IMPACT FROM THE USE OF BIM IN ARCHITECTURAL DESIGN OFFICES: REAL ESTATE MARKET OPORTUNITIES

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ABSTRACT

This work analyzes the impacts resulting from the implementation of the BIM - Building Information Modelling - technology in architectural design offices, seeking to identify the most relevant aspects of its use on the design process. It also casts a look at the potential spaces and opportunities that rise from the use of the tool. Several international studies have demonstrated the benefits and the changes triggered by the use of the BIM in design concerns, but, as regards the recent Brazilian experience very little is known or has been reported. This way, this work seeks to contribute towards filling this gap, identifying the peculiarities of the Brazilian case, seeking to improve the conditions for the implementation of the new tools and to facilitate the adapting of the technology to Brazilian standards. The research covered the formulation of field studies in architectural design companies located in the city of Rio de Janeiro, São Paulo, and Curitiba. Analyses were made of the difficulties found and the main advantages obtained in the adoption of the BIM technology by these offices. The evaluation of the experiences allowed the identification of countless problems in the transition from the present traditional technology to new information systems: high cost of software, resistance to change by the team, lack of integration between designers, amongst others. It is believed that the data generated in this research can contribute to the promotion of improvements and advancements in the BIM technology, propagating its possibilities and facilitating its larger-scale implementation in the country towards the modernization of the processes in the Brazilian civil construction scenario. The results presented lead to the discussion of the role played by the architect in the real estate market and also demonstrated that there is much to reflect upon on the opportunities to be explored with the use of the BIM.

Keywords: BIM, Architectural design office, Real estate market

1. INTRODUCTION

It was in 1982 that the first programming code was used in a calculator of a system to create a 3-D design of a nuclear power plant in Hungary. The calculator had a 64K memory and the system was ArchiCad. Gallello, president of Graphisoft, the system developer, reports this fact remembering that the introduction of computing in Architecture occurred in the 1980s, 'revolutionized the process of creation, design and even the creation of the space' (FRANK, 2008). From that time on the CAD - Computer-Aided Design - acronym started to represent this technology.

To Scheer et al (2007) the CAD technology is the most important innovation in the last 40 years. This author points three separate generations in the evolution of computer use in Architecture: the first one is that of computer-ai8ded drawing, the second one that of geometrical modelling and, finally, product modelling, starting in the late 1980s (KALES;ARDITI, 2005 apud SCHEER ET AL, 2007). The main goal of this last generation is the conjunction of two information groups: the geometrical information, as related to the spatial characteristics of the product such as form, position and dimensions, and the non-geometrical, which include cost, resistance, and weight, amongst other characteristics. This conjunction coupled to the collaborative approach of an entire life cycle of the enterprise forms the BIM - Building Information Modelling - technology.

In the design stage, the BIM technology, more than a drawing tool, provides the architect with the possibility of conceiving a design constructing one's parameterized model which allows one to visualize the volumetric aspects, estimate costs, quantify and qualify the material applied, observing and adjusting the environmental comfort and other project items, and facilitating the communication between the many professionals that form the process. The modifications and improvements to the design are processed automatically in the cost plans, in the floor plans and elevations of the construction, allowing a significant increment to the quality of the communication and, consequently, to the quality of the final product, the building. Several works (KIVINIEMI, 2005; GARCIA et al., 2003) relate this set of items to the coordinated development of enterprise models. Cheng and Law (2002) propose that a design team simultaneously use software to plan, monitor, organize, estimate costs, and visualize the progress of the

construction, saying that, in a diversified environment, the simultaneous engineering and the interoperability of information play an important role in enterprise management.

The implementation of new BIM-based technologies, however, assumes the re-structuring of companies through the reorganization of processes, the implementation of a new form of work organization and of a new way to think the design process, now seen in a fully integrated manner. Apart from that, the use of the BIM requires new qualifications for the professional, acquisition of new equipment, and a new way to deal with the remaining agents in the process (JUSTI, 2008).

It is possible to see in Europe and in the US the growth in the application of the BIM concept in architectural and engineering projects, dealing, in an integrated manner, with the elements of design, of the work and management processes from the formulation of virtual models (FIESP, 2008a). The international experiences have been confirming the strong tendency for the adoption of the technology that has demonstrated sizeable potential to be applied to the development of projects for the AEC industry (Architecture, Engineering and Construction), improving productivity and boosting quality.

