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los procesos digitales de diseño bajo la mirada de la colaboración
digital design processes from a perspective of collaboration

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Abstract:

In the field of Architecture, Engineering and Construction (AEC), during the design cycle, several specialties associated with different areas of knowledge are involved. Integrating them remains a challenge. Thus, the aim of this article is to discuss the peculiarities of collaboration when adopted in digital design processes. Using a theoretical-conceptual approach, a literature review was carried out to evidence possibilities and limitations of the implementation of collaborative work forms in the AEC field and, more specifically, in digital design processes. Based on the subject matter discussed on the issue 16 of V!RUS magazine, "parti.cipar + co.laborar", the article reflects about the horizon of collaborative instances in digital design processes, interdisciplinary collaborative work and digital media, which often focus on informational-digital aspects to promote processes that are essentially social-human.

Keywords: Collaboration, Compatibility, Interdisciplinarity, Digital design process. Interactions

1 Introduction

Digital technology allows cognitive processes to be more explicit, enabling the used data in a digital process to be duly declared, making them able to be manipulated and understood by the different actors wishing to participate. This influences interpersonal interactions and forms of working together that are developed over the course of creative processes.

For the purposes of this study, collaboration is understood based on a broad spectrum, in which non-technical aspects are considered for its development. This is essentially social and one cannot expect collaborative instances with digital tools alone (Kvan, 2000). Thus, in order to collaborate, it is necessary to improve interactional and intersubjective aspects over time as, etymologically speaking, the word means sharing the efforts and misfortunes implicit in joint activity, emphasizing sharing as the process, rather than the result (Salvá, 1843). Its organizational arrangements can be described as horizontal configurations, without authority and control levels, which enables self-management (Corrêa, 2010). This is done through collaborative leadership, which is formed by a comprehensive, open-minded figure with the ability of understanding, globally, the common goal toward which it was decided to collaborate (Alves; Barbosa, 2010).

Although collaboration has been explored for several years, its most recent use stems, in part, from the technological revolution and informationalism that have propelled the creation of a interconnected and geographically distributed knowledge networks (Castells, 2000). Therefore, collaboration could also be shown at two levels, 1) traditional and 2) digital, each with its peculiarities and similarities. In this way, it is possible that certain characteristics and specificities of traditional collaboration have changed due to the exponential advances in digital technologies.

Therefore, centered on a theoretical-conceptual approach, this article proposes to reflect on collaboration in digital design processes, after understanding the characteristics both of the concept and of the field of Architecture, Engineering and Construction (AEC). For such, and in the context of contemporary processes of collective construction of knowledge in different areas, it carries out a broad literature review in which social and informational aspects regarding collaboration in digital project processes were considered, which, therefore, relates the discussions and reflections below to the subject matter of the issue 16 of V!RUS magazine, "parti.cipar + co.laborar". This study is part of a masters research developed based on the concept of collaboration, focusing its analysis and reflections on the design process of an interinstitutional team, with remote and face-to-face activities.

2 Interconnections and disconnections

One of the main characteristics of the AEC field is the knowledge fragmentation, evidenced by the great number of disciplines that are part of it. Herbert and Donchin (2013) argue that the complexity of the field derives from this fact and from the proportional increase in consultants and specialists involved. This is further affirmed when it understands that it is due to the implicit complications of the multidisciplinarity of this phenomenon that communication and information flows in design processes are constant challenges on the development of AEC designs.

In this way, when trying to bring together the diverse disciplines of this field, their interactions must be considered because their multidisciplinarity is already known. However, few times designs are developed in an interdisciplinary way, and the usual practices of design compatibilization do not indicate neither interdisciplinarity nor collaboration.

Multidisciplinarity is the mere coexistence of two or more disciplines, each maintaining its specific character without attempting to integrate them. On the other hand, interdisciplinarity integrates theories and methods from one discipline to be used in others (Gnaur, Svidt and Thygesen, 2012). Therefore, the multidisciplinarity resulting from the knowledge fragmentation does not indicate interlocking interactions between disciplines nor common objectives by itself. It merely indicates the existence of several disciplines. Thus, we understand the importance of closer and more interdisciplinary relationships between the various AEC disciplines.

