BIM E ARQUITETURA

Processos e gestão de informação no Projeto de Arquitetura.

Caso de Estudo – Quadrante

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1. Introduction

The AECO (Architecture, Engineering, Construction and Operations) sector is, like almost all other professional areas, an area where the exchange of information among the various project stakeholders is essential. The way information is generated, exchanged and worked is what we call information management and should be as optimized and organized as possible.

For many centuries, few records have come to us regarding construction projects. Until the Renaissance there were no written or designed records of the projects carried out. The information was transmitted orally and the works were carried out based on the knowledge acquired by the masters of works (Maciel, 2006).

In the Renaissance, the first records of building projects begin to appear through the use of plans, elevations and perspective. Still, it's only in 18th century that the orthogonal projection systems emerge and assume the main design features, accompanied by the model and perspectives to make the transition from 2D to 3D (O'Connor, 1999).

It is only in the second half of the twentieth century that we witnessed a very important evolution that is the invention of CAD (Computer Aided Design) technology. The change from hand drawing to digital processes has brought great advantages to the speed of production and the accuracy of the drawn pieces. However, despite this significant evolution, CAD software is no more than a new concept of stretcher. The drawings are made on the computer, in digital format, and not on a table, on paper. As for the design process and information management, little has changed. In fact, CAD drawings are printed and archived and the traditional methodology remains practically unchanged (Garcia, 2014).

BIM (Building Information Modeling) methodology, born at the beginning of the century with the evolution of CAD technology, presents itself as a revolution in the design process and associated information management. The concept consists on the creation of a digital model of the building that, unlike CAD technology, is not limited to representing the building, but to digitally simulate it, through its capacity to store and combine geometric information with non-geometric information. This model presents itself as a unique support to manage all the project information, allowing a simulation of the various stages of the building's life, throughout its entire life cycle (Eastman, et al., 2011).

The objective of this thesis is to understand what the information management processes in BIM are, applied to the architecture project and, through this understanding, draw conclusions about the effects that these processes have on the productivity and quality of services in the AECO sector.

2. BIM Methodology

Traditionally, the AECO sector is an area that is very dependent on the transmission of information between actors that, sometimes, are not in full cooperation. For this reason, the traditional method, which also includes CAD, is extremely conducive to errors and delays that will be corrected during construction, increasing the cost of the project and the time of construction. These delays and cost increases are detrimental to all project agents involved in information exchanges and dependent on them to carry out their work.

The concept consists of creating a digital model of the building to be designed that is not, as before, a three-dimensional model that represents only the geometry of the building. While the CAD model was composed of objects with predefined three-dimensional dimensions, the model built in BIM consists of a series of intelligent and parametric objects to which certain properties are associated. These characteristics allow the objects composing the model to contain non-geometric information and, through some of this information, to establish intelligent relations between them. It is through these interactions that the model becomes a digital simulation of the constructed building, prior to its construction (Eastman, et al., 2011).

One of the advantages of this new methodology is the ability to maintain the same 3D model with information throughout the life of the building, from its conception to its maintenance (Figure 1). Through this model, BIM methodology presents itself as a tool that allows a greater, more constant and more effective sharing of information between the various agents involved in the project. These ways of exchanging information allow us to correct and alleviate some of the major problems associated with the traditional methodologies mentioned above.

Figure 1. BIM process. (Source: https://bimnapratica.com)

The fact that the CAD model does not have the capacity to serve as a management tool is due to its dimensional limitation at the information level, since the information desired for the execution of a project transcends its three-dimensionality. The CAD model is thus no more than a digital representation of the building geometry, being limited to the three geometric dimensions.

The BIM model, while based in the same three dimensions of the model, gives the user the ability to work in seven dimensions: a three-dimensional geometric model that represents all the geometry and volumetry of the building; planning the work as a function of time, relating the time of each task with the spatial constraints and relation with other activities (4D); quantification of the working costs to make approximate estimates based on the non-geometric information inserted in the objects (5D); possibility of simulations to achieve a more sustainable construction and management of the building (6D); management / maintenance over the project's life cycle so that the building is monitored based on the model, for maintenance, alterations of uses and even demolitions (7D).

A BIM model contains a huge amount of information. This model is, first and foremost, a computerized file and, consequently, the weight of the information contained therein must be taken into account and well controlled.

In order to determine the point at which each model is developed, the concept of LOD (Level of Development) appears. Level of Detail is essentially the amount of detail that is included in the constructional element model. Level of Development is the level at which the geometry and non-geometric information of the element, meaning, the degree of confidence and detail that this information is given to the user of the model, was designed. Briefly, the Level of Detail can be seen as an input given to the model. Level of Development is a reliable output (BIM Forum, 2013).