Motivated by the countless possibilities and facilitations provided by the BIM technology, some Brazilian design offices followed the international movement, moving to the forefront in the application of BIM systems in their companies still in the early 2000s. This process intensified in recent years, given the evolution of the programmes and the stimulus to buy the software, having them move to the shelves in the offices, but not definitively to the designers' machines.

The lack of skilled labour, resistance to change, high investment in machines and training, as we shall see below, are some factors that hamper the effective implementation of the technology in the design offices of the country. Due to risks and uncertainties, the companies end up by creating obstacles, and waiting for the consolidation of the technology to implement it (NASCIMENTO; SANTOS, 2003).

Brazilian industry needs to follow the world evolution, seeking to adapt the BIM technology to the Brazilian profile to facilitate its larger-scale implementation in the country, seeking to modernize civil construction processes.

1.1 Objectives and expected results

This article comments on the nature of the working process for the architect, with the objective of pointing the opportunities provided with the use of the BIM. It seeks to characterize the use of the BIM in Brazilian architectural offices by analyzing how the technology is being applied in Brazilian companies, identifying the benefits generated, the difficulties found and the changes provoked by its implementation. Thus, this work analyzes the perception of Architecture offices of the possible perspectives that are suggested with the adoption of the BIM. Questions are also made on the spaces and opportunities that are crystallizing for architects from the advances enabled by the BIM. The evaluation of experiences and the publicizing of the results obtained with the adoption of the BIM by Architecture offices can contribute through encouragement, and giving better support to allow new Brazilian companies to implement the technology, opening room for discussion towards the formation of new strategies in the provision of architectural services.

2. BUILDING INFORMATION MODELLING (BIM)

2.1 Origins of the BIM

The concept of product modelling gained momentum in the late 1970s, amidst countless economic changes, with the globalization of the markets and increased pressure on the companies. In the search for improving the processes it was essential to make an integrated approach of the different aspects related to the product, to reach a market whose demands on terms, quality, and costs were on the increase. Product modelling rises then, as an important tool to assist the conception, validation, and construction of the product, guaranteeing an increase to productivity and the survival of the business. The modelling is based on the integration of the systems involved in product development and on the use of information technology as a support to these processes (AYRES, 2009).

In the context of civil construction, the increase in the complexity of the processes caused the need for the insertion of an industrial mentality, seeking the application of solutions adopted in the manufacturing industry. In this sense, the notion of product modelling adopted by other industries gave rise to the BIM concept (Building Information Modelling), as modelling that seeks to integrate all the processes related to the construction of the building product.

Several works on product modelling in the AEC industry were developed still in the 1970s and 1980s, in the US and Europe. The initial concept was named Building Product Models in the US whereas in Europe and Finland it was presented as Product Information Model (EASTMAN et al., 2008).

Some of the first lines published on the BIM can also be found in the Eastman article, published in 1975 in the *AIA Journal*. The concept developed by Eastman was named Building Description System (BDS). It was a system where the representation of the elements of design was based on geometrical information associated to other attributes. This way, apart from creating drawings, the system allowed the generation of reports and analyses related to materials quantities, cost estimates, amongst others. The design would be a result of the arrangement of constructive elements that, when modified only once, were updated in all of the visualizations (EASTMAN, 1975 apud EASTMAN et al., 2008).

2.2 Adoption of BIM systems in the AEC industry

In the fragment context of the AEC industry, the BIM proves to be an important tool, capable of contributing to the integration of processes, from the elimination of inefficiencies and redundancies, increasing collaboration and communication, to ensure better productivity results (CAMPBELL, 2007). The BIM allows greater integration of projects and of all processes involved in the construction, bringing greater quality to the building, with smaller costs and reducing design time (EASTMAN et al., 2008).

The use of 3D models allows the comprehension of the design to be accessible to all, not being restricted only to those that know the symbology and representations of the drawing (KYMMEL, 2008). This facilitates the understanding by the client and end user, and contributes to the formulation of solutions more in line with its needs.