This could lessen the mistrust created by the distance between them, through the union and intelligent use of the knowledge available in the design teams. On the one hand, specialization enables the reduction of individual workload in a design team, and on the other, it requires immense efforts of coordination between participants, considering that solutions found collaboratively are the result of an organizational configuration based on synergistic interactions between members with complementary knowledge (Forgues, et al., 2016; Carraher, Smith and Delisle, 2017).

According to Pikas, et al. (2016), collaboration in design processes can be approached based on two perspectives: 1) based on constructivist approaches and communication theory, which considers the act of design as a social phenomenon in which common understanding is created through social and cultural

interactions; and 2) based on informational thinking, derived from information and mathematics theory, in which the main focus is the data flow between two or more members, groups or teams.

Thus, this study approaches collaboration in AEC field from both perspectives: 1) as a social phenomenon, in which non-technical aspects are used to understand this concept and how it is adopted in digital design processes, and 2) understanding its relation with the informational aspects and the phenomena widely known as globalization, technological revolution and the connectivity in current society, that bring forth instruments and tools on the perspective of what is called ICT (Information and Communication Technologies) and influence the conceptual processes of the AEC field.

3 Beyond information exchange

Usually, an architectural design is developed by bringing together knowledge to solve certain problems, involving several disciplines in the process, as well as the various specializations within the field of architecture itself. However, most of the time, the contributions of these disciplines occur separately, in an interdependent process that evolves step by step. A process in which one moves between disciplines without the concomitance of others that could be involved in this process. Interactions in these processes occur on demand, so that the flow of ideas and communication is segmented, making it difficult to create common understanding amongst all those involved.

The above indicates that the emergence of ideas and the informational flow occur segmentedly, subjected to the demand of the previous discipline. It goes on this way until the end of the design, through certain phases in which communication exists as a tool to report errors or conflicts between and also within the various disciplines rather than being used as a means to avoid them.

For collaboration in digital design processes to flow and occur successfully, members must be able to receive and capture the knowledge of others while putting their collaborative experience into practice. This suggests that, it is not only about interactions, but also about communication and sense of sharing. Therefore, social interactions between collaborating individuals should be considered part of collective development in co-creation processes. It is supported by two fundamental levels: 1) exchange of specific knowledge, and 2) exchange of experiences about the collaborative process itself.

Riese (2011) states that the collaborative design process is configured according to the required and existing knowledge, forming collective intelligence distributed among the team members. This integrates, unifies and focuses efforts on problem solving by recognizing the specific abilities of other members. The author states, furthermore, that collaborating is difficult, although in theory it does not seem to be. Collaboration requires skills that provide common knowledge bases and common tools for the team.

Carl and Stepper (2016) emphasize that the design process is already complex in itself and, when collaborating, complex interdisciplinary and intersubjective aspects will be added. Teamwork recognizes the individual value of each member by encouraging open dialogue to avoid separation between them, which could lead to failure for the team in general. Thus, more than knowledge, it requires trust, respect, understanding and personalities that can work together, understanding the need of outer knowledge from each discipline.

4 Design process

Broadly speaking, the design process is every and each one of the procedures, techniques, tools and instruments that help to achieve a certain outcome. In turn, they are also the distinct classes of activities that the designer uses and combines in a general design process. In this context, design processes and thinking have changed significantly in recent years, going through different forms and cognitive structures, perspectives and methods.

Jones (1992) argues that in the mid-20th century, designers did not explicitly know the reasons why their designs achieved a final result: they only knew the way to do it, based on their memories, creativity and experience in the design act. The design process itself was visible only to the designer, who at times did not know how he discovered such solution. In this way, Jones considers it necessary to make the designer's thinking public and to formalize the design process with the intention of making it more manageable and so others can perhaps accompany and contribute to it. The author also distinguishes two points of view which he calls 1) black box, for the creative point of view, in which the mysterious creative leap occurs, and 2) transparent box, for the rational point of view, in which a fully explicable rational process can be visualized and understood.

Based on the difference between theory and design method, Michael Brawne (2003) discusses the processes and lines that can be approached in design. The author supports the thought that the final design is the result

of the personal knowledge of the designer, who goes through sequential phases until he is satisfied with one of the possible results.

It can be seen, therefore, that in spite of the diverse perspectives, theories and methods, the key aspects to carry out a traditional design process are usually the knowledge, memories and experiences of the designer, and that such a traditional process can be through a black box or a transparent box.

With regard to the changes that have occurred in cognitive forms and design thinking, Rivka Oxman (2017) differentiates and characterizes them, starting with design thinking models from the 1980s, stating that these were more introspective and personal, based on drawings and defined steps. Years later, according to the author, cognition in designs began to adopt thoughts of reflection and action based on the observation of the design process documentation, systematizing it through representation. Then, with the gradual diminution of processes based on paper drawings, design found support in digital technologies, which, in principle, were generally used as new media and representational forms.

Such technologies did not take long to become generative tools of form, which led to a change in design methods and process. The impact of the support and use of digital technologies generated new perspectives linked to cognitive structures, theoretical thoughts of the digital in architecture and, moreover, contributed to the integration of several computational and other fields, such as mathematical, informational science, biological science, among others, processes into the design process. In this way, changes in design thinking appeared, with the arise of parametric and algorithmic thinking, of which requires abstract, mathematical and algorithmic thinking and knowledge from its designers - rather than basic knowledge - enabling them to generate alternative and functional forms based on theorems and script language (Oxman and Gu, 2015).

In this order, the phases of the design process are dynamic, open and influenced by social and technological characteristics of the time in which it is developed. As mentioned above, architectural design has advanced from creative processes that are difficult to explain rationally, though paper drawings, sequentially configured phases, at the same time of the increase on the number of theories, methods and design processes that have contributed, and continue to contribute, to the integration of digital knowledge, disciplines and technologies. These changes, and some others, have allowed us to approach the concept of designs based on a more logical thinking with more stated and objective information, making it possible to manage design through parameters. This results in a process which the introspective and idealized role of the architect decreases, while that of digital technology increases.

Integrating digital technologies to the design process allows the designer to schematize the process, approaching architectural cognition from new modes, theories and concepts, aiming at a conscious approach to the potential of design tools based on computable functions. Digital design is not about the formalization of the design processes or automation of decision-making, but rather the interaction of formal processes with architectural thinking; it is not about informatization, but about computation (Kotnik, 2010).

In spite of agreeing, to a certain extent, with the taxonomy proposed by Oxman (2006) for digital design process models such as: CAD models, digital training design model, generative design model, performance design model and composed design model (made up of several models), Kotnik (2010) distinguishes three approaches to the use of digital technologies coinciding with Oxman’s five models: representational, parametric and algorithmic. He defines and differentiates methods based on levels of computability, with the representational level not being considered a digital design method. Computational support is limited to the ease of architectural representation, maintaining the traditional paper-based design paradigm in which the relation of design thinking to computability is so low that there is no apparent contribution.

In this way, the transition from non-digital to digital design processes happens when the contributions of digital technologies and computability go beyond the representational level. The parametric level requires a broad understanding of the input and output processes of data and information to use the parameters and possible variations as a scheme of interdependence between various parts of the design (Kotnik, 2010). Parametric design can be defined as a process of forming parametric structures of associative geometry, which generates the geometry of objects (Oxman, 2017). At the algorithmic level, the focus of design thinking is centered on logical and computational development through algebraic and analytical operations to manipulate data of different natures, deriving into informed forms that can be operationalized to produce architectural properties (Kotnik, 2010).

In this sense, it can be seen that architectural thinking has undergone a great change, as the implicit cognitive process has become explicit due to the possibilities of interaction between the designer and the architectural object (Oxman, 2006). It was possible to manipulate the data that feed the model, enabling decision regarding the level of influence of the script that operationalizes the processes. That is, countless understandings about digital design processes are generated, which can be schematized and manipulated by

the designer, thanks to the ease and speed in which the explicit and rational data of the process schema can be extracted, modified and handled.

Therefore, the digital design process is, for the most part, characterized by dynamic aspects in which various computability activities can occur simultaneously and complementarily, with the possibility of extracting, exchanging and using information more quickly, but also in a more complex way, promoting changes in the relationship between the architect and the stages of the design process. For example, some of the most common current tools in design processes are described, which can operate on some or on all three levels of computability at the same time.

AutoCad operates strictly at the representational level, although some of its representations can be parameterized, such as SketchUp. However, the latter has more parameterizable options, moving more easily between the representational level and the parametric level, although not totally. Some parametric programs are limited to the information qualification of a BIM model - AllPlan, ArchiCad, Vectorworks, Microstation, ACCA, Autodesk Revit, among others -, but with the support of external plugins, they can transit and operate in parallel on the three levels of Computability, such as Dynamo for Autodesk Revit. The Rhinoceros software operates at the representational level as a 3D modeler from NURBS (non-uniform rational B-spline), and with the Grasshopper plugin it operates simultaneously at the representational, parametric and algorithmic levels.

5 Collaborative design? Collaboration as a continuous state

Some researchers see collaboration as a subphase of the design process, arguing that it is in this subphase that knowledge is gathered to achieve proper use of resources. That is to say, collaborative actions occur only when the members are brought together discussing possible project solutions, or in the specific stages in which the disciplines are involved, depending on the needs and the knowledge required to be able to move forward with the solution.

However, forms of joint work, such as these, move away from the concept of collaboration adopted so far, which presupposes that all members must work together from its beginning, gathering and building knowledge, but not in a segmented way only bringing together results. Therefore, because of the complexity of the social interdependencies created by sharing more than data, collaboration cannot be considered as one of the phases that composes design process, but a continuous state in which the phases of the process are developed based on the sense of sharing.

6 Non-technical and free essence

Paes and Anastassakis (2016) suggest that the most appropriate way to design, in an increasingly heterogeneous world, is to consider new co-creative forms, supported by current communication and connectivity tools in order to collaborate. However, in some cases, the social foundation of interactions between individuals with common goals is omitted, raising the idea of the need for technology to achieve a state of collaboration.

In this sense, Achten and Beetz (2009) and Wiemann (2016) coincide in arguing that most research is centered on the technological field, omitting the social and psychological approaches of collaborating, thinking technological solutions to a cognitive process that is essentially inter-human. This promotes an unspoken faith in which technological solutions enable the development of the collaborative design. Even knowing that eighty percent of successful collaboration depends on the social-human sense and only twenty percent is related to technological aspects (Wilkinson, 2005).

Collaborating requires more participation and communication than the traditional, vertical form of work. Thus, the larger the design, requiring more disciplines involved in the process, the more hierarchical the organization becomes within a team, making communication, and therefore collaboration, more difficult. By allowing more members to participate in decision-making, an appropriate way of organizing time, knowledge and tools is needed to make the process less and less horizontal (Rahmawati, et al., 2014). It should be ensured that interactions and decision-making are expressed as horizontally as possible. To do this, the social pressure present in the collaborative teams makes self-management possible.

In this context, Brandon (2009) suggests that such management should be carried out internally, supported by social commitments and trust created within the team, once the sense of sharing and joint work is consolidated. Collaborative work involves joint efforts between stakeholders, and it is thanks to this participation, of everyone, through unplanned, interrupted and unforeseen dialogues, that co-creation of common knowledge bases is possible (Dossick and Neff, 2011).

Thus, by having shared knowledge, interests and goals, human and technical interactions are developed on a horizontal scale, allowing unplanned discussions in which interruptions can contribute to the generation of new ideas and/or questions.

Therefore, collaboration in digital project processes should be thought of as a state of psychosocial relationship based on dialogue between individuals, generating trust and a sense of reciprocal support, since in this way it is possible to gather knowledge from different perspectives.

Collaborative design proposes more than the exchange and sharing of information. It proposes environments in which the context is understood by all members of the team, in order to ensure exploitation and development of concepts and ideas together. Knowledge must be built collectively through continuous communication between disciplines, as an open process in which intersubjective relationships complement each other and take place on a horizontal scale, promoting the synergy characteristic of collaborative teams.

7 Conclusions

Collaboration in the AEC field, particularly in digital design processes, is a form of work hampered by various aspects of the knowledge fragmentation in the field and the corporate contexts that influence design production. In some cases, by the lack of understanding the focus of the concept.

In essence, collaboration goes beyond technical and digital limits to be based on social aspects such as trust, sense of sharing, common sense, mutual respect, horizontal scales, among others. The distance produced by the fragmentation of the AEC field makes it difficult to develop interdisciplinary collaborative processes, digital or otherwise.

As expressed above, although the non-digital design process is a non-rational sequence of phases, with non-manipulable data, it is also possible to develop collaborative designs. However, most of the time, they are carried out through disciplinary interactions, considering that the cognitive processes of a designer can only be followed by another professional from the same AEC discipline or field. It should be noted that this does not directly indicate the impossibility of interdisciplinary collaboration, but rather highlights a difficulty. In these processes, usually only one discipline plans and executes it, as shown in Figure 1.

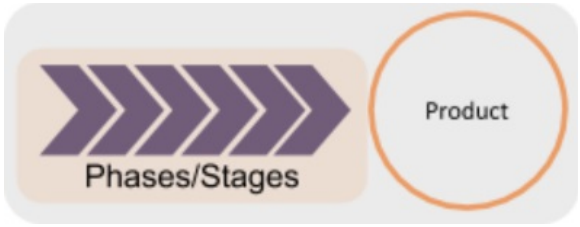

Fig. 1: Traditional design process. Source: The Author.

In digital design processes, thanks to the possibility of declaring, manipulating and understanding the explicit data of the process, interdisciplinary collaborative instances are facilitated. Since it is not made up of defined phases, feedback is possible because several computability activities can happen simultaneously and complementarily. Furthermore, participants from other disciplines who wish to take part in the process, depending on their abilities, can understand it and possibly contribute. In such processes, one or several disciplines design and execute them, as shown in Figure 2.

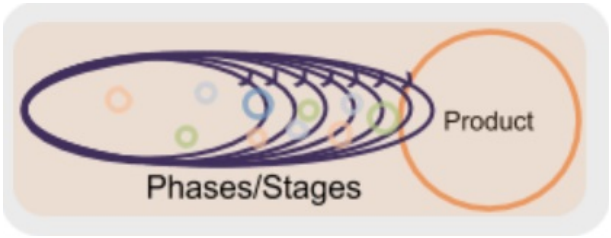

Fig. 2: Digital design process. Source: The Author.

Thus, digital design processes, compared to traditional processes, offer the possibility of being saved, exported and shared through the current networks of knowledge supported by the Internet, in which collaboration could come from any study field. The same happens with virtual communities which share open source code, such as Linux, Wikis, Maker, Hackers, among others (Elliot, 2016).

It is in this sense that the characteristics and peculiarities of collaboration change to a certain extent and are demonstrated by its two levels, 1) traditional and 2) digital. At the traditional level, the emphasis is on recognizing the personal attitudes of those taking part in the process, making the quality of interpersonal interactions imperative. At digital level, meanwhile, such acknowledgment of attitudes and skills is omitted, first of all, because those whose collaborate don't know the others involved. Second, because all those connected to the network can collaborate, leaving a larger role for interpersonal interactions.

Thus, it can be inferred that when it comes to collaborative design processes, these are processes in which participants express their desire to collaborate, and have the knowledge, skills and experience necessary to do so, and to contribute, in some way, to its progress, independent of the level at which it develops.

It should be noted that, although collaboration in digital design processes can also occur at digital levels, it is not developed by machines and digital technologies, but people. It is people who take the initiative to participate using technologies and tools in order to do so.

However, it is possible to collaborate if the main characteristics of the concept and the importance of bringing together holistic understandings to be able to propose reflections on the horizon of the collective knowledge construction in different areas are understood. Thus, regardless of environment, technology and type of design, the very essence of collaboration will provide the most appropriate answers in each case, and also whether it is really necessary to be submerged in collaborative actions. It is worth remembering that it is not always necessary to collaborate.

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