LOD is defined for each element of the project. The LOD of a wall, for example, may be different from the LOD of a toilet element in the same model. The prior definition of the level that each element must achieve is essential for understanding the overall LOD of the model. At the same time, it is this definition that will later ensure that the information entered into the model is balanced and is sufficient without being unnecessary.

A very good example for having a visual perspective of what LODs are applied to a model element is a window frame. The different LODs of the same model are presented in figure 2.

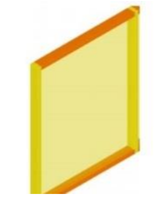
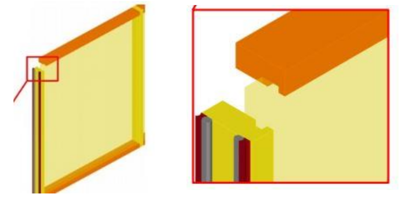
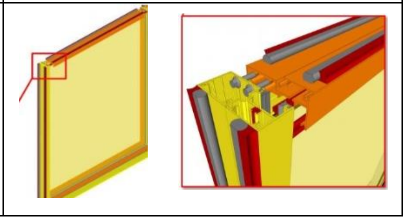
LOD 200	LOD 300	LOD 350	LOD 400
			

Figure 2. Level of Development of a frame system (adapted from source: BIM Forum, 2018).

The great key to successfully work according to BIM methodology is the constant collaboration and sharing of information among the various stakeholders of the project. Cooperation and responsibility are essential in all projects, regardless of methodology. However, the level of dependency that is created between the various entities in a BIM environment is much higher. The models of the various design disciplines are linked and consequently all interventions influence the rest of the team in real time. This factor makes the sense of responsibility and commitment of each person involved even greater. The concept of the methodology is thus based on a teamwork environment and simplification of workflows and communication between staff.

In this collaborative environment, each specialty will have the duty to build its individual model with its geometric and non-geometric information. The model of each of the teams should be collaborative and consequently be developed as shown in figure 3. The central model is stored on the server and is not used to work. When any of the intervening parties intervene in the project, it must create a local model on its computer that will be connected to the central server model. When making changes to its model it should synchronize its model with the central to update the central model and at the same time receive the updates synchronized by the remaining collaborators.

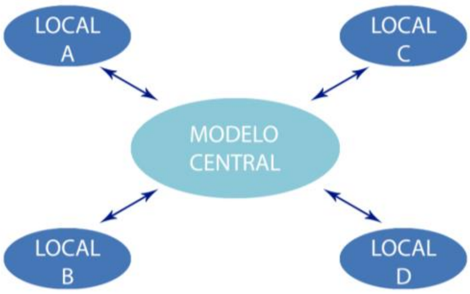


Figure 3. Collaborative process in BIM. (Fonseca, 2019)

These models are all digitally connected to generate a shared model. The result of the overlapping of all the models allows the existence of an information medium where all the information is integrated. Through specific BIM softwares for this purpose, in this model are automatically detected all the inconsistencies between specialties, in a process called Clash

Detection. Consequently, after this process, the incompatibilities are debated and solved by the designers.

Part of the problems of building inefficiency is related to the fact that each actor has a completely different specialty from the next and therefore uses different digital tools to perform their tasks. This incompatibility between softwares causes the project, in what is its digital component, to demonstrate serious failures in the level of information exchanges. The use of different software that is unable to exchange usable information makes the project similar to a project developed by actors from different languages who cannot communicate with each other. (Ferreirinha, 2017).

Interoperability is, therefore, a fundamental concept that comes down to the ability to exchange electronic data between different computing platforms (Baptista, 2015). This information must be transmitted and received clearly and unequivocally, despite the various formats and software available (Lopes, et al., 2018). The information, in addition to being shared under appropriate conditions, must be usable by the receiver software so that the interoperability is fully functional. Interoperability is the ability of two or more systems or components to share information and use information that has been shared (Pontes, 2016).

In a concept that has collaboration as one of its great pillars, as is the case of BIM, failures in the transmission of information are not allowed and interoperability is an extreme necessity for the correct application of this methodology. In fact, only with the full ability of BIM software to freely exchange information between each other will it be possible to implement BIM and its survival in the industry. Figure 4 confronts what is the exchange of project information through traditional information (2D) and when these processes are based on interoperability (BIM).

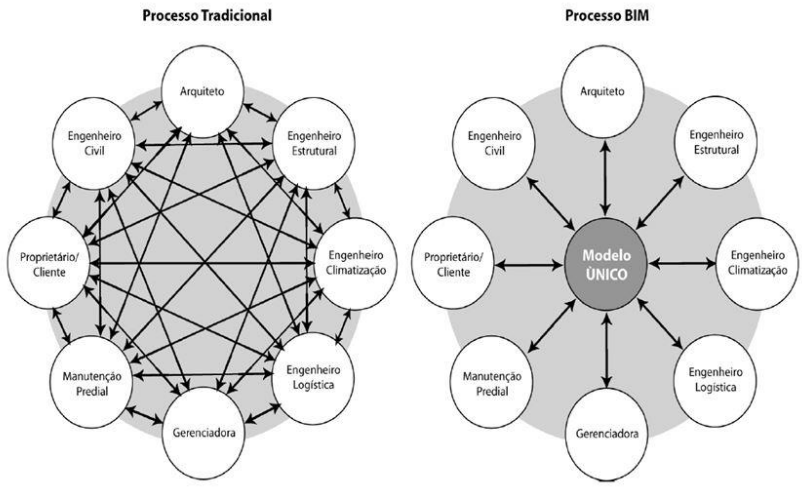


Figure 4. Information flows: Traditional vs. Interoperability model. (Ferreira, 2013)

Through the BIM model it is possible to automatically generate all the parts that compose the project, with prior preparation of it. The drawings, quantity maps and other important documents will already have incorporated the information on the projects of the various specialties, inserted by the users. Since all of this information is loaded in a shared template, they will not display the incompatibilities of traditional methods. If a problem is detected during the modelling process, the solution chosen for this situation will automatically be passed to all drawings drawn, in a process that makes the project team gain a lot of time and spend less financial resources. The graphs in figure 5 demonstrate the difference between traditional design processes and new design methods based on interoperability and process automation.

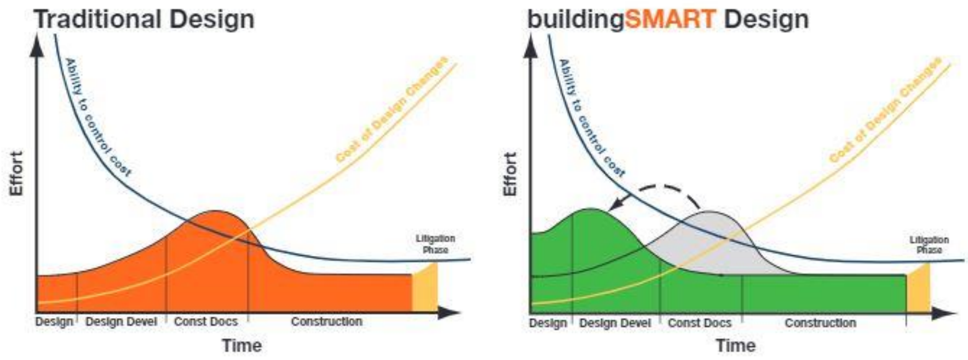


Figure 5. Comparison between traditional workflow and BIM workflow. (Bernstein, 2007)

3. The implementation of BIM processes in Portugal

The AECO sector is an industry that moves many resources of the most varied natures. Of course, the financial question is very important because, given the size of the investments required in private or public enterprises, the activity of this sector involves a lot of money. The financial amounts associated with construction projects make this sector one of the most relevant for the economy of a given country or region (Pontes, 2016).

The high relevance that BIM presents for the development of a given country leads to the conclusion that its implementation is increasingly essential. It is clear that, being a useful implementation for all stakeholders, it should be promoted by all those same actors. BIM implementation must be sought by everyone: legislation imposed by government authorities on the efforts of the project teams to carry out their work with BIM tools, involving customer contractual requirements and training architecture students since college.

Portugal has a working culture in the AECO sector which is still very much embedded in traditional project methods. BIM implementation in Portugal is still at a relatively early stage compared to the rest of Europe and some non-European countries. According to a study by Venâncio (2015), in 2015 BIM deployment was very low, with only 52.5% of respondents to the survey saying they are aware of the BIM concept (Carvalho, 2016).

By comparing Portugal with some of the most developed countries in BIM implementation in the world, it is concluded that, although there are a number of positive initiatives for BIM implementation and several companies are already in transition, Portugal still has a long way to go to achieve these same countries. The efforts of CT 197 and other groups have been notable and there is a growing willingness to implement BIM processes in the corporate sector. PTBIM, the BIM course and some of the universities are beginning to look for the training and discussion of BIM with both professionals and students, but they have faced great difficulties. It is therefore essential that, as in most of the studied countries, improvements in education are promoted and there are incentives and government standards that lead to change, either through the process implementation obligation or through support provided to the design offices for to adopt those same procedures.

4. The QUADRANTE Experience

In Portugal, BIM implementation has been driven mainly by private companies, such as the A400 or QUADRANTE, and by private builders such as Mota Engil and Teixeira Duarte. These companies realize that BIM is a very important work methodology for the productivity of companies and that the initial investments, in the long term, are compensated by the control of costs of the several projects. Also, since this big companies are the ones which have the greatest contact with the international market and since international competitions have BIM requirements, companies seek to implement and consolidate BIM methodologies as soon as possible.

In the context of the thesis, a traineeship in the QUADRANTE was carried out to serve as a case study and thus to make a practical and concrete evaluation of how the transition to BIM happens. It also allowed me to understand how to work in BIM in one of the most advanced companies in this implementation in Portugal, realizing to what extent BIM plays an important role in the design process of the company.

The work developed using the BIM methodology requires a great capacity for organizing information. The concentration of all project data on a single platform, the BIM model, means that there must be a large filter of the information introduced and a large management of how this information is organized in the model. It is necessary to have an entity that manages the model in parallel with project management, carried out by the traditionally responsible entities. This management of the model and the modeled information is, in the case of QUADRANTE, the responsibility of the BIM Division and the BIM Manager of the company.

Three projects were presented that reveal the evolution of the BIM implementation in QUADRANTE.

Project A corresponds to a housing project in which BIM maturity was still at level 1. This project's model had a series of 2D elements drawn in the model views that, although solving immediate problems, compromised the BIM process and made those that would be the later problems difficult.

This project allowed me to conclude that the misuse of BIM tools can bring more problems to the project, the work process and the ease of communication between actors than the use of CAD technologies that often leads to problems of incompatibilities and errors of project referred to in chapter 2. The adoption of BIM must be carried out with time and progressively, at the risk of otherwise damaging the projects involved in the transition phase.

The constant management and organization of the model is very important. Filtering the families being used, ensuring that there are no 2D elements superimposed on the 3D elements, and certifying that the geometric and non-geometric information contained in the model is correct and clear are fundamental principles that must be followed and applied in parallel with the development of the project.

Project B is the design of a commercial building in which BIM maturity was at level 2. The entire architecture project was developed using a collaborative model but the other specialties did not use BIM tools and there was thus no process with the various models. It was, however, an evolution since project A because there was no overlap with two-dimensional elements.

From this project we conclude that the use of collaborative models in REVIT brings enormous advantages to the designers. The constant updating of the work base of all the elements of the project team and the separation of the work by worksets promotes a rapid exchange of information and allows a greater control of the changes made to the material of representation of the project.

The correct modelling of objects and the absence of unnecessary 2D elements in the views allow faster production of drawings. The process is almost automatic after the definition of the view templates and the constant updating of the drawings before the changes to the model allows to focus on more important themes like the conception of the project than in its representation.

Project C is the design of a football stadium. This project was developed in a fully integrated process with all the specialties working with REVIT collaborative models, linked to each other. On the other hand, unlike the previous projects, it had a deep work of model preparation, in which the document templates were planned, a library of families was created and a series of

BIM standards were established and fulfilled that allowed the documents to be direct consequences of modelling.

Collaboration among all stakeholders in all design disciplines around a single model contributes to greater agility in communication, greater capacity for information exchange, and faster delivery of coherent representational elements. At the same time, prior preparation of the model promotes better organization of information from day 0 of the design phase and creates the basis for a healthy development of the project in BIM.

The introduction of non-geometric information into the BIM model turns the model into an easily accessible and simple-to-understand information management element that allows for representation pieces containing data, such as tables and drawing legends. This filtered concentration of information associated with the project is an asset for the development of the project and makes it possible to produce a large scale project in relatively low times, promoting the productivity of the company for the benefit of all stakeholders.

5. Conclusion

BIM is a work process that changes the way AECO projects, namely the architecture project, are developed.

The integrated project changes not only the relationships and forms of information exchange between the different project teams, but also the timings in which these exchanges of information take place. This process, combined with the use of BIM models, allows greater control of costs and incompatibilities in the projects of the various specialties. Through the involvement of the client in all phases of the project, the management of the building can also be carried out using the BIM model.

The production of project's representation elements, whether they are drawn pieces or written pieces, have their operation changed. Through the BIM model, elements are not produced, but are extracted and then treated. The correct development of the model is very important so that these elements are also generated correctly. This working method totally changes the mindset of BIM tools users, against the mentality before the CAD tools. No longer does it continue to draw with the computer, but to model objects to simulate the building before its construction.

BIM implementation is a progressive, ongoing and time-consuming process. The transition involves changes of mentality and the means of work. This change is complicated because there is a natural tendency to maintain the previous mindset and work habits in CAD tools and, of course, because the transition costs are very high. Change is, however, necessary to achieve more efficient, optimized and parametric information-based information management processes.

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