Despite the efforts of software manufacturers and of organizations to promote the BIM, the vast majority of building projects are still made with the traditional method, with 2d drawings and text documents. The design sector is generally resisting the change towards this new model of information. The causes for this resistance are many and amongst them is the long learning process, lack of time

and financial resources of design offices and the deficiency of the software (BAZJANAC, 2004).

The contracting party is that which obtains the most profits and benefits with the adoption of the BIM technology and as main party interested should encourage the development of the teams and the implementation of the tools (KYMMEL, 2008); however, it is the subcontractor design offices that end up bearing the expenses and risks in the implementation of the technology. In the Brazilian case this is aggravated by poor funding, resulting from the de-valuation of the design activity although, in spite of that, offices need to make high investments in equipment, software, and training to modernize their businesses when adjusting to the technology. Many times these companies are not financially rewarded in this re-structuring and continue to receive a rather small payment in relation to the global cost of the construction (JACOSKI; LAMBERTS, 2002).

Due to its being a recent technology, the number of professionals effectively using the BIM tools is restricted. This fact causes a certain isolation of those that invested in the technology and causes the incipient use of all its possibilities (CAMPBELL, 2007).

The legal aspects related to the BIM deserve highlighting, and it is necessary that legal solutions are sought to assign the ownership of the model and of the responsibility in the exactness of the information contents. The constant updating of the model, even during the construction and later during the use of the building, makes it necessary to formulate contracts that guarantee the intellectual property rights of the designers but that allow the insertion of new information and the access to the model by all the other participants in the process (KYMMEL, 2008).

The facilitated 3D visualization as enabled by the software, as it is a big advantage of the BIM, is also a hurdle to designers as the visualization easily points all the incompatibilities and difficulties, requiring immediate response (KYMMEL, 2008). In this sense, the BIM tools demand a certain level of projecting knowledge and related to construction technology of the user to formulate the model. Coupled with this, the 'technology gap' that exists between what is taught at the universities and the design market makes the hiring of skilled labour difficult.

The big difficulty in finding qualified people leads the companies to provide training to their employees, demanding time and hefty financing investment. Apart from that, it is necessary to face the reluctance of some professionals to replace the existing computer tools with the BIM system and the resulting change in the design process provided by the technology. The use of the BIM requires the design team to have a much different integration than that occurring in the traditional ways of design. Team composition will directly influence the final result obtained, making the effective management of human resources essential to attain a satisfactory result from the use of the tool (KYMMEL, 2008).

2.3 Perspectives for the BIM

Birx (2006) states that the Geometrical CAD did not significantly change the way architects work, and only computerized the drawing practice which in the past was done on the boards. According to the author, contrary to what happened to traditional CAD systems that affected the design process in a restricted manner, as soon as the propagation of the use of the BIM in the civil construction industry there will be cultural changes in several design aspects, constructive processes, services offered, organizational structure of the companies, amongst others.

The success in the application of new BIM-based technologies in product development should take into account human and organizational factors and 'failing to consider any of these factors during the implementation of the modelling produces poor ROI or even losses' (AYRES, 2009).

Kymmel (2008) states that the construction industry will only move towards the BIM in a more concrete manner when it becomes necessary, whether through a requirement of the contracting party or through the competition between designers and constructors that will lead to its implementation as a way to survive in the market.

Only the introduction of new software will not succeed, in an isolated way, in producing effective changes in the construction industry processes. The collaborative approach of all involved in the chain becomes necessary, from the integration of the agents involved in the planning, design, construction, and

supplying, towards a more generalized adoption focused on the better use of the possibilities offered by the BIM (KYMMEL, 2008).

The ideal situation to define the elements of design, for example, would be that where suppliers would provide their catalogues in a neutral format, so to allow the downloading of the objects from the Web with all the specifications, and including them directly into the project. With the availability of the components from the manufacturers, it will be possible to reduce the time spent by the designers with modelling, allowing the insertion of objects that are more detailed and in line with the products effectively found in the market. Apart from that, manufacturers would be responsible for the consistency of the information supplied, which could be constantly updated (IBRAHIM; KRAWCZYK; SCHIPPOREIT, 2004).

