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Análisis de la implantación de tecnología BIM en oficinas de proyecto y construcción en una ciudad de Brasil en 2015

Analysis of the implementation of BIM technology in project and building firms in 2015 in a Brazilian city

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Abstract

Building Information Modelling (BIM) offers a wide range of tools and allows integrating all disciplines of a building project within a virtual and unique model. However, the full use of BIM requires careful planning and implementation by the firms. The objective of this study is to follow and analyze BIM implementation processes in design and building firms and relate them to the literature. We undertook a study in five firms, comparing companies that have implemented the platform and others that are currently implementing it. A partial implementation of BIM tools was found in all cases. There were some problems such as the need for changes in the equipment and the design process, which required more time and higher costs for staff training. Even so, we conclude that there was an increase in the quality of design and execution of the works, and incompatibilities between design and execution were reduced as well.

***Keywords*: BIM, design, civil construction**

Resumen

Las plataformas Building Information Modelling (BIM) ofrecen una amplia gama de herramientas y permiten integrar todas las disciplinas de proyecto en un modelo virtual único. Sin embargo, el uso pleno del BIM en las oficinas requiere planeamiento e implantación cuidadosos. El objetivo de este estudio es acompañar y analizar el proceso de implantación de BIM en oficinas de proyecto y ejecución de obras y compararlos con la literatura. El estudio fue realizado en cinco oficinas, comparando algunas que ya implantaran BIM y otras que están en fase de implantación. Se verificó en todas las oficinas que hubo una implantación parcial de las herramientas BIM. Ocurrieran algunos problemas, tales como la necesidad de mudanzas en equipamientos y en el proceso de proyecto, que exigirán más tiempo y costos para implantación y entrenamiento de la equipe técnica. Aun así, se verificó que hubo un aumento en la calidad de concepción y ejecución de las obras, bien como fueran reducidas las incompatibilidades entre proyecto y ejecución.

Palabras clave: BIM, proyecto, construcción civil

1. Introduction

The Information and Communications Technology (ICT) develops rapidly and new possibilities are available for the construction sector through data modelling with platforms like the Building Information Modeling (BIM) technology. BIM allows professionals to develop projects with virtual 3D-models representing real projects in all its details, both concerning the materials and simulated behavior. Furthermore, the model is linked to a data bank, where cost estimates, manufacturing details and other data can be retrieved. Modifications in the 3D-model lead to modifications in the data base, which are automatically transmitted to 2D-documents, such as drawings, sections, elevations and facades, as well as budget and estimate charts, and other specifications (Eastman et al., 2014; Succar, 2009).

Parreira and Cachadinha (2012) state that investing on BIM increases the efficiency in the construction industry, which has several barriers and high loss levels. Authors describe BIM as a favorable environment for the innovation and upgrading of concepts. In this context, it is essential to consider the final product and the production chain.

According to Eastman et al. (2014), the use of BIM considerably reduces the time needed for producing construction documents. This transfer of efforts implies more time to take decisions during the project and construction process, which occurs in a phase where project modifications have a lower cost.

Sheer et al. (2007) carried out studies regarding the impact of CAD packages and BIM on the project's process. According to the authors, the CAD system increased the production speed of designs, in relation to drawing tables, and allowed more standardized drawings. On the other hand, BIM offers easier 3D-modeling, which improves the visualization and creation of floor plans, sections, elevations and facades of the 3D model, since they are all automatic procedures. For example, it is quite easy to create the documentation and different views of a project based on the BIM model (Figure 1).

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According to Menezes (2011), the BIM platform is not just a 3D modeling function, but a new work philosophy that gathers professionals of the building sector, with the aim of creating an integrated virtual model, which generates a data bank serving as a reference and assistance for preparing budgets, energy efficiency simulation, and activity planning, among others. The author believes that BIM is different from a 3D modeling software, because the latter models 3D objects as a design. Instead, BIM models the objects with parameters, thus allowing its automatic edition and modification. Additionally, BIM modeling is based on the creation of different materials and components, each one with its physical, chemical, mechanical and manufacturing characteristics. Each unit of modeled material can be added to a final estimate, thereby enabling the compilation of estimate and budget charts with a smaller error rate in relation to the traditional process. A good detail level can be achieved in all parts by identifying each component of the wiring system or bathroom facilities. Figure 2 shows part of a bathroom facility (Hahn, 2016). Parts can be identified by colors: ventilation pipes are purple; wastewater pipes are green; and connectors are white. Based on Scheer et al. (2007), BIM modeling includes a larger universe than electronic models. The authors compare the conception of the 3D model with the creation process in the aerospace industries, where the model's spatial notion can find incompatibilities almost instantly, thereby supporting the decision-making in an intuitive manner. In this sense, Taboada et al. (2011) present a study regarding the detection of incompatibilities and interferences within the projects.

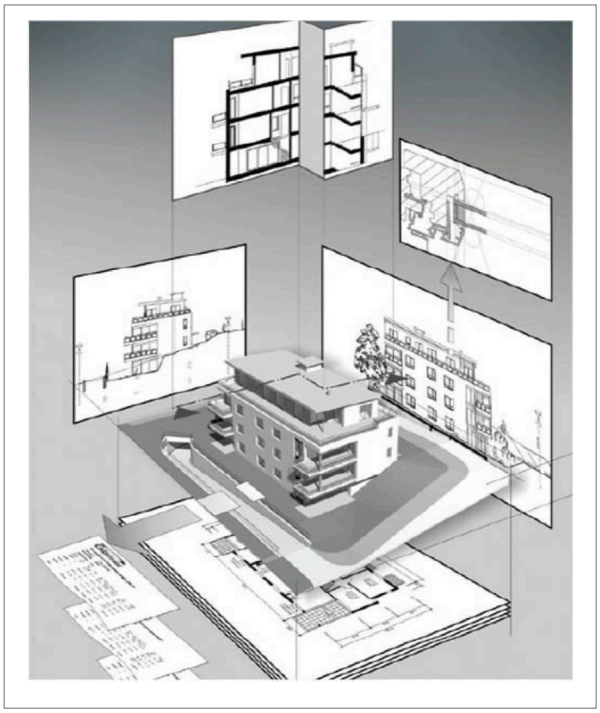

Figure 1. *Creation of the documentation and different views based on the construction model (Lins, 2013)*

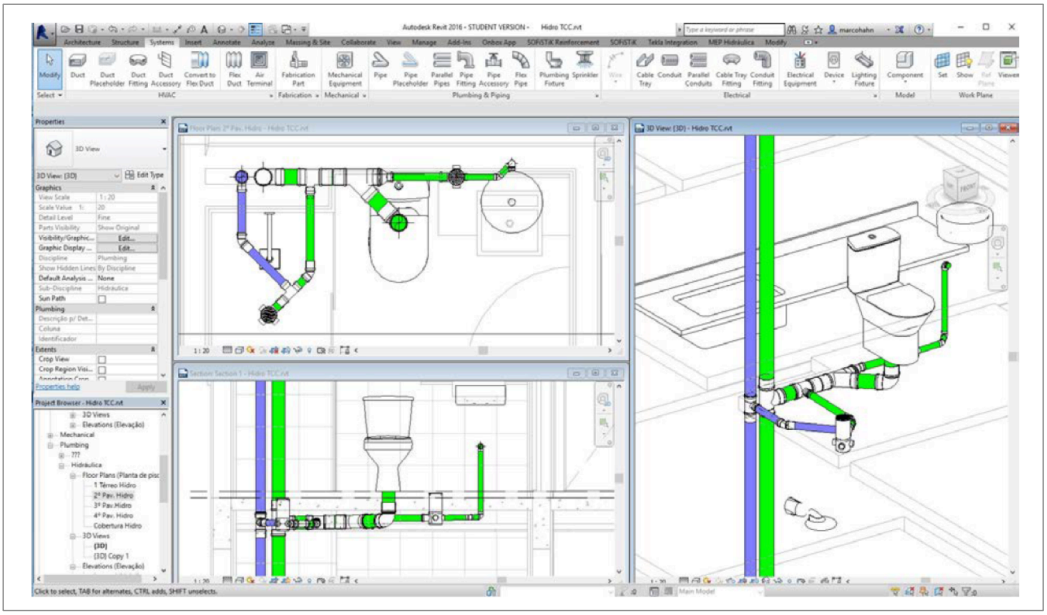

Figure 2. *Detail of a bathroom facility (Hahn, 2016)*

Eastman et al. (2014) consider that models have different information levels, where each level represents an evolution in relation to the previous level. These information levels are called dimension levels: 1D, 2D, 3D, 4D, 5D and 6D (one, two, three, four, five and six dimensions). CAD and BIM platforms include the first three levels. 1D and 2D levels are representations of geometrical data formed by lines and dots, which create the building plans; while the third dimension complements the volume of the constructions. CAD-based projects achieve the three dimensions, although they generally use only 2 dimensions. Figure 3 shows an example of a 3D rendering project (Jobim, 2015).

According to Menezes (2011), the implementation of the BIM technology is not easy, because using the software requires training, and also changing the culture and education of the staff working in the project area. Eastman et al. (2014) state that the implementation of BIM systems in replacement of 2D and 3D CAD systems requires the procurement of software and hardware, and staff training. The implementation planning should be carefully prepared. Changes are needed in all areas of the company, but specific changes will vary from one firm to another, and they will still depend on the construction sector in which they interact.

The 4D model incorporates the time variable. A works' scheduling can be made by a parametric modeling, where the creation of objects is associated to a period of time. Thus, a range of possibilities is created, such as dividing the project in phases, simulating site schedules and planning the materials' arrival process (Parreira and Cachadinha, 2012). There are some recent studies addressing the BIM application in the planning of construction works, such as those presented by Cabrera et al. (2015) and Duarte Hinojosa (2014).

According to Czmoch and Pekala (2014), the 5D level incorporates the cost of materials, labor and equipment for each item in the project. These authors believe that the model enables to assess project alternatives, because their estimates can be compared with reduced efforts and time.

Although there is no consensus regarding the content of the 6D data level, some authors link this BIM model level to facility management. Considering this, the 6D model details a building's life cycle, generates as-built projects and allows defining the necessary maintenances throughout the service life of the building (Addor et al., 2010; Menezes, 2011; Parreira and Cachadinha, 2012). However, other authors relate the 6D level with the sustainability analysis, which evaluates energy consumption and information regarding LEED certifications, for example. For these authors, the facility management would be the 7D level (Czmoch and Pekala, 2014; Ferreira, 2015).

Andia (2008) carried out a study with the purpose of understanding the problems faced by firms when implementing the BIM technology. This author described the process in three phases: the first phase envisaged the transition from 2D CAD plans to 3D modeling projects with BIM. In the study, the 3D modeling phase was made once the execution of the works had already started, after all the necessary documentation had been made in 2D, the objective of the 3D modeling was to control the geometry and visualize certain potential disagreements between the projects. In the second phase of the study, the firms had already begun to master the use of BIM. These companies worked to find process routines to estimate costs during the project conception, and they started the incompatibility simulations and the analysis of the construction phases. These changes also modified the staff distribution, where more experienced architects worked more hours than the apprentices did. In a third phase of the study, the firms had control of the data bank in BIM and coordinated the modeling process.

There is an increasing use of BIM at global level with a strong development in the USA and some European countries (Monfort Pitarch, 2015; Eastman et al., 2014). However, in Latin America, the use of BIM is still at an early stage (Cabrera et al., 2015; Duarte Hinojosa, 2014). In Brazil, the use of BIM started in the year 2000 (Menezes, 2011). According to this author, the high cost of training the staff, the software and latest computers are the biggest obstacles for a broader use of BIM technology in the country. Nevertheless, the expected investment return for the BIM application is in a short to medium term. Menezes (2011) states that Brazil had a late start with BIM models, as with the CAD systems.

By replacing the existing CAD models by parametric models, the company undergoes a change in the way of representing the construction, mainly by modifying the way of modeling a project and replacing the old creation concept line by line (Eastman et al., 2011). Hippert and Araújo (2010) understand that the main change from CAD systems to BIM regards the process. With the BIM technology, the project is stored in a server, where different professionals who are part of the project constantly update the model. Everyone has access to the process (but with modification restrictions). The retrieval of documents, reports, estimate charts, materials specifications and any other kind of information annexed to the project is done in a simple way.

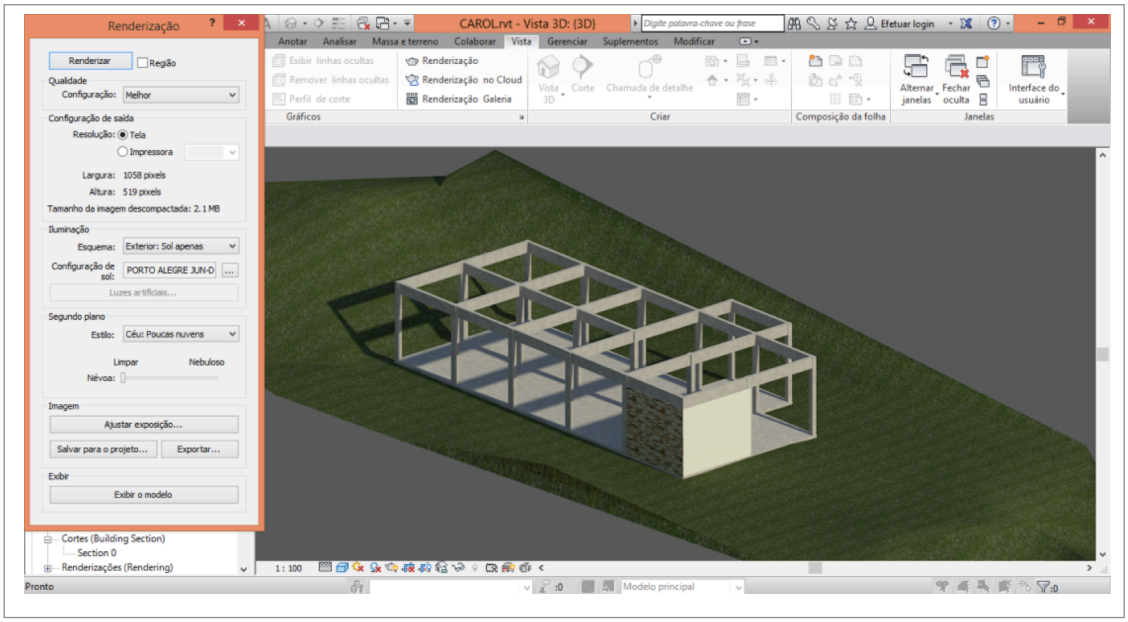

Figure 3. *Prototype rendering (Jobim, 2015)*

2. Used method and results

BIM implementation processes were studied in five project and construction firms. The analyzed companies have their headquarters in the cities of Porto Alegre, São Leopoldo and Novo Hamburgo, located in the south of Brazil. Two of the analyzed companies are architecture firms specialized in projects, and three of them are specialized in project and construction of real estate businesses. Interviews were made to the professionals working in these firms, generally involving one of the partners (Table 1).

The needs and decisions of these companies were verified, including the selected platform, motivations and objectives concerning the BIM implementation. Regarding the implementation phase, the questions dealt with the implementation year, changes within the team and in the project process, and implementation costs. As for the process modifications, questions addressed the measures and procedures adopted for carrying out the first projects with BIM, use of 4D, 5D and 6D, compatibility procedures and software used. Results are described below, and summarized in Table 2 and 3.

3. Company needs

In Company A, partners chose ArchiCAD for having a data flow that was best suited to the company, a more intuitive interface and for being more flexible and agile. They work with interior and architectural projects, mainly commercial ones. Professionals consider that ArchiCAD is a software more related to architecture. The purpose is to increase productivity and reduce the number of errors, because they have a considerable project demand, thereby obtaining short-term economic benefits. They are also interested in becoming one of the first firms of the region to innovate in technology, mainly because they already did so when they were pioneers in using CAD and 3D CAD (Table 2).

Company B has a central project coordinator and the Revit installation started in 2013. The first objectives were to increase the agility of the projects' compatibilization and parametrization, thereby increasing the company profits. The implementation process is not yet completed. The company chose the Autodesk Revit for being the most popular BIM, because they already worked with AutoCAD, and due to the compatibility with the TQS software, a Brazilian structural calculation software, which is widely used in the region. The professional who makes the structural projects uses TQS. This company does not retrieve all the 2D documentation from the software and it is still creating sets. Professionals will get a better visualization of construction elements and processes by using the 3D model.

Company C expected to improve the projects and felt the need to detail some of the systems used. They understood that BIM was a means to speed up the preparation of documents. They also perceived that the visualization of 3D projects could improve the project process and, furthermore, they expected the employees to achieve their full potential through more accurate and reliable planning. They began to implement Revit in 2013 and they are currently executing the full compatibilization of projects with the help of the model. They retrieve estimates and create schedules with the Autodesk Sync software, and model the hydrosanitary project with Revit.

***Table 1**. Presentation of the Companies*

Company		Team/Functions	Scope	City	Beginning of Activities
A	Project	2 architects (management) 3 architects (coordination; buildings, interior architecture) 1 arch. apprentice	Housing; multi-family residential buildings; commercial properties (medium and high standard); architectural projects; interior arch. and landscaping	Porto Alegre	1994
B	Project		Housing; multi-family residential buildings; commercial properties (medium and high standard); architectural projects; interior arch. and landscaping	Novo Hamburgo	1987
C	Project & c Construction		Multi-family buildings (high standard)	Novo Hamburgo	2007
D	Project & Construction		Multi-family residential buildings in structural masonry, low and medium standard	São Leopoldo	-
E	Project & Construction		Housing; multi-family residential buildings; commercial and industrial properties; Consulting	São Leopoldo	1983

Source: The Authors

Company D had problems in the construction phase due to a lack of dialog between the project and the construction teams. In general, what was projected could not be adapted to the execution, which led to project modifications at the construction site. The project architect already knew the BIM technology and thought that this platform could be a possibility to improve the work of the whole team and integrate project and construction. They started the implementation at the end of 2012, with the expectation that the company should keep improving their technology and innovating in the market. Their aim is to use BIM at all levels. Those studies are easier with the use of BIM. They chose Revit, because they know that the manufacturer has worldwide acknowledgement. Currently, they already retrieve 2D documentation and estimates from the platform, and they are beginning to prepare budgets. They perceived an improved dialog between the teams, because project modifications and details are made based on site observations.

In Company E, the partners perceived some issues in the preparation of projects. When analyzing the possibility of using the BIM technology, they observed that many of their problems could be solved by using a single software. The firm works in project and construction. One of the architects is in charge of the works execution, and he manages, supervises and makes the materials' procurement. The project compatibilization was made informally, with superposition of floor plans. Sometimes, errors were unnoticed. Moreover, apprentices, who lacked the experience and could not perceive certain construction conflicts, generally executed this phase. Projects undergo several reviews, and the necessary modifications are transmitted to those in charge, so that they can update floor plans, sections, facades and projects. The ArchiCAD platform is fulfilling the expectations of the company, but not all of the expected benefits have been achieved.

4. Implementation

The team of Company A carried out a one-year study concerning the implementation of ArchiCAD, and then joined two other firms in Porto Alegre to make the training and implementation together. Thus, they reduced costs and training was more focused on their objectives. A Graphisoft team of São Paulo was in charge of the training. During the study phase, the team was divided in groups: one for templates, one for advanced studies, and another for creating the data flow diagram; a project manager was appointed. The template group created a set adapted to the needs, which was similar to what was already used in CAD. The advanced studies group searched for information regarding the possibilities of the new platform, thus enhancing the initial knowledge. The data flow diagram group prepared a best practice manual for projects, in order to create a model that could be followed in the project process. A one-week training followed this study phase. The platform was put into use two months later, which meant to completely uninstall AutoCAD copies. In addition to the skills obtained during that process, one of the partners is a member of the BIM workgroup of the AsBEA-RS[2], which contributes with new knowledge to the firm. Computers got new video cards, memories were extended, and data cables were replaced by CAT6. Files are stored on a local server and data is sent to the cloud backup. It was not easy for the company to find professionals with a good know-how of the construction process who could also master the BIM technology. The interviewed partner believes that, in order to fully run the BIM platform, the modeling team should be given construction knowledge beforehand, so that they can create a model close to reality. The interviewee stressed that project deliveries still have the same deadlines, but the time previously designated to prepare drawings and modifications in sections and elevations is currently used for project study and details (Table 2).

In Company B, the Autodesk representative in Porto Alegre provides training and it was ongoing when the survey was carried out. The problem encountered in the training is the qualification of the professionals offering the courses, since they generally lack an education in the engineering or architecture fields, and they do not have any knowledge concerning the construction processes. Regarding the equipment, investments were not significant, because it is a small team. They bought two computers and upgraded the rest. Files are stored on a server of their own. They already have a standard template, but they are still working on the set creation.

Company C bought a computer with the proper configuration for BIM. Moreover, they obtained a Revit license, an AutoCAD license and a Sync license. The project team created templates, materials and sets. The template was based on a standard model of the software. The sets that were not available in the Internet libraries were created based on advanced modeling. The components of modeled sets are more specific, like walls with differentiated materials and details. File storage is shared in the cloud and they do not make file backup. The company has actually been working with BIM for two years, and they consider that the system is still being implemented, because they feel that it is a progressive process and they have not defined a deadline to conclude the implementation. The interviewed professional indicated that one of the major issues is the interoperability between software from different platforms, and that there is a loss of information when using IFC file format. They also mentioned the problem of finding professionals and firms that were qualified to make complementary projects that are compatible with BIM, and they have an internal problem with set modeling. They mentioned that more time was designated for analysis, visualization, communication and compatibilization, which in turn increased the size of the project team. They used some guides and manuals available on the Internet for set modeling and materials creation, and they expect to create a user manual for the company projects.

2 Brazilian Association of Architecture Firms, department of Rio Grande do Sul

***Table 2**. Needs and Implementation*

Implementation					
Implementation Year	*2011*	*2013*	*2013*	*2013*	*2014*
Platform	*ArchiCAD 18 (Graphisoft)*	*Revit (Autodesk)*	*Revit-MEP, Sync (Autodesk)*	*Revit (Autodesk)*	*ArchiCAD (Graphisoft)*
Changes in Team and Processes	*Longer conception time Less time for design details*	*None*	*Higher time and staff demand*	*Physical integration of all sectors*	*Staff reduction*
Implementation Costs	*US$8,900 – 5 ArchiCAD licenses and updates and supports; US$690 – 8 licenses for Windows 7; US$405 – Done technical support; US$390 – basic hardware upgrade; US$2,600 – 260 training hours; US$480 – laboratory location and coffee break*	*US$ 2,000 – 2 licenses US$600 – annual renovation US$1,500 – hardware US$390 – training (ongoing training)*	*US$2,500 – hardware US$2,000 – Revit + CAD US$1,200 - Sync*	*Unable to inform*	*US$3,900 – software and course*

Source: The Authors

The professional interviewed in Company D could not inform about the implementation costs. Apprentices, collaborators and managers are still developing the process. In order to update the hardware, they bought new computers, with medium software requirements, and they will replace network cables by Gigabit CAT6, which enables networking with linkRevit. When the project is not too big, all the information is kept on a single file; otherwise, the project is divided in several files (architectural, structural and complementary) connected through linkRevit. The project team created the standard template, without using standard Revit templates. They use set libraries from Autodesk and others from the Internet. They also model the proper furniture, and walls with different details that cannot be found in standard libraries, such as those with isolation layers. Initially, they worked in the creation of specific sets for structural masonry and standard properties, which are financed by Brazilian banks. They have had trouble finding training that can fulfill the needs of the professionals and not just a generic BIM learning.

The professionals of Company D have searched for information and tutorials on the Internet, but they still feel they lack teaching on construction details, such as the creation of ceramic sheathing, for example. One of the initial problems was the training of the project team, because some of the professionals of the sector do not have any knowledge about constructive procedures and execution details, which makes modeling more difficult. Considering this problem, the project and construction areas were joined, thereby enabling the communication and solution of site problems that were previously not communicated to the project team. Interviewees believe that the implementation has not concluded and they expect to create a user manual for the type of project they execute.

The main investment of Company E was on a software license and training. Computers are Dell desktops with Core i5 processor, with 8 Gb RAM memory. In order to be compatible with ArchiCAD, video card need to be replaced and the memory, extended. A complete computer was bought. Files are stored in a cloud system (Dropbox). Currently, the Company has a 50 Gb storage space. Since the computer links are always updated, there are no access problems, even without Internet. This is a paid service and the space can be increased. The template used by the firm was created based on the standard ArchiCAD file, and it was modified over time, according to the usage needs. The interviewed professional mentioned that the major problem was the communication with the collaborators in charge of the complementary projects, since their software cannot interoperate with the selected BIM. This entails the need to redesign the complementary projects. Before the platform's implementation, the team was composed of three apprentices, who were reduced to two once the BIM technology was implemented. In relation to guides and manuals, they only used notes and instructions provided by the hired training team. The company still expects to use the mobile app for BIMx, when the adoption of the new technology has been completed. The app is a BIM project viewer, which navigates in ArchiCAD 2D and 3D projects, and it is available for Android and iOS.

4. Process modifications

Company A decided to start using BIM with a full implementation, thereby developing the projects from the beginning to the end with BIM. This meant to abandon the tools previously used. A collaboration spirit was observed among the members of the team, because they were all in a new phase, with the same difficulties and objectives. They use additional tools, such as TeamWeek, which operates as a task manager. They also use the Energy Model Review, which is part of the ArchiCAD system and simulates the model's energy consumption. The partners of the firm realized that the end product had a better quality, the project process was more reliable and the generated documents were more transparent and accurate. Reviews, compatibilizations and updates of the project modifications were also faster. The company made no modifications to the project delivery model nor the contracts (Table 3).

Company B initially appointed one project general manager and two assistant managers. They faced some problems after the implementation, because the professionals reduced their production and had difficulties adapting to the Revit platform. They do not execute complete projects in the platform, nor do they plan a procedure to carry out a project with BIM from its conception. They converted some AutoCAD projects to BIM, and then verified the possibilities provided by Revit. The company modeled some of the projects and only the architectural and structural projects are compatible. The compatibilizations of the hydrosanitary and electrical projects are still made manually. They use AutoCAD for the projects' conception phase, Sketchup for rendering and MS Excel for budget creation. They do not use 4D, 5D or 6D.

In a first stage, Company C created the most frequently used materials and sets. The interviewee was not able to inform about the first BIM project, since he did not work in the Company at that time. They perceived details that made the project process more fluid, such as confirming errors before the beginning of the construction, thereby anticipating their correction and improving the construction process. The preparation of 2D documents was faster and had less errors. The materials estimate was also faster. This company uses error reports that are automatically created by Revit and does not have standardized review procedures. Reviews are made only when a problem is detected. Once the project process is completed, documents are printed to deliver them to the client or to be used on site, in case the Company executes the construction works. There is compatibilization between the architectural, structural and hydrosanitary projects, since the company itself prepares the structural projects (with TQS) and the hydrosanitary projects (with Revit MEP). They already prepare 3D and 4D documents, but 5D still needs interference. The Company retrieves estimates from Revit, but uses Sienge (a special planning and management package), which does not have a direct connection and demands the manual entry of estimates to prepare the budgets.

Company D started the implementation process by creating sets and then some projects were manually transferred from AutoCAD to Revit, entering the necessary data to complete the projects. Two projects were concluded with the new process and works were initiated. Before starting the construction of the services, different incompatibilities were found and corrected with the help of Revit. These projects, made directly with BIM, showed a time reduction in the preparation of 2D documents and in the project's conclusion phase. The use of BIM also reduced the time for preparing materials estimates, which were made according to the traditional way. The created documents are printed and delivered to the construction team. The team does not usually create reviews, and the construction team informally reports the problems, which are corrected by the project team. The compatibilization between the architectural, hydrosanitary and structural projects is made with BIM, including the project objects. The structural project is relatively simple, because it is structural masonry. They use MS Excel for budgets and Sketchup for rendering certain elements. An external professional does the electrical project. The hydrosanitary project is prepared by the team, with sets obtained from a materials manufacturer. The Company had decided to buy a plugin to make the hydrosanitary project with Revit (Ofcdesk), thus enabling modeling, preparing estimates and compatibilization. The Company also uses Sienge. They make the 3D model, which allows retrieving the documentation and the materials estimate chart. They were creating algorithms to enter labor and equipment in order to be able to retrieve a complete analytical budget.

The team of Company E started the process by creating basic blocs and materials, so they could begin the transcription of an entire project to the selected platform. Here, the conception of the projects starts with handmade drafts and sketches, and then gradually introduces project decisions.

Before adopting BIM, the Company E prepared floor plans and sections with AutoCAD. 3D representations were made with Sketchup. The new platform showed a more agile retrieval of 2D floor plans, and allowed anticipating problems that would otherwise appear at the time of construction.

The team of Company E does not prepare the documentation; they still make reviews in all project phases, which were previously handmade, thus demanding more time and being more subject to errors. 3D floor plans and elevations are only printed for client delivery or on-site use. Regarding the compatibilization, it was not yet completely made with BIM, mainly due to a lack of interoperability with the software of external professionals. Sometimes, certain parts of the facilities can be modeled, so that compatibilization is possible. Since the Company was in the initial phase of the implementation, they did not use additional simulation tools, nor did they use 4D or 5D.

Table 3. *Process Modifications*

Company	A	B	C	D	E
Initial Measures	Designation of a project manager Creation of the "templates" group Creation of a data flow Creation of an advanced studies group	Designation of a project manager and assistant managers	Materials and sets	Materials and sets	Materials, blocs and transcription of the first project
First Project	Total implementation, with a project from start to end	Does not apply	Not informed	They transformed some projects for BIM and works of some of these project are beginning	Project coming soon
Error Report	They confirmed errors during compatibility process, but no report was generated	They do not generate reports, but they are undertaking a study for this purpose	With Revit	The site team reported errors	Not made
3D – 4D – 5D – 6D	Modelling and energy simulation	Modelling	Modelling, Planning and Estimates (Budgets)	Modelling, Estimates and they are starting with Budgets	Modelling
Compatibility	Only virtual (hydrosanitary and structural designers generate compatible files)	Structural design is made with Revit; hydrosanitary and electrical are manual	Projects: architectural, structural and facilities	Projects: architectural, structural and facilities Electrical with lines	Partial
User Manual	No	No	No	Yes, but not retrieved from BIM	No
Software, Plugins and Other Tools	Task organizer: TeamWeek (Toggl) CAD viewer Excel Energy Model Review (within ArchiCAD)	AutoCAD Sketchup Budget: Excel	Planning: MS Project Architecture: Revit Electrical: AutoCAD Structural: TQS Hydraulic: Revit MEP Sanitary: Revit MEP Budget: Sienge 4D: Sync	MS Excel Project Sketchup Electrical: hired, Revit format file Hydraulic: Revit Sanitary: AutoCAD Budget: Sienge	Excel Sketchup

Source: The Authors

4. Discussion and final considerations

It is worth highlighting some difficulties encountered by the studied companies during their BIM implementation processes. Regarding the phases prior to using the platforms, it was observed that it is necessary to understand the BIM concept and the transformations occurring along the project process. The total change embraces more than just the modifications in the project process, because the team needs to work together (gathering designers from different disciplines and constructors). Additionally, the project must be developed with the aim of facilitating the construction.

The lack of knowledge concerning the works execution processes is an issue observed in some members of the team. For example, 2D CAD designs do not require a broad knowledge of the building's construction stages, because drawings are made of lines and objects with no chronological or hierarchical connection. However, in order to properly operate BIM, the team who prepares the projects should know about the practices of site workers, the characteristics of the materials and the construction processes, as well as understand the construction planning.

The studied companies also mentioned some difficulties in relation to the training. The market options offered in the region of Porto Alegre were considered deficient in terms of the platforms' planning and implementation. Courses consist in practical exercises teaching the use of software tools, but they do not include a specific support for companies of the construction field. Most of the teachers have no knowledge of engineering or architecture and they lack the technical knowledge of the projects. Therefore, difficulties arise when it comes to clear up some doubts, such as the creation of sets or the incorporation of object properties that are not commonly used. Implementing BIM together with other firms sharing the same interests can reduce costs and allows hiring a training more adjusted to the preferences of the firms.

In relation to the amount invested on the implementation of the platforms, it can be observed that it is high considering the size of the firms and it requires a good planning from the company. The implementation must be programmed in detail, defining the needs of the projects that will be executed by the company and the objectives, such as a speedier project process or higher profitability. Furthermore, the functions of each member of the team must be well delimited, and a chronological flow of the project phases should be established.

It can be concluded that the available BIM platforms have different purposes and provide countless tools to achieve the complete use of BIM, which is the use or operation simulation. Despite this, commercial packages still need other apps in order to perform the entire project cycle. In order to achieve all the information levels of the model, so that it can naturally flow, the interoperability among different software is required. This does not occur naturally, because, in general, the created files do not contain all the information within the model, something that is also confirmed in software packages of the same manufacturer. The BIM technology can be beneficial for the construction market. However, since it is somewhat new, professionals still put up some resistance, and packages show some integration problems and other deficiencies that delay the BIM adoption process in the firms.

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