concept Design, Shared Understanding and Social-Constructive Interactions.*

Introduction

The poor performance of construction projects generates cost overruns and client dissatisfaction. One of the main causes for this is the fragmentation of the industry, usually manifested through the traditional sequential nature of decision-making processes and the cultural dispersion involving individualisation in training and specialisation of disciplines (Coyne and Snodgrass, 1993; Bertelsen, 2003; Zimina et al., 2012). In order to overcome such fragmentation, many researchers in last 40 years have investigated the nature of integration in terms of collaborative efforts (Crichton, 1966; Arup, 1970; Koskela et al., 2003; Shelbourn et al., 2007; Forgues and Koskela, 2009). A critical analysis on the literature show that definitions have been proposed with a partial view of the phenomena, in which collaboration is achieved through the implementation of new context and new media (Coyne and Snodgrass, 1993; Dorst, 2006; Forgues and Koskela, 2009). It could be argued that while the development of such new context and new media can contribute for integrating organisations, process, communication and coordination, they have limited capacity to support collective reasoning on decision-making, especially during concept design.

In concept design, the wicked nature of design (Rittel, 1987; Bertelsen, 2003) requires collaboration to be conceptualized in terms of collective creative actions to be developed through team interactions. Building on previous work from Schön (1983), Rittel (1987), Dorst and Dijkjhuis (1995) Arias et al. (2000), Craig and Zimiring (2002) Dorst (2006) and Cardoso et al. (2016), it is suggested that collaborative concept design requires the ability to conduct collective reflective actions, so that collaboration is intrinsically related to actions to build shared understanding about concepts of product and process among the design team (Valkenburg, 1998). Therefore, design actions will evolve as a set of compromises on design decisions, as a product of social-constructive interactions to build shared understanding, which is deeply situated (Suchman, 1987), and cannot be prescribed in terms of collaborative organizations and tools (Gharajedaghi and Ackoff, 1984).

In this context, the aim of the paper is to discuss how the diverse concepts of collaboration hamper the development of collective reasoning in concept design. Alternatively, it is suggested that collaboration in design should be considered as dependent on the group ability to engage in self-reflective actions, allowing the group to conduct collective decision-making. Further development will provide ways of investigating and measuring how a multidisciplinary design team can improve collaboration.

Collaboration in Design

In construction design research, there is a myriad of conceptualisations of collaboration, which are diverse, creating problems on how it may be addressed in practice. In order to better understand the characteristics of each conceptualization of collaboration and the further research related to adoption and improvement of collaborative practices in construction, this research uses the framework of Activity Theory developed by Engeström (1987; 2001).

If we agree that, design team's interactions will involve the negotiation of shared frames, in which individuals understanding of the design situation are conceived and externalized through artefacts, making the implicit frame more explicit, which than become target of negotiation to establish a shared frame resolving eventual conflicts (Schön, 1983; Hey et al., 2007). It is possible to say that, an integrated design team can be considered as sophisticated activity system (Forgues et al., 2009), following the Activity Theory proposed by Vygotsky (1978) and further developed by Engestrom (1987).

According to Vygostsky (1978), every human act should be understood as an Activity System, in which human actions involve a triad of subject, object and mediating artefacts, leading to a cultural mediation of actions (figure 1). In Activity Theory, human actors work within a broadly objective, but socially and culturally defined reality (Nardi, 1996). More importantly, their activities are themselves mediated by tools, as mediating artefacts, that are culturally biased, and which consequently, are developed and transformed during the activities (Nardi, 1996; Engeström, 2001). Further development on the Activity Theory model expanded it to consider collective activities (Engeström, 2001), in which the uppermost sub-triangle represents individual and group actions embedded in a collective activity system (figure 1). The model suggest that object-oriented actions are always, explicitly or implicitly, characterized by ambiguity, surprise, interpretation, sense-making, and potential for change (Engeström, 2001). The third generation of activity theory was developed towards understanding the interactions to form new meanings that goes beyond two or more activity systems (Engeström, 2001). This author suggest that in this situation (figure 1) the initial state of the object(1) is unreflected, moving to a following state of collectively meaningful object constructed by the activity system (object(2)), and to potentially shared or jointly constructed object(3).

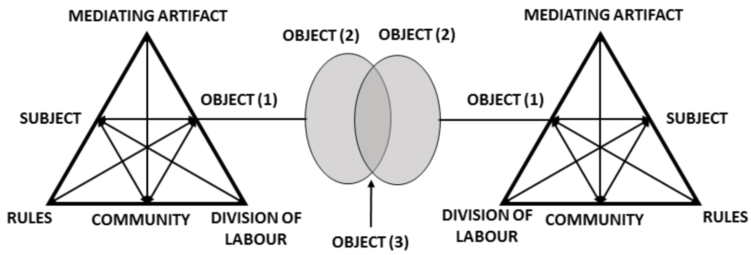

Figure 1: Third generation of Activity Systems Theory model

Assuming the socio-constructive nature of collaborative design proposed by Schon (1983) and Hey et al. (2007), the Activity Theory model offers a framework to help understand the diversity of approaches on the conceptualization of collaboration in design. In order to do that, this study draws attention to the dynamic interaction between the components of the Activity

Theory Model, in which the interactions between different subjects, their mediating artefacts and the object, configure a system called Media. While the set of interactions between subjects using mediating artefacts defining rules, community and division of labour, can be considered as system defining the context.

We argue that these two sub-systems of interactions within the Activity Theory Model can be related with two parallel and complementary perspectives conceptualizing collaboration in construction (figure 2). One, in the upper part of the model, related to Kvan's (2000) definition of collaboration as means of interaction, and dealing with systems to support the mediation of perceptions and interpretations involved in communication and coordination between activity systems. The other, in the lower part of the model, related to Mattesschi and Monsey (1993) definition of collaboration as specific king of relationship, and dealing with the context of the organization and its processes, establishing roles and responsibilities between activity systems.

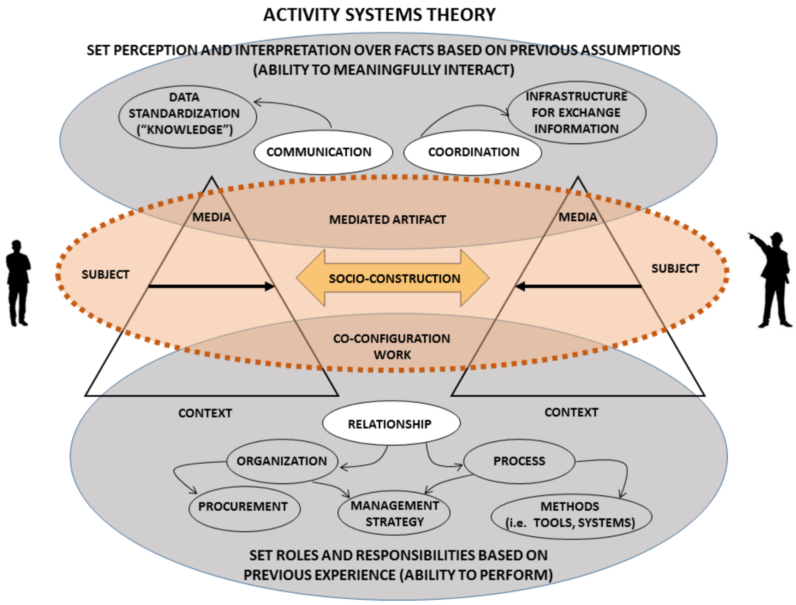

Figure 3: Activity Systems framework to analyse concepts of collaboration in AEC projects

In the next two following sessions, this dyad of concepts of collaboration is explored briefly, considering the two frames of the Activity Systems theory model suggested above. The objective is to characterize those conceptualizations and their limits to support collective decision-making, especially in concept design.

Collaboration as Context of Interaction

Collaboration have been considered as a type of relationship involving integrated stakeholders sharing resources (Mattesschi and Monsey, 1993; Schottle et al., 2014). Under this perspective, collaborative situations are realised by redesigning the relationship context in terms of organizational structures and processes (Arup, 1970; Ballard, 2000; Parrish et al., 2008; Mossman et al., 2011). Collaboration is built on a common vision within an organizational structure commonly developed by the team in a new project (Schottle et al., 2014).

In order to improve collaborative performance, some studies have been focusing in changing the organizational structure by the suggestion of new procurement routes (i.e. Integrated Project Delivery) along with new project management strategies (i.e. Target Value Design) (Mossman et al., 2011; Zimina et al., 2012). While other studies to improve processes have been proposing solutions based on methods and tools to enable integrated approaches (i.e. Last Planner System, Set-Based Design, Concurrent Engineering and Choosing-by-Advantages) (Ballard, 2000; Parrish et al., 2008; Parrish and Tommelein, 2009; Fundli and Drevland, 2014; Arroyo et al., 2014; Alhava et al., 2015).

To achieve collaboration in terms of organizational change, the fragmented context of construction projects defined by transactional procurement routes should be abandoned (Egan, 1998; Koskela et al., 2003; Bertelsen, 2003; Zimina et al., 2012) and new forms of relational contracts have been developed (Forgues and Koskela, 2009). Those new forms of procurement, like the Integrated Project Delivery (IPD) enable the early involvement of the different stakeholders and support the alignment of commercial terms for project-level teams, in which profits and risks are shared among stakeholders to create a unified project culture (Parrish et al., 2008; Mossman et al., 2011). However, results from a study on the influence of new procurement forms in the performance of integrated teams, showed that the adoption of a relational contract was not sufficient to mitigate socio-cognitive barriers between the players (Forgues and Koskela, 2009). According to these authors, while new procurement routes can provide a better context for integrated teams, it is possible to recognize fundamental limitations regarding project managers and designers' ability to perform in a new collaborative context.

In terms of new process approaches, previous research showed that, particular methods as Set-based Design and Choosing-By-Advantages, in a Co-location situation, have the potential to engage project participants in situations in which they are capable of engaging in collective decision-making actions on concept design stage (Parrish et al., 2008; Parrish and Tommelein, 2009; Arroyo et al., 2014; Gomes et al., 2016).

The limitation of this perspective of collaboration seems to be that, while tools and methods can play an important role in changing traditional systems of work, changing roles and responsibilities between participants, they seem to be not enough to provoke changes in attitude and behaviour (Zimina et al., 2012). For example, Howell et al. (2004) criticise traditional project management models in construction saying that they fail to create the necessary situations of conversation necessary to develop shared perspectives and common concerns. Moreover, Howell et al. (2004), rightfully recognize that creating a coherent team takes time, engagement and reflection, in order to align and connect the diversity of individual interests within the project.

Collaboration as Means of Interaction

Collaboration have also been considered as a media framework enabling enhanced communication and coordination between stakeholders (Maher et al., 1996; Kvan, 2000; Wang et al, 2002; Anumba et al., 2002; Eastman et al., 2011; Singh et al., 2011). Under this perspective, efforts have been made to develop integration through the redesign of the interaction means, as systems of mediating artefacts between agents (i.e. software tools). Working on the interactions between human and computer systems to support collective design activity, researchers following this approach have been developing communicative and coordinative capabilities as two complementary structures for mediation, as systems for standardization and infrastructure for data exchange (Maher et al., 1996; Kvan, 2000; Wang et al, 2002; Anumba et al., 2002; Eastman et al., 2011; Singh et al., 2011).

Because of the wicked nature of design situations, the highly distributed nature of design teams and the diversity of design tools, these approaches are becoming insufficient to support collaborative design (Wang et al., 2002). Mostly, because the majority of these tools do not support a rapid and reliable evaluation of several design options with the necessary input from people with a multidisciplinary background, and more importantly, complex activities as conflict resolution and generating new solutions are still left to the human expert (Wang et al., 2002).

For example, the pattern of actions in collaborative design shows that designers tend to document less information in a collaborative session because they can describe their intentions verbally (Maher et al., 1996). According to these authors, new models of representation are not enough, and the complexity of design artefacts requires different methods of interaction (i.e. the manipulation of graphic models). In these situations, semantic descriptions define the purpose and performance of design artefacts, and may be represented differently considering the various disciplines involved (Saad and Maher, 1996). The challenge is to integrate the various perspectives emerging from different reasoning process articulated by team members (Arias et al., 2000). Ideally, these approaches would allow designers to work on the combination of shared visual and semantic representations of design artefacts, in a way that could communicate their understanding using different media (Saad and Maher, 1996).

One problem is that, while researchers suggest that the use of computer systems and shared ontology, to address the diverse nature of data in terms of information and knowledge in AEC projects, could help to improve communication between participants in design (Anumba et al., 2002; Eastman et al., 2011), they fail to direct support collaborative nature of team interactions (Saad and Maher, 1996).

These limitations wer identified in the study of building information modelling (BIM) and how it can influence the patterns of interaction in the concept design (Forgues et al., 2009; Adamu et al., 2015; Forgues et al., 2016). The core principle of BIM is about sharing data in common platforms (Forgues et al., 2016). Ideally, BIM can improve the quality of decisions made during concept design, based on quick feedbacks supported by more precise information regarding the building program, environmental considerations and costs constraints (Eastman et al., 2011). However, the current technology base is still not in the place to support the necessary change, and paper and pencil remain as dominant tools in concept design situations (Eastman et al., 2011). According to Shelbourn et al. (2007) collaborative approaches that are purely based on information technology are bound to be less than successful, unless the aspects of organization and human interactions are considered as part of the implementation, and take into account the barriers within the workplace when people are confronted with technological change. Recent studies on computer systems to support collaboration (i.e. BIM) indicate the need to advance in the social aspects of collaborative interactions involving discussions around abilities for social construction of meaning (Adamu et al., 2015; Forgues et al., 2016).

Collaboration as Purpose of Interaction (Collective Creation)

Effective collaboration requires that the three different aspects of context, means and collective reasoning (i.e. as collective decision-making in design) to come together (Shelbourn et al., 2007). However, the recognition that new contextual and mediated components have limited capability to promote changes towards collaborative creative practices, invites to explore the cognitive components of these activities. It starts with an interpretation of the phenomena of collaboration as a natural and integral part of human life, in a way that, collective actions cannot be dissociated from individual meaningful interactions. Following the Activity Theory (Engeström, 2001) rationale, context and media are product of those interactions, and should be created and manipulated only through purposeful actions of social construction, which seem to be missing from the approaches mentioned previously.

Alternatively, collaboration can be defined as a situation of shared creation, in which the collection of agents with complementary skills interact to create a shared understanding about a process, a product or an event that does not pre-exist to that collective situation (Schrage, 1995). Following this definition, collaborative design be a situation in which stakeholders could reason directly about emergent conflicts and collectively work towards new perspectives to mitigate it (Craig and Zimring, 2002). According to these authors, the effects of a collaborative approach in design is to allow collective reflection-in-action (Schön, 1983), in which collaborators help each other to discover unintended consequences of design moves.

In collaborative design, designer will differ from one another in respect to design judgments and ways of framing problems, coming to interact with different perspectives and systems of inquiry (Schon, 1984). It seems that, to be aware of a conflict of appreciation, may lead designers working on the same task to carry out another sort of inquiry, which eventually can reveal both the intractability of their dilemma and an alternative approach to the design solution (Schon, 1984).

Parallel to that, collaborative design deal with a representational process in social aggregation (Qu and Hansen, 2008), and artefacts are means to embody these reasoning (Fischer, 2004). It is more than a simple aggregation of individuals and involves discussing and negotiating representations structure to achieve a level of consensus. Since the coupling of representations and understanding cannot be assumed, a collective effort is necessary to support change in each collaborator's internal representation and meaning, to come to a collectively constructed shared understanding (Peng, 1994; Qu and Hansen, 2008; Oehlberg et al., 2012).

During these negotiations, designers usually find themselves in a field of positions with competing arguments, which must be assessed in order to establish a project position (Rittel, 1987). In this perspective, commitment to particular positions matches personal beliefs, convictions, preferences, and values, unless someone else, as the client or a team member, acts to persuade or convince of his own insight. Rittel (1987) highlights that, design as plan-making aims at the distribution of advantages and disadvantages in committing resources within a social context. Therefore, plans can never be beneficial to whole group and design outputs will usually be compromises resulting from negotiation and the application of power (Rittel, 1987).

This socio-constructive and conversational nature of design is one that depends on a set of abilities allowing the social construction of possible futures (Lloyd and Busby, 2001). According to these authors, conversations take place over a bedrock of common assumptions and experiences, allowing participants to interact without extensive explanations. Common assumptions usually refer to technical properties of a design solution, and common experiences relates to past events or facts that serves as ways of contextualize the current situation (Lloyd and Busby, 2001). Both can be seen as discursive objects (i.e. mediating artefacts), serving as objective reference for interpretation of the situation. Analysing the occurrence of disagreements, the authors identified that they often happen over the consequences of certain "facts" in the evolving situation. In these occasions, the designers put their technical skills in second and displayed a certain set of skills to make a convincing interpretation of the situation. Designers showed a set of skills to construct an effective argument to get their version of the consequences on a situation accepted by the meeting (Lloyd and Busby, 2001).

According to these authors, designers in a meeting can demonstrate rhetorical abilities, using language mechanisms, as of engagement, exaggeration and imagery, in which they try to create situations of implied objectivity regarding a common agreement and/or past experience. Rhetoric works as means for human productive interaction, in which persuasion acts towards compliance (Koskela, 2015), on design decision for example. Moreover, rhetoric skills seem to be key to support the collective construction of thought that decision-making demands in AEC projects. As well as graphic representations can help designers to explore the consequences of a design move, the use of discourse can provide a kind of collective sketching function remaining ambiguous for longer, as first level of prototyping (Lloyd and Busby, 2001).

Consequently, it would be possible to suggest that collaborative design requires further exploration of the nature of the skilful team interactions for social construction of meaning.

Conclusion

The Activity Theory model offers a framework to help understand the diversity of approaches on the conceptualization of collaboration in design. Following this model, it is possible to recognize that two parallel and complementary definitions of collaboration have dominated the literature in construction. The problem is that those perspectives seem to imply that the integrated collective effort defined as collaboration, is considered to exist as a pre-condition of the system (i.e. context and media). Consequently, those approaches to collaboration have created a partial view of collaborative activity, limiting the capacity of design team to operate creatively. More importantly, the Activity Theory Model brings to light the importance of considering the interaction between subject and object, putting into evidence collaboration defined as the purpose of the interaction between two or more activity systems.

From this perspective, the purpose of Collaborative Design is to be a collective creative situation, in which a multidisciplinary team collectively contribute in the representation activity to compromise on design decisions while being collectively aware of the consequences of those actions. This socio-constructive account of collaboration should support the development of more appropriate strategies to overcome the lack of integration on decision-making caused by misunderstandings between team members in the collaborative concept design. Further steps on this research will use this perspective to inquire on ways to measure and improve collaborative performance of design teams.

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