Another important trend with the expansion of the use of the BIM is the rise of new supplementary software linked to the structure, building installations, construction planning, cost estimates and assorted analyses that could communicate with the architectural model taking it as a reference to carry out a specific task (IBRAHIM; KRAWCZYK; SCHIPPOREIT, 2004).

3. BIM IN REAL ESTATE PROMOTION

According to the data in the seventh edition of CONSTRUBUSINESS (FIESP, 2008b), the productive chain in civil construction mobilized in 2007 11. 3% of a total of R$5.7 trillion, corresponding to the year's GNP, where 0.5% of that (equivalent to R$13bi) correspond to the Real Estate Services category which includes projects, real estate activities and property maintenance. Amongst the measures and actions proposed to the industry, at the end of the event, it is possible to point the recommendations to maintain the focus on projects and that steps are taken to reduce the costs of the final product, amongst others (FIESP, 2008). This is the background on which the property services market moves on, and where Architecture projects are included. Investment decisions from those who direct the project activities are naturally under the influence of the economic moment and a great deal of the work generated in this sector comes from the conversion of real estate market opportunities into projects to construct whose main agent is the real estate promoter.

The adoption of the BIM or otherwise by design concerns is therefore configured as the strategic decision that is linked not only to the technologically advanced practices for the project sector, but should also be based on the observation of the challenges and opportunities found in the entrepreneurial scenario. The BIM can be rated as an approach (ITO, 2007), instead of a technology, although it 'demands an acceptable technology, ... such as the parametric CAD "(op.cit) and this widens the analysis spectrum on its adoption, suggesting the need for a managerial and systemic vision for the design activity.

Most importantly, projects are required to technically enable productive investments which subrogates them to the entrepreneur, to the real estate promoter. Fabrício (2002) describes the development of construction enterprises in three stages:

> According to the analysis by Gobin (1993), [...] firstly, the entrepreneur intends to promote a new product starting from one's own experience and from the demand found in the market to develop a programme that is provided to an architect that will generally identify flaws in the programme and propose the re-opening of the funnel to include one's own ambitions. Finally, the construction company tends to identify flaws in projects, especially as related to the constructability, leading to a new re-opening of the funnel that represents the ripening process of the project.

When starting the enterprise generation process it is very important that the entrepreneur obtains more structured information on the building one is to promote. It is also important that one deals with detailed estimates and that one deepens to the maximum extent the notions on the management of one's enterprise so to better assess the risks and correct the deviations and distortions that may occur in the management as soon as possible for the construction one is to conduct. The adoption of the BIM allows a better fitting between the construction opportunities offered in the real estate market and the execution of the building made through the design, becoming a valuable tool for the entrepreneur as it can assist one in the decisions, allowing one to deal with managerial information via the manipulation of a virtual model of the building. This way, one can control, adapt, and modify the building much before it becomes a reality. And this represents a reduction of costs and risks, improving the chances of success, and the quality of the process.

4. USE OF THE BIM IN ARCHITECTURAL OFFICES

4.1 Methodology

This document is based on field study analysis, as is part of a M.Sc. dissertation in the domain of the NITCON-UFF research group and of the BIM Brasil Network.

The selection of the companies for the studies was made after a contact with BIM software resellers and training centres. An initial list was obtained with around thirty companies and it was found that some offices, even investing in the purchase of programmes and personnel training, still did not use the software in a wide manner. The acquisition of the BIM software without the goal of using it can be attributed to the commercial practice of a particular supplier that offered CAD packages with a BIM application included at no extra cost.

The data survey occurred with the application of a questionnaire, created as an e-form, where the interviewee filled in the fields in the very digital file. The formulation of questions was made from the analysis of similar studies in the international context and from preliminary conversations with users and resellers in Brazil. The questions were of the multiple choice kind and allowed more than one answer, without a maximum number of marks.

A preliminary test of the questionnaire was made, applied initially in only one office, in which some minor adjustments were made. Following the end of the document, an initial telephone contact was made with the previously selected companies and the questionnaire was sent by email to the offices in the months of August and September, 2008. After that 13 (thirteen) companies replied.

A meeting was held in October, 2008 at the IAB-RJ with some of the offices surveyed and other interested parties, with around thirty participants where the issues raised could be dealt with more detail.

4.2 Characterization of the companