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ARTICLE

Metaphors of collaboration in construction[1]

Danilo Gomes and Patricia Tzortzopoulos

Abstract: Collaboration is essential for the success of construction projects. However, the concept of collaboration is unclear, and the term is often related to different meanings. Construction research defines collaboration in different ways, having been influenced by other research fields (e.g., social sciences and philosophy). This paper discusses existing definitions of collaboration and how they relate to three perspectives on the nature of collaborative interactions, linked to organisational metaphors. The research was developed through a literature review, including the conceptual analysis of existing definitions of collaboration. The discussion proposes that metaphors not only describe collaboration ontologically, but also establish different appreciative systems by which individuals conceive and evaluate their collaborative performance. The aim of this discussion is to address the lack of consistency in defining collaboration in construction, embracing the coexistence of interpretations. This can help researchers and practitioners understand how to overcome misunderstandings and explore initiatives to improve collaboration.

Key words: collaboration, appreciative systems, metaphors, misunderstandings, socio-construction.

Résumé : La collaboration est essentielle au succès des projets de construction. Cependant, le concept de collaboration n'est pas clair, et le terme est souvent lié à plusieurs sens. La recherche en construction définit la collaboration de différentes façons, ayant été influencée par d'autres domaines de recherche (p. ex., sciences sociales et philosophie). Cette étude examine les définitions actuelles de la collaboration et leur lien avec trois perspectives sur la nature des interactions collaboratives, liées aux métaphores organisationnelles. La recherche a été élaborée au moyen d'une revue de la littérature, y compris l'analyse conceptuelle des définitions existantes de la collaboration. La discussion propose que les métaphores non seulement décrivent la collaboration ontologiquement, mais aussi établissent différents systèmes d'appréciation par lesquels les individus conçoivent et évaluent leur performance collaborative. Le but de cette discussion est d'aborder le manque de cohérence dans la définition de la collaboration dans la construction, y compris la coexistence d'interprétations. Cela peut aider les chercheurs et les praticiens à comprendre comment surmonter les malentendus et explorer les initiatives visant à améliorer la collaboration. [Traduit par la Rédaction]

Mots-clés : collaboration, systèmes d'appréciation, métaphores, malentendus, socio-construction.

1. Introduction

Human activity, whether we are aware of it or not, is collaborative and public (Coyne and Snodgrass 1993). Throughout history, the term collaboration has been used widely, carrying a variety of meanings (D'Amour et al. 2005; Thomson et al. 2007; Poirier et al. 2016). In construction, the broad use of the term means that the concept of collaboration remains amorphous (Poirier et al. 2016). The most influential theoretical definitions of collaboration were originally proposed in the fields of organisational theory and sociology (D'Amour et al. 2005), and these have been adapted and transferred to construction (Schottle et al. 2014; Poirier et al. 2016).

In practice, this lack of consistency in defining collaboration in construction can have negative implications when participants from diverse disciplinary fields try to make sense of the project activity based on different experiences, values, and history of professional relationships (Gray 2004). Divergent understandings of what constitute collaboration become evident when stakeholders use the same term to refer to tasks that may vary in intent and degree of participation (Kvan 2000; Forgues et al. 2016).

People may be locked into "patterns" of understanding that obscure other ways of conceiving and perceiving collaboration (Coyne and Snodgrass 1993; Schrage 1995; Leon and Laing 2014). Thus, collaborative initiatives fail when participants cannot find satisfactory approaches to understand each other, or when they cannot find suitable ways to reinterpret and reshape the situation (Gray 2004) and align expectations to overcome any conflict of understanding.

In this context, the aim of this paper is to discuss the lack of consistency in defining collaboration in construction, by answering the following questions:

(*i*) Why is there no consensus over definitions of collaboration in construction?
(*ii*) How collaboration tends to be interpreted in construction?
(*iii*) What are the consequences and implications of such diverse interpretations of collaboration in construction?

As such, the paper explores why individuals construct different understandings about collaboration and how these understandings lead to different ontological standpoints in the project activ-

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Table 1. Key publications on collaboration in construction.

Journal title	Reference	Citations*	Title of paper
Automation in Construction	Kvan (2000)	533	Collaborative design: what is it?
Construction Management & Economics	Bresnen and Marshall (2000)	358	Building partnerships: case studies of client–contractor collaboration in the UK construction industry
Design Studies	Valkenburg and Dorst (1998)	480	The reflective practice of design teams

*Number of citations according to Google Scholar visited at 2 May 2019.

ity. The paper presents a way to interpret the diverse and situated nature of collaborative interactions, suggesting that research should embrace the coexistence of diverse interpretations of collaboration that allow reflective interactions between project participants to build mutual intelligibility across the project team.

2. Method

The review of prior literature is a fundamental feature of academic research (Webster and Watson 2002), and it helps to justify and demonstrate the relevance of the research, based on existing knowledge (Hart 1998; Gill and Johnson 2002). It also outlines the main limitations of existing research in a field (Seuring and Müller 2008).

A literature review is an explicit way of selecting, evaluating, and interpreting the existing body of knowledge on a topic, to fulfil a specific aim, or express a certain view (Hart 1998; Fink 1998). It usually aims at identifying patterns and themes that summarise existing research, contributing to theory development by identifying conceptual contents (Seuring and Müller 2008). Thus, it can support the description and critical analysis of the historical development of knowledge in a specific subject of study (Jankowicz 2000).

A literature review can reveal the interchangeable use of certain terms, or constructs, as well as the lack of consistency in operationalising these (Garcia and Calantone 2002). Thus, considering the lack of consistency around the concept of collaboration in construction (Schottle et al. 2014; Poirier et al. 2016), the development of a literature review to map different "patterns" of understanding about the topic is needed.

A snowball method was adopted for this literature review. A backward snowballing is a literature review method that starts by focusing on important sources of references and expands the search via references found in these key publications (van Aken and Berends 2018). The set of relevant publications expands, just as a snowball grows larger and larger (van Aken and Berends 2018). Thus, it is wise to add some selection criteria, as the snowball method can yield a large amount of potentially relevant publications.

In this study, the search for relevant publications on the topic of collaboration in construction started with a structured keyword search for the term collaboration, in three key journals, namely *Design Studies* (Elsevier), *Construction Management and Economics* (Taylor & Francis), and *Automation in Construction* (Elsevier). These journals were selected because they are all Q1 journals with H index above 70, according to Scimago Journal & Country Rank, SJR. Moreover, as each of these journals focus on different aspects of construction (design, automation, and management), they would potentially provide a wide range of perspectives about collaboration. The snowball literature review took into consideration publications that attempted to define collaboration. Considering their date and number of citations, three of those journals were considered key publications, as presented in Table 1.

Next, the literature review expanded to include some of the references identified in these papers. This process took into consideration the fact that construction management research tends to be informed by fields like organisational theory, social sciences, and philosophy. Overall, around 120 publications were reviewed to verify if they presented a clear definition of collaboration, 26 of which were included. Subsequently, the content of the 26 selected publications was assessed through a qualitative analysis of the concept of collaboration presented. These concepts of collaboration were clustered in three main categories of collaboration in construction projects.

The first part of this review follows a sequential approach (van Aken and Berends 2018), in which the ideas and concepts of collaboration are presented in a chronological order, according to each metaphor of collaboration. This approach was adopted because it fits the goal of familiarising the reader with a certain perspective on the topic (van Aken and Berends 2018). The second part presents a qualitative integration of these ideas and concepts (van Aken and Berends 2018). Through the use of matrices, the authors make distinctions and compare different aspects of the three perspectives of collaboration here identified.

The main limitation of this literature review is the subjectivity involved in the procedures adopted. It is recognised that the review can be biased, which may lead to lack of rigour (Tranfield et al. 2003). As opposed to a systematic review, which suggests a positivist and quantitative intake to research, the approach adopted in this study focuses on a qualitative assessment, exploring the different meanings given for collaboration.

3. Appreciative systems and metaphors of collaboration

Previous research suggested that conflicts of understanding amongst project participants, whether perceived or not, emerge as dilemmas or contradictions related to conflicting appreciative systems (Schön and Rein 1994; Gray, 2004). Appreciative systems (Vickers 1965), interpretive schemes (Dougherty 1992), frames of reference (Schön and Rein 1994), or object worlds (Bucciarelli 2002) are different terms indicating the existence of distinct systems of meaning, acting as underlying structures of belief, perception and evaluation. These systems of meaning render selective filters in individuals' interpretation of similar information. Consequently, different appreciative systems produce a qualitatively different understanding of a situation (Schön 1983; Dougherty 1992).

An appreciative system provides shared assumptions about reality, influencing how people organise their thinking and action, identifying relevant issues and supporting sense-making (Vickers 1965; Dougherty 1992; Schön and Rein 1994).

In the case of collaboration, the existence of different appreciative systems has been related to the use of metaphors (Morgan 1980; Tomelleri et al. 2015). In essence, a metaphor means that one thing is seen as another; consequently, the existing description of one thing is taken as a commonly believed redescription of the other thing (Schön 1963; Schön and Rein 1994). Such reinterpretation carries over to a new situation a set of familiar notions as, for example, the evaluation implicit in the previous one (Schön and Rein 1994). As a result, both the familiar and unfamiliar come to be seen in new ways (Schön and Rein 1994). Moreover, a metaphor implies a socially shared way of perceiving a situation, and it conveys the way in which it is possible to produce changes in the situation, unconsciously establishing a sense of performance (i.e., success or failure) in practice (Tomelleri et al. 2015). For this reason, people tend to use metaphors to describe shared artefacts

of their interactions, e.g., institutions, organisations, norms, and rules (Tomelleri et al. 2015).

Metaphors have been used to interpret the nature of human organisations in different ways, providing an insight as regards reality and conveying a shared understanding of the motive and purpose of people's interactions (Morgan 1980). One of the first attempts to suggest the existence of such a kind of shared understanding was presented by the French sociologist Emile Durkheim in his work *Division of Labour in Society* (Durkheim 1893), in which he describes two metaphors of functional interactions in society: Mechanic Solidarity and Organic Solidarity. As such, organisational theory has been dominated by the two metaphors, the machine and the organism metaphors (Morgan 1980), which influence the way people acquire information, knowledge, and understanding about collaborative interactions (Gharajedaghi and Ackoff 1984).

The machine metaphor conceptualises collaboration as something existing within a mechanism, as a machine made up of purposeless and passive parts that operate predictably (Morgan 1980; Gharajedaghi and Ackoff 1984). Such structure is rationally devised focusing on an expected performance to achieve prespecified ends (Morgan 1980). The machine metaphor implies that individuals should focus on the design and analysis of the formal structure of an organisation and its technology (i.e., standard operations) as a means–ends relationship by which collaboration, as purposive rationality, is established (Morgan 1980).

The organismic metaphor conceptualises collaboration as an organism with a purpose of its own, which is to grow and survive (Morgan 1980; Gharajedaghi and Ackoff 1984). In this case, the functioning of the organism is dependent on its ability to learn and adapt to a changing environment from which it gets essential inputs as resources (Morgan 1980; Gharajedaghi and Ackoff 1984). Consequently, an organismic system seeks a dynamic equilibrium instead of a static one, adjusting the behaviour of its parts as a way to maintain the properties of the whole within acceptable limits (Morgan 1980; Gharajedaghi and Ackoff 1984). In this organismic metaphor, survival is the ultimate objective, where profit is the means, growth is the end, and planning represents predictions of environmental changes and the preparations set for them (Morgan 1980; Gharajedaghi and Ackoff 1984). Moreover, the purpose of an organismic system is to make the best of a future that it believes to be largely out of its control but is predictable. Consequently, to cope, the system depends on its ability to bring its future under its own control.

The literature highlights that the machine and organismic metaphors only provide a limited understanding of collaborative interactions (Morgan 1980; Gharajedaghi and Ackoff 1984). Additionally, collaboration can be interpreted through the social system metaphor, in which collaboration is seen as a social construct (Gharajedaghi and Ackoff 1984; Tomelleri et al. 2015). As collaboration involves a high level of interdependence between its parts (i.e., individuals, professional groups, and organisational units) (Gharajedaghi and Ackoff 1984; Tomelleri et al. 2015), effective management of a social system requires individuals' collective construction and management of the interactions between them and their environment (Gharajedaghi and Ackoff 1984). As such, the performance of the system does not result from the sum of independent performances of its parts but, rather, from the product of the parts' interactions in both coded and informal ways. Thus, to collectively coordinate their interactions, participants will avoid the idea of adopting existing "controlling structures" (a fundamental condition in the previously discussed metaphors) and will arrange themselves on the basis of situated actions, which means that participants need to socially construct the means to build mutual intelligibility and align their behaviour according to the specific situation in hand (Suchman 1987). Mutual intelligibility refers to individuals' ability to conduct interpretive actions to effectively understand each other's intentions and interact in a meaningful way (Schutz 1962; Suchman 1987; Eckert et al. 2010).

Table 2 presents the key ontological aspects of collaboration embedded in the three metaphors presented. The next section explores how definitions of collaboration found in the construction management research literature can be linked to these three metaphors.

4. Defining collaboration in construction

4.1. Collaboration as a mechanism

Research on collaboration in construction has been partially based on the idea that project activities, including design, can be described as problem-solving activities (Simon 1969). Advancements in computer-aided design (CAD) focused on identifying how these "tools" (i.e., information systems) could support collective problem-solving. Such investigations assumed that collaboration can be enabled by artefacts acting as media, combining the cognitive capacities of human beings with computer systems.

One of the first and more extensive works on such collaborative systems to support project activities in construction was developed by Peng (1994, 2001) (Table 3). In Peng's (1994) definition of collaboration, the use of the words communicate and coordinate seem to imply that collaboration can be reduced to interactions directly related to the capability of information systems (i.e., what computers can do to support collective project activities). This assumption about the role of information systems, as the basis for most CAD systems, is also present in Edmonds et al.'s (1994) definition (Table 3). Edmonds et al.'s (1994) argument, that collaboration is a "complex activity", seems to align to the idea that information systems should be employed to support a higher information processing capacity, which could not be achieved through sole human cognition.

This perspective was advanced by research led by Mary Lou Maher. The definition proposed by Saad and Maher (1996) (Table 3) also assumes that design is a problem-solving activity. These authors refer to an environment as the nature of these information systems, which are expected to behave as a continuum of space and time, defining where and when collaborative interactions between project participants should happen. This implies a deterministic idea of how such environments come into existence in the first place as an object of prior design. According to Saad and Maher (1996), information systems support collaborative design because they would allow shared understanding to emerge and be maintained through standard computer representations. Following such developments, the use of the term collaborative system became common in CAD research to refer to computer systems as predetermined structures to exchange information, supporting distributed communication between designers (Kvan 2000).

Kvan's (2000) concept of collaboration (Table 3) seems to have informed subsequent research, most of which did not question the assumptions embedded in this mechanistic perspective of collaboration. Kvan's (2000) breakdown of the design activity is influenced by Simon's original concept of design reasoning and becomes relevant to understand and explain diverse types of reasoning involved in design by reducing it to "smaller tasks". Consequently, such reduction would allow the development of artificial mechanisms to support and reproduce these tasks within a collaborative system, as suggested by Simoff and Maher's (2000) definition (Table 3).

A key task in such a reductionist perspective is communication, seen as a means of collaboration and sometimes as the whole object of the collaborative interaction, as suggested by Haymaker et al. (2000) (Table 3). In this case, possibilities and constraints of collaborative interactions are assumed to be communicated through verbalisations and representations of the project (Haymaker et al. 2000), putting most of the responsibility in the design of the structure of communicative artefacts. A similar

Table 2. Three metaphors as different ontological instances of collaboration. [Colour online.]

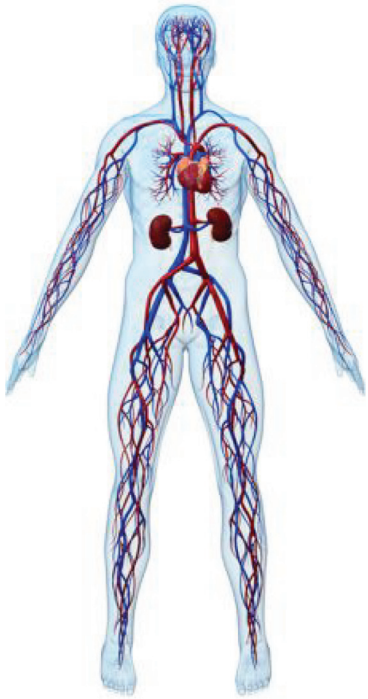
	Metaphor		
Aspect of collaboration	Machine	Organism	Social construct
			
Situation (system)	Static equilibrium	Dynamic equilibrium (growth)	Idea of an "equilibrium" is a social construct
Participants (nature of interactions)	Parts that operate predictably	Parts adjust their behaviour (learn and adapt to a changing environment)	Parts jointly construct the activity (sense-making)
Result	Future is a prespecified end	Future is out of control but predictable	Future is socially constructed (avoiding predetermined structures)
Means (embodied)	Standard operations (rationally devised structure); normalising actions	Organisational structures; management strategies	Situated actions; mutual intelligibility

Table 3. Defining collaboration as a mechanism.

Peng (1994, p. 21)	"…when participants of different technical specializations communicate and co-ordinate with each other to achieve, or, to cope with, design unity in final products. …Cooperative architectural modelling, a clearer picture of communication in collaborative design can be gained."
Edmonds et al. (1994, p. 41)	"...is a complex activity involving participants with heterogeneous skills… and support agents are viable for design tasks."
Saad and Maher (1996, p. 183)	"...an activity in which teams of designers work together toward a final solution. The activity of designing through the interaction of designers and the environment is what we refer to as collaborative design."
Kvan (2000, p. 413)	"Collaborative design consists of parallel expert actions, each of short duration, bracketed by joint activity of negotiation and evaluation. Thus, the design activity itself is discrete, individual and parallel, not intimately linked. The participants act as individual experts addressing design issues from their perspectives."
Simoff and Maher (2000, p. 139)	"Collaborative design denotes activity itself when more than one person works on a single design problem, having a common goal or intent. Collaboration is possible when the collaborators share activities and information to achieve common goals. Effective collaboration occurs when the collaborators share design tasks, communication, representation a documentation."
Haymaker et al. (2000, p. 206)	"Traditional collaborative design relies on verbal communication and artefacts representing aspects of the design to share and negotiate this knowledge. However, the forces of expansion, specialization and distribution of knowledge often make traditional modes of collaboration difficult."
Anumba et al. (2002, p. 91)	"There are essentially four modes of collaboration depending on the nature separation and pattern of communication, between project participants."
Li et al. (2005, p. 931)	"In a collaborative design system, designers and engineers can share their work with globally distributed colleagues via internet/intranet."
Kleinsmann (2006) apud Kleinsmann and Valkenburg (2008, p. 370)	"…the process in which actors from different disciplines share their knowledge about the design process and the design content. They do that in order to create shared understanding on both aspects, to be able to integrate and explore their knowledge and to achieve the larger common objective: the new product to be designed."
BSI (2016) Collaborative production of architectural, engineering and construction information — code of practice (p. 1)	"A major constituent of these collaborative environments is the ability to communicate, re-use and share data efficiently without loss, contradiction and misinterpretation… the use of this standard is particularly applicable where technology enable processes are used to support projects."

interpretation can be seen in Anumba et al. (2002) (Table 3), which conceptualises four modes of collaboration according to the nature of separation and patterns of communication between project participants.

The understanding of collaboration discussed above influenced research initiatives that were focused to further develop information systems in construction. For example, much effort was devoted to conceiving the computational capabilities and ontological structures of what would become the core of Building Information Modelling (BIM) systems (e.g., Kiviniemi 2005; Eastman et al. 2011; Singh et al. 2011).

Research also expanded the capabilities of such collaborative systems for distributed arrangements of project activities. For example, according to Li et al. (2004) (Table 3), a collaborative CAD system needs distribution and collaboration. Li et al. (2005) emphasise that these two aspects can be described as two requirements of a system: the first takes into consideration the geographical distribution supporting remote project activities, and the second is with regards to coordination between individual systems focusing on the way in which information is structured.

The focus on information processing capabilities led to further development of strategies and approaches to improve project activities, in which collaboration has been defined as knowledge transfers (Kleinsmann 2006; Kleinsmann and Valkenburg 2008) (Table 3). From this perspective, knowledge is conceptualised as a thing capable of being exchanged, as a piece of data or information, and the whole purpose of collaboration is to promote knowledge exchanges and coordination.

This conceptualisation of collaboration also suggests the idea that the process and content of design can be dissociated and perceived as two distinct dimensions of the same phenomenon. Consequently, within this perspective, collaboration has been assumed to be the activity of sharing knowledge through a structured environment supporting communication (BSI 2016) (Table 3) (Cardoso et al. 2016; D'souza 2016).

4.2. Collaboration as an organism

Collaboration has also been conceptualised as the organisational structure designed to engage a collection of individuals in problem-solving activities. Most research following such perspective was originally conducted in the fields of organisational theory, management, and operations research, with some influence from social and behavioural sciences, as well as from studies on psychology.

For example, Deutsch (1949) apud Tjosvold and Tsao (1989) proposed a theoretical model of cooperation (Table 4), suggesting that collaboration should be conceived as a model of interdependence. From this point of view, an organisational model should exist prior to individuals' participation in it. The concept of such an organisational model implies a sense of "control" and predefined responsibilities regarding the way actors operate and with whom they should interact. Such an idea is present in Shea and Guzzo's (1987) definition of collaboration (Table 4), which suggests that, within such structure, important outcomes become equally distributed among the participants, while participants aim for high task interdependence. Such definition seems to imply that the role of an organisation is to establish its members' interactions. Moreover, there is an underlying assumption that these structures are something designed and controlled by high-level managers in the organisation and not actually by the individuals that operate in the activity.

One of the main consequences of seeing collaboration as an organism manifested on the organisation system is that it can be defined as the locus of collaboration. Consequently, such systems of relationships can be seen as an object of design (i.e., institutional artefact), which is instantiated through other represen-

Table 4. Defining collaboration as an organism.

Shea and Guzzo (1987, p. 26)	Collaboration exist when someone "structures the jobs of group members so that they have to interact frequently with each other in order to get their jobs done." Consequently, "important outcomes are distributed equally among group members and the members will aim for high task interdependence."
Deutsch (1949) apud Tjosvold and Tsao (1989, p. 189)	"…a model of interdependence that stipulates how values, tasks, and rewards affect interaction in organizations. Specifically, shared vision, supportive culture, group tasks, and common rewards are hypothesized to induce cooperative interdependence and interaction. In cooperation, people believe their goals are positively linked; one's goal attainment helps other reach their goals."
Wood and Gray (1991, p. 146)	"…when a group of stakeholders of a problem domain engage in an interactive process, using shared rules, norms, and structure, to act or decide on issues related to that domain."
Vreede and Briggs (2005) apud Briggs et al. (2006, p. 122)	"…collaboration is in fact joint effort towards a group goal". The authors propose that a collaborative engineering process can be designed and deployed for those which are effectively engaged in the task.
Schöttle et al. (2014, p. 1275)	"Collaboration is an interorganizational relationship with a common vision to create a common project organization with a commonly defined structure and a new and jointly developed project culture, based on trust and transparency; with the goal to jointly maximize the value for the customer by solving problems mutually through interactive processes, which are planned together, and by sharing responsibilities, risk, and rewards among the key participants."
Poirier et al. (2016, p. 785)	"Collaboration is conceptualised as a system comprised of four interacting core entities; structure, process, agents and artefacts that are conditioned by a fifth: context." "The core entities and their interactions possess powers that prompt and conditions events and their empirical manifestations."

tational artefacts that help instruct and support people in complying with the organisation's purposes. In this case, the notion of process seems to have a fundamental role as a designed system of relationships, becoming a tangible representation of the organisation. For instance, in Wood and Gray's (1991) definition, collaboration is seeing as an interactive process (Table 4), in which functions of control and responsibilities are instantiated in terms of shared rules, norms, and structures. Moreover, this concept of collaboration as a process seems to imply that it can be predetermined, as a set of relationships and actions, in advance of the situation.

In construction, such interpretation was incorporated in discussions around contractual approaches. For example, according to Bresnen and Marshall (2000), "partnering" has been described as a form of contract emphasising the use of management techniques to "engineer" collaboration (e.g., formal contracts, dispute resolution mechanisms, teambuilding workshops, continuous improvement programmes). In addition, researchers have also tried to define sets of management practices or general strategies to generate collaboration through a determined process. For example, focusing on promoting early project collaboration, Whelton et al. (2004) suggested a set of management practices that can engage multiple stakeholders in resolving the purposes of the project. These authors discuss that this would happen through the implementation of a process that seeks early and frequent feedback to establish up-to-date information about needs and values between the stakeholders. In this case, the workplace planner is the individual responsible to design the process and produce information from the focused dialogues with stakeholder groups (Whelton et al. 2004). It can be said that this argument assumes the existence of a process as sufficient to produce collaborative outcomes.

In another example, Briggs et al. (2006) conceive collaborative engineering as an approach to design collaborative work practices for high-value recurring tasks (Table 4). According to Briggs et al. (2006), collaborative engineering involves deploying the design of collaborative systems in which practitioners should operate. Similarly, the concept of integrated design is proposed as a processual approach that assembles, integrates, and harnesses all the collective skills and capabilities of clients and stakeholders engaged in a supply chain (Forgues and Koskela 2009). Likewise, the terms co-design and participatory design have been used to refer to a processual approach that puts together the expertise from designers and the people that will be affected by the changes produced by the design (Sanders and Stappers 2008).

More importantly, the understanding of collaboration as a specific form of organisational arrangement leads project participants to believe that the success of collaboration depends solely on the "quality" of these pre-existing structures. For example, Howell (2013, p. 28) suggested that: "common sense tells us that the best solutions to complicated complex problems arise when teams are structured for the situation at hand". It could be said that Howell's (2013) argument implies that teams are structured by someone outside the team, emphasising the role of managers in designing these processes.

Therefore, from this point of view, collaboration lies in the nature of relationships between organisations and their members. Such perspective focuses on how key members of the organisation can establish collaborative interactions, by redesigning organisational structures, mostly instantiated in terms of processes (Arup 1970; Ballard 2000; Parrish et al. 2008; Mossman et al. 2011; Poirier et al. 2016). Consequently, individuals who see collaboration working as an organism expect that the relationship established between its parts will determine how those parts interact in a project (Schottle et al. 2014) (Table 4).

4.3. Collaboration as a social construct

Collaboration has also been conceptualised as a social construct. This perspective assumes that participants interpret collaboration individually, thus collaborative interactions should avoid predefined conceptions and focus on the collective construction of the activity. This notion can be related to works in sociology (Weber 1949), which argued that collective actions in society should be understood as a historical event, where individual actors seek social construction of shared meanings in a situation of functional interdependence.

This suggests that shared understanding is a fundamental basis for social interaction. Wirth (1948) argued that the "mark of any society is the capacity of its members to understand one another and to act in concert toward common objectives and under common norms" (Wirth 1948, p. 2). Moreover, Wirth (1940) suggested that a shared understanding among members of a society and their ability to act collectively towards common goals is what distinguishes humans from other animals' organisations. In this case, human society can be defined as "a set of common understandings, a system of reciprocally acknowledged claims and expectations expressed in action…" (Wirth 1940, p. 473). The main aspect of this interpretation of collaborative interactions is that agreement cannot be imposed by coercion or fixed by custom (Wirth 1948). Agreement is always under development and has continuously to be won, resulting from the interpretation of views based upon feelings, thinking together and mutual consent (Wirth 1948). Wirth (1948) described this as the "art of compro-

Table 5. Defining collaboration as a social construct.

Ackoff and Emery (1972, p. 197)	"...if someone's presence increases the expected value of another's state, then there is cooperation (collaboration). However, if someone's presence reduces this expected value, then this one conflicts with the other. If, one has no effect on the other's expected relative value, then one is independent of the other."
Engeström (1987) apud Bardram (1998, p. 7)	"Human activity is always embedded within a socio-cultural context of other humans and work activities thus always take place within some community of practice. Collaborative activity as one that has a unique objective distributed onto several actors, each performing one or more actions in order to achieve the shared objective, thus a division of work is established and regulated by different set of rules and norms."
Coyne and Snodgrass (1993, p. 163)	"Human activity, including design, is "collaborative" and "public", whether we are aware of it or not, involving a "collective" that is much more extensive than the individual or even a particular group. Designing involves bringing collective or shared experience to bear in making judgements."
Schrage (1995, p. 32)	"Collaboration is the process of shared creation: two or more individuals with complementary skills interacting to create shared understanding that none had previously possessed or could have come to on their own. Collaboration creates a shared meaning about a process, a product, or an event." "Collaboration is a state of grace we switch into and out as the moment and the task demand."
Valkenburg (1998, p. 119 and 120)	"Creating a design in a team requires constructing a shared understanding within the team. This shared understanding is the desired result of the team members turning into each other, connecting the essential topics within the design task and making the necessary decisions. Shared understanding is a mutual knowledge of all team members on what they are doing, why, and how they are doing it."
Macmillan et al. (2001, p. 170)	"Shared understanding is the key to successful collaboration... and can be achieved if all of the team members can agree on a shared design strategy, i.e. clarify and agree on the methods and processes of design to follow."
Stempfle and Badke-Schaub (2002, p. 477)	"Design teams are expected to learn through experience and self-reflection how to assess the conditions of the given situation considering an overall range of requirements, in order to flexibly adjust their collective path of actions."
Fischer (2004, p. 159)	"Collaborative design demands a balance between collective capability to establish connections and interdependence, as well as individual capacity to develop autonomous actions and to trust in their potential performance."
Thomson et al. (2007, p. 3)	"Collaboration exist when autonomous or semi-autonomous actors interact through formal and informal negotiation, jointly creating rules and structures governing their relationships and ways to act or decide on the issues that brought them together; it is a process involving shared norms and mutually beneficial interactions."
Hill et al. (2014, p. 5)	"…when diverse people collaborate to generate a wide-ranging portfolio of ideas…collaboration should involve passionate disagreement. Yet the friction of clashing ideas may be hard to bear…that only stifles the free flow of ideas and rich discussion that innovation needs."

mise", suggesting that this is one of the foundations of democracy. According to Wirth (1948), shared understanding in mass democracies is not a matter of agreement of all issues, but rather, as Dewey (1938) also had suggested, the established habit of discussion, debate, negotiation, and compromise over issues.

These works on philosophy and sociology suggest a dialectic and socio-constructive nature of collaboration. Later, similar ideas emerged in the context of operations research with Russell L. Ackoff and Fred E. Emery, in their book *On Purposeful Systems: An interdisciplinary Analysis of Individual and Social Behaviour as a System of Purposeful Events* (1972), proposing a comprehensive interpretation of collective interactions in social groups, seen as purposeful social systems. In this case, a social group is a type of purposeful system where its members are intentionally co-producers of a common objective. As the common objective is an outcome intended by each member of the social group, the intention — or, in other words, the purpose — to co-produce common objectives is what generates interactions (Ackoff and Emery 1972). This suggests that individuals and, consequently, organisations can change their goals (Ackoff and Emery 1972).

These social systems assume that relevant choices to system functions are distributed and interdependent, making individual parts responsible for different parameters of choice. This is particularly relevant because individuals will make choices related to not only their own purposes, but also the purposes of others (Ackoff and Emery 1972). In this case, if someone's presence increases the expected value of another's state in the situation, then this person perceives this situation as collaboration (Ackoff and Emery 1972) (Table 5). If someone's presence reduces this expected value, then this person perceives the situation as in conflict with the other. Furthermore, if a person believes they have no effect on the other's expected relative value, then this person perceives themselves as independent of the other. Consequently, what Ackoff and Emery (1972) seem to suggest is that collaboration is relative, depending on the individuals' perceptions about each other and the purpose of their interactions on the situation.

According to Appley and Winder (1977), collaboration is achieved when a group holding common objectives can balance between awareness of interdependences and reciprocity of actions. This assumes that the result of a project collaboration derives from the compromise on individualistic choices of project participants, which are influenced by diverse value systems — or, in other words, different appreciative systems (Rittel and Webber 1973). In this case, design, as plan-making, has the objective to distribute advantages and disadvantages in the commitment of resources among social individuals (Rittel 1987). The result of these interactions will never be beneficial to the whole group, and the designed course of actions will represent compromises resulting from negotiation and the application of power (Rittel 1987).

From this perspective, a core aspect of collaboration is the fact that different points of view are brought together in a project activity, and individuals may experience breakdowns, in terms of

misunderstandings about the consequences of their assumptions (Rittel 1984). Reflection and awareness of those conflicts of appreciation may lead project participants to understand the intractability of their dilemmas and to suggest an alternative design decision (Schön 1983; Rittel 1984). This means that, under such perspective, project collaboration is not reduced to the design and adoption of mechanism and organisational system supporting the resolution of supposedly defined problems, but rather, it is socially constructed by the argumentative and dialectical nature of these interactions (Rittel and Webber 1973; Rittel 1984).

Collaboration involves commitment to the definition of these mutual relationships and its goals, requiring mutual authority and accountability in a joint effort to develop a structure in which responsibility, resources and rewards are shared (Mattessich and Monsey 1992). Such activity seems to depend on questioning behaviours within dialogues among project participants, in a way that a dialectical interaction is conducted, increasing their shared understanding on how to best construct the activity and proceed in the task (Engeström 1987 apud Bardram 1998; Coyne and Snodgrass 1993; Schrage 1995; Valkenburg 1998; Macmillan et al. 2001; Stempfle and Badke-Schaub 2002; Thomson et al. 2007; Hill et al. 2014) (Table 5).

In this context, it is contended that effective collaboration depends on the construction of situational awareness among team members (Adamu et al. 2015). Situational awareness can be defined as the capacity to perceive and comprehend the characteristics of an environment in a specific set of time and space supporting the realisation of predicted futures aligned with a task on project activity (Endsley 1995). The consequence of situation awareness is that each participant knows about the understanding and workload of the other participants, and this is supported by their intercommunication (Endsley and Jones 2001). Thus, from this point of view, the participants' ability to collectively construct the activity and establish a balance between individual and collective perceptions of the situation seems to be fundamental for collaboration.

According to Fischer (2004), collaborative design demands a balance between the collective capability to establish connections and interdependences, as well as the individuals' capacity to develop autonomous actions and to trust their collective potential performance (Table 5). Badke-Schaub et al. (2010) also suggested that collaborative design relates to the existence of two dimensions of collective interactions. Accordingly, when individuals attempt to satisfy their own concern, actions belong to the assertiveness dimension, and when individuals aim to satisfy another's concerns, actions belong to the cooperativeness dimension. Similarly, Stompff et al. (2016) suggested a collaborative design ability existing as two iterative dimensions in the reframing action in social context: one the sensemaking, involving reconstruction of prior operating frames of understanding; and the other, the future framing, which is the designing of frames for future activities. Such idea of prior operating frames seems to be related to the concept of appreciative system, which is constructed from the team's perception of the situation, and the second type of framing, which guides the future activities of individuals in collaboration (Stompff et al. 2016). Moreover, these two dimensions of framing seem to be particularly related to an idea that collaboration is socially constructed as a collective perception of the situation and the collective conception of a course of actions to change that specific situation.

5. Misunderstandings as consequences of diverse interpretations of collaboration

One consequence of having diverse interpretations of collaboration is that it can promote misunderstandings in collaborative interactions (Gray 2004). Misunderstandings happen when individuals experience a state of contradictory cognition, belief, and attitude (Badke-Schaub et al. 2010). In this case, project participants committed to a particular metaphor of collaboration may perceive alternative views as misguided, as presenting threats to the nature of their activities (Morgan 1980). This happens as approaches and techniques conceived within a certain metaphor are usually interpreted and evaluated in inappropriate ways by individuals holding another metaphor, causing a great loss of significant meaning in these interactions (Morgan 1980). Consequently, individuals in collaborative interactions tend to experience misunderstandings, hostility, or calculated indifference, hampering or making impossible an open and constructive debate (Morgan 1980).

Previous research evidenced the emergence of misunderstandings related to individuals' different metaphors, which consequently hampered project interactions in construction. For example, Green (1996) explored how implicitly different metaphors of client organisation held by practitioners in construction projects often affect how client briefing activity is approached. Accordingly, construction professionals exhibit difficulties in what Green calls a "pigeonholing" approach to diagnosing a client's problems, in which the "default" paradigm sees the client as "unity" and not as a "pluralistic" entity. In this case, the underlying metaphor, which sees organisations as machines, led construction professionals to take for granted that the client's objectives are clear, predetermined and remaining static over time (Green 1996). However, such approach became contradictory when the client organisation was interpreted as multifaceted, with no broad agreement on the objectives (Green 1996). Following this second perspective, the brief needs to be socially constructed through debate amongst client members and construction professionals over a period of time (Green 1996).

Tzortzopoulos and Cooper (2007) also identified that divergent and sometimes conflicting perspectives on what constitutes "design management" within construction organisations created difficulties in establishing company-wide strategies. According to these authors, the lack of a clear theoretical foundation for design management, as well as the lack of agreement on the potential benefits of managing design, led to a poor definition of the company's and its members' role in the design management activity.

In another example investigating participants' interactions when developing a BIM strategy in a construction project, Forgues et al. (2016) identified that misunderstandings can emerge when stakeholders, which usually have been organising their activity in a highly linear and fragmented way, have difficulties in understanding and representing how their collaborative interactions operate in the project. This was aggravated by the fact that participants have difficulties in knowing the activities of the other members and how to represent their interdependencies (Forgues et al. 2016). Misunderstandings were identified when compared participants' process maps of design activities in a BIM context (Forgues et al. 2016). In this case, misunderstandings emerged when different maps showed how semantic ambiguities related to design activities (e.g., actions, mechanisms, or data). This was evidenced when each participant defined the distribution of the work in a different set of phases and using different terminology (Forgues et al. 2016).

Overall, misunderstandings become problematic when not addressed, and the differences in understanding and approach result in uncoordinated actions (Valkenburg and Dorst 1998). Project participants will find resistance to resolve misunderstandings in collaborative interactions, because different metaphors of collaboration can emerge as contradictory appreciative systems, determining what counts as a fact and what arguments are taken to be relevant (Schön and Rein 1994). This means that the nature of misunderstandings and how they should be resolved differ fundamentally according to each metaphor of collaboration in construction.

5.1. Resolving misunderstandings according to the mechanistic metaphor

A mechanistic perspective of collaboration sees misunderstandings as a problem of communication. Thus, research aligned with this metaphor have concentrated on redesigning media frameworks (i.e., software tools and communication standards), working on the interactions between human and computer systems to support project collaboration (Maher et al. 1996; Kvan 2000; Wang et al. 2002; Anumba et al. 2002; Eastman et al. 2011; Singh et al. 2011).

Advances in computer-integrated design systems have been made based on the need to share data between several design software (Saad and Maher 1996). The challenge for these computer systems is to integrate the various perspectives emerging from different reasoning processes articulated by team members in this interaction (Arias et al. 2000). In principle, these systems would allow project participants 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).

To solve the problem posed by the use of heterogeneous software tools, researchers have suggested the development of intelligent agent systems, which consist of self-contained knowledge-based systems with the capability of handling the specialist problems and which provide a collaborative framework for interactions (Anumba et al. 2002). The use of intelligent agent systems and shared ontology would address the diverse nature of data in terms of information and knowledge in construction projects (Anumba et al. 2002; Eastman et al. 2011).

However, previous research identified that the adoption of new models of representation, as proposed by the mechanistic perspective, is not enough to resolve misunderstandings, and the complexity of design artefacts requires different methods of interaction (Maher et al. 1996). In addition, because of the highly distributed nature of collaborative project teams and the diversity of tools they usually employ, these approaches can be considered insufficient to support early project collaboration (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 diverse disciplinary background (Wang et al. 2002). Consequently, activities related to resolution of misunderstandings and generation of new solutions are still left to human expertise (Wang et al. 2002), and collaboration still requires participants' social abilities to coordinate their interactions with other agents (Anumba et al. 2002), which can be related to actions of negotiation and evaluation (Kvan 2000), occurring outside these systems.

Recent research also identified key limitations of current computer systems to support these "social abilities" in construction projects collaboration (Adamu et al. 2015; Forgues et al. 2016; Paavola and Miettinen 2019). According to Forgues et al. (2016), BIM systems work as common platforms to share data, which require changes in the way team members produce and exchange project data to support information processing in these platforms. In this case, the traditional linear and fragmented nature of conceptualising construction projects hampers the initiative to understand and represent how information should be created and processed among project members (Forgues et al. 2016). As a consequence, the dependencies of tasks and information exchanges in a process are not sufficiently comprehended by the project members, which hinders successful collaboration process (Kiviniemi 2011).

The pattern of interactions in collaborative situations shows that designers tend to document less information in a collaborative session because they can describe their intentions verbally instead (Maher et al. 1996). In these situations, semantic descriptions used to define the purpose and performance of design artefacts may be represented differently considering the various disciplines involved (Saad and Maher 1996). This generates a paradox because, although a computer system can provide a collaborative structure to support the coordination of design information to be exchanged, it does not necessarily support the situated and indeterminate nature of collaborative interactions, requiring a change in the collective mindset (Forgues et al. 2016).

5.2. Resolving misunderstanding according to the organismic metaphor

An organismic perspective of collaboration sees misunderstandings as a problem of integration, in which the fragmented nature of construction projects, embodied into transactional procurement routes, should be abandoned (Egan 1998; Koskela et al. 2003; Bertelsen 2003; Zimina et al. 2012) and new forms of relational contracts should be developed (Forgues and Koskela 2009). Thus, a great number of initiatives to improve collaboration from this point of view have been focused on resolving or avoiding misunderstandings by changing organisational structures through the adoption of new procurement routes along with new project management strategies (Mossman et al. 2011; Zimina et al. 2012).

From this point of view, new forms of procurement, like the Integrated Project Delivery (IPD), are expected to 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 studies on the influence of new procurement forms in the collaborative performance of project teams showed that the adoption of a relational contract was not sufficient to mitigate socio-cognitive barriers (i.e., misunderstandings) between the project participants from different disciplinary backgrounds (Forgues and Koskela 2009; Zimina et al. 2012). According to Forgues and Koskela (2009), although new procurement routes can provide a better context for project collaboration, it was possible to recognise fundamental limitations regarding project managers and designers' ability to perform in the new situation. One of the problems seems to be that such organisational changes will involve changing traditional systems of work (i.e., practices and understandings) and changing roles and responsibilities between participants. In this case, although new relational systems can play an important role as structural collaborative artefacts in the organisation, they seem to be not enough to provoke the necessary changes in attitude and behaviour (Zimina et al. 2012).

Under the organismic perspective of collaboration, individuals' purposes in the activity have already been predetermined by a central "brain" of the organisation (i.e., the high-level managers). The consequence of conceiving and predetermining the means of collaboration within the design of an organisation system is that conversations about trust, in a context of a command and control management model, tend to generate resignation and cynicism from the participants (Howell et al. 2004).

5.3. Resolving misunderstandings according to the socio-constructive metaphor

A socio-constructive perspective of collaboration does not see misunderstandings as a problem to be resolved, but rather, it sees it as a natural aspect of human interactions (Vaaland 2004). In fact, it questions the grounds upon which the mechanism and organism metaphors are built (Morgan 1980). Overall, the mechanism and organism metaphors suggest a functionalist approach, in which notions of what constitute collaboration are based upon the assumption that the reality of collaborative interactions rests in a network of ontologically real relationships (Morgan 1980). They assume that these relationships are relatively ordered and cohesive, thus focus is drawn on how human beings may attempt to shape collaborative activities (Morgan 1980). However, a socio-constructive perspective denies the concrete ontological status of collaborative systems and suggests that the resolution of misun-

derstandings in the context of collaborative interactions emerges as rule-governed symbolic structure, as individuals engage their worlds through the use of specific codes and practices to vest their situations with meaningful form (Morgan 1980).

This means that, from this point of view, people tend to create rule-governed symbolic structures, expecting them to operate as social institutions (e.g., a standard procedure or a software tool from a mechanistic perspective; a relational contract, or management system from an organismic perspective), objectivating their conception of collaboration, making whatever they believe to be collaboration possible (Boaz 2015). This conception can be related to what Max Weber (1930 apud Weber 2007 called rationalisation of existence, suggesting that people tend to see key elements of modern life, like science, capitalism, and bureaucratic organisations, as triumphs of rationality and, therefore, take them as an objective reality. These individuals tend to believe that rational order is embedded "…into legal codes and administrative organizations that promise order, predictable decisions, regularity of procedures, and responsible, objective, and qualified officials; into economies that operate according to principles of calculated advantage, efficiency, and means–ends strategies; and into technologies that promote standardization, mechanical behaviour, and uniform tastes." (Weber 2007, originally presented at The Protestant Ethic and the Spirit of Capitalism, from 1930, online source).

Weber's argument for the rationalisation of existence can help to explain why collaboration has been so vastly conceptualised in different ways (e.g., as a mechanism or as an organism). Arguably, this implies that these specific forms of interpreting collaboration are ways to imply rationality into human interactions and assure the maintenance of existing power structures, allowing control and avoiding changes by means of institutionalising those interactions (Berger and Luckmann 1966). This also explains why certain individuals tend to interpret collaboration deterministically and why they expect collaboration to be "well-defined" (e.g., as institutions).

However, the idea that any human activity (e.g., collaboration) can reach a definitive "well-defined" relationship can be questioned (Berger and Luckmann 1966). For example, Ostrom (1998) questioned the inefficiency of collaborative approaches influenced by the over-reliance on rationalistic models of behaviour. According to Ostrom (1998), approaches based on a rational perspective of collaboration, in support of allowing the determination of mechanisms and systems of control over the tasks, tend to fail to account for the autonomy and free will of project participants. In this case, considerations about "social" abilities to conduct collaborative dialogues and how shared meanings emerge in relation to these activities simply do not exist (Ostrom 1998).

Contrary to the other two metaphors of collaboration, the socio-constructive perspective sees misunderstandings as part of the inherently indeterminate and situated nature of collaboration. Consequently, the resolution of misunderstandings is subject to dialectical interactions in which different concepts of collaboration held by different participants "coexist" in the situation.

From this perspective, collaboration is not one thing, but it will have different configurations in different situations for different players (Bardram 1998). Collaboration emerges when the collection of individuals in the situation interact to resolve misunderstandings around multiple interpretations of what makes collaboration in the situation (Van Amstel et al. 2016) (Table 6).

Thus, to address misunderstandings emerging from different ways of interpreting collaboration, the situated nature of collaborative interactions needs to be considered. A key aspect is that the three metaphors of collaboration should not be seen as competing views but, rather, as complementary perspectives, which fit different purposes at different "levels" of interaction in a construction project.

According to Engeström et al. (1997) and Bardram (1998), collaboration involves dynamic transitions between three different "levels" of interactions, namely co-ordination, cooperation, and co-construction (Fig. 1).

The first refers to co-ordination, where actors are considered as passive participants in the activity (Bardram 1998). This will involve routine interactions, in which the diverse actors will interact upon a common (well-known) object, but their individual actions are only externally related to each other. The participants know that, to accomplish these tasks, they have to follow scripted roles, achieving success in their individual actions (Engeström et al. 1997). These scripts usually become tacitly assumed traditions and norms, coded in written rules, standards, plans, and schedules (Bardram 1998).

The second refers to cooperation, which suggests that participants share an object of activity that enables them to relate to each other in a distributed way and make corrective adjustments to their own and others' actions to achieve the overall objective (Bardram 1998). In this case, the object is stable and generally agreed upon, but the means — or, in other words, the artefacts and interactions — by which the activity will be developed may not be present or known. Consequently, cooperation requires that these means are established in a way that each actor has to balance his own actions with the actions of the other players, which might involve persuasion (Engeström et al. 1997).

The third refers to co-construction, in which interactions will emerge when the object of work is not stable — or, more frequently, when it is not existent (Bardram 1998). These require the collective construction of the activity, in which the actors will focus on the re-conceptualisation of their own organisation, redefining the purpose of their interaction and their relations with their shared objects (Engeström et al. 1997).

Overall, the model (Fig. 1) suggests that collaboration in any human activity (e.g., construction projects) will not exist in only one "level" (Bardram 1998). In fact, these three "structural levels" represent different analytical perspectives that may coexist in the same collaborative activity (Engeström et al. 1997). These perspectives seem to be influenced by the way participants see their object of work (e.g., the project activity; Table 7). Thus, these different "levels" do not exist objectively, but they are embedded within different ways in which individuals interpret and conceptualise collaboration.

The description above about the nature of interactions embedded in each of these "structural levels" allows us to suggest that these "analytical perspectives" can be correlated to the three different metaphors of collaboration presented earlier, namely co-ordination and mechanistic metaphor, cooperation and organismic metaphor, and co-construction and social construct metaphor (Table 7).

Bardram's model reinforces the suggestion that three metaphors of collaboration constitute different appreciative systems, framing the way in which individuals interact in collaboration. The main aspect that can be abstracted from this model is that it suggests that the natural evolution of a collaborative activity (e.g., the construction project) depends on individuals' interactions towards the dynamic transition between these "levels" (Bardram 1998), which is articulated by individuals' capacity to resolve misunderstandings and build mutual intelligibility among the project team.

Therefore, by adopting this model, collaboration in construction can be seen as a spectrum of collaborative interactions towards the socio-construction of the overall project activity. Although individuals and organisations coming from diverse cultures of practice join the activity with different purposes and tasks, they are expected to contribute across different aspects of the project activity. These aspects can be seen as different "levels"

Table 6. Three different conceptions of collaboration in construction.

	Mechanism			Organism		Social construct	
In construction, collaboration addresses:	Communication problem among project participants			The "fragmented" nature of construction projects		The challenge of create something together, in a context where individuals interpret (see) "things" differently	
Collaboration is addressed as:	Problem-solving activity			Problem-solving activity		Interactions to promote change (course of actions)	
Aim	Work on interactions between human and "machine", combining human cognitive capacities with computer systems (e.g. software, platforms)			Provide a better context for integrated teams		Reflect upon individuals' objectivation (of collaboration)	
Objectives	Develop communicative and coordinative capabilities of information systems (as tools to support collective problem-solving) based on standardisation strategies			Promote organisational changes (changing traditional systems of work based on roles and responsibilities) by developing organisational structures		Achieve social construction of shared meanings in a situation of functional interdependence	
Collaboration is seen as:	Media framework			Organisational framework		Concerted actions	
Manifested in:	Information processing system (an environment), previously designed with a specific purpose			Relational system (an institutional artefact), previously designed and controlled by "managers" (relies on leadership)		A set of common understandings (which is always underdevelopment), in which the continuous co-production of common objectives generates the interactions	
Core function	Information processing = a set of operations (e.g. breakdown of the activity)			Relationship = a model of interdependence (e.g. process)		Co-production = ability to act collectively towards common goals	
Key collaborative features	Produce	Communicate	Coordinate	Interdependence	Control and adaptation	Sense-making	Choice/negotiation/ compromise
Implications (implies)	Information as "carrier" of knowledge	Relies on predetermined structures to exchange information	Integrated set of tools (interoperability)	High task interdependence, in which outcomes become equally distributed (i.e., collection of skills)	Group goal or individual purposes are predetermined by a central brain (managers); implies a sense of control and predefined responsibilities	Ability to collectively construct the activity	Individuals display will to choose their goals and means; choice to system functions are distributed and interdependent (social dilemmas — individual vs. group rationality)
Embodied into	Standard computer representations	Data exchange standards	Intelligent agent systems	(New) project management (strategies, methods, approaches)	(New) procurement routes (contractual arrangement)	Mutual intelligibility	Situation awareness
Description	Manipulation of predefined objects based on shared ontology			Institute early and frequent feedback (to adapt), and the development of unified culture (i.e. shared rules and norms)	Support commercial alignment (shared profit and risk), promoting shared responsibilities, resources and rewards	Collaboration is not one thing (different configurations in different situations for different players)	Collaboration emerges from autonomy and free will of project participants, thus the "relationship" is always underdevelopment

Fig. 1. Dynamic levels of collaboration adapted from Bardram (1998, p. 11).

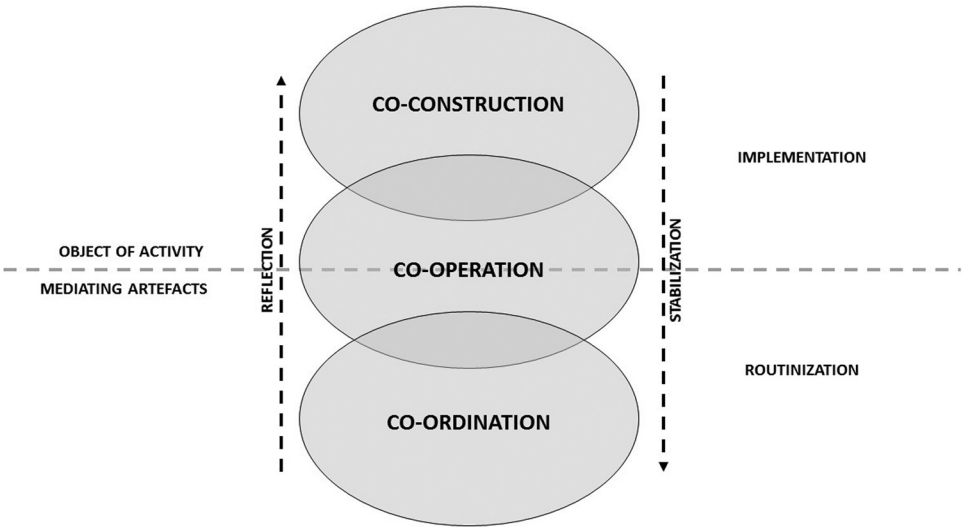


Table 7. Three different instances of collaborative interactions in project activities.

	Co-ordination	Cooperation	Co-construction
Object of activity	Common object (well-known)	Object is stable and generally agreed upon but the means are not	The object of work is not stable or is not existent
Nature of interactions	Routine interactions	Make corrective adjustments to their own and other actions	Interactions will emerge
	Passive participants	Share an object of activity; relate to each other in a distributed way	Collective construction of the activity
	Actions externally related	Balance his own actions with the actions of the other players	Redefine the purpose of their interaction and their relations with the shared object
	Follow scripted roles (success depends on individual actions)	Require that these means are established	Reconceptualise their own practice (organisation)
Mutual intelligibility	Tacitly assumed traditions and norms, rules, standards, plans, and schedules	Might involve persuasion	Co-creation (collective sense-making)
Correspondent metaphor	Mechanism	Organism	Social construct

within the construction project, in which interactions seems to require different mind sets — or, in other words, different metaphors.

The challenge for collaborative interactions in construction projects seems to be the transition across the different "levels" in the spectrum of collaborative interactions. Upward or downward interactions within this spectrum require individuals' capacity to reflect upon their practice and their notion of collaboration, as well as their capacity to interpret how collaboration can be objectivated on other levels of interaction. Therefore, effective collaboration depends on project participants' capacity to socially construct the means to overcome misunderstandings across the spectrum of collaborative interactions and reach a dynamic state of mutual intelligibility across the project team.

6. Conclusions

In this paper, we discussed that one of the reasons for the lack of consensus around definitions of collaboration in construction is the fact that individuals holding different appreciative systems and backgrounds of experience tend to interpret collaboration differently.

In this context, we have explored how some initiatives to theoretically define collaboration in construction and other subject areas can be aligned with three different metaphors of collaboration. We argued that the notion of collaboration metaphors, as ideal types shared by social groups, can be referred to as an indication of how academics and practitioners have historically contributed to the continuous construction of diverse ideas of collaboration. We propose that metaphors of collaboration can be seen to have evolved as socially constructed appreciative systems, framing the way project participants perceive, as well as conceive, their interactions and artefacts on collaborative interactions.

As these conceptualisations of collaboration differ fundamentally in ontological terms, the challenge that participants face in construction project interactions involve overcoming misunderstandings, in which actions and artefacts from one stakeholder can be interpreted by others as incoherent and even contradictory.

Thus, with this literature review paper, we have tried to demonstrate the dialectical nature of collaborative interactions, which suggests that successful collaboration requires project participants to have the capacity to reflect upon their idea of collaboration and build mutual intelligibility around their interactions. This suggest that collaboration depends on individuals' capacity to set situated measures of success in each interaction. Consequently, participants' perception of performance in collaboration

should be based on their ability to question and reflect on their concepts of collaboration and how they have been objectivated in the situation, potentially revealing misunderstandings.

We suggest that further research should address the question of how to stimulate and enable such collective reflection on the situation without disrupting project activities. Such exploration could provide a better understanding of what project participants usually do to overcome misunderstandings throughout different stages of a construction project. Further exploration of these aspects of collaborative interactions could also reveal ways to improve project performance by identifying collective reflective initiatives that might work as triggers for interactions supporting the social construction of collaboration in the situation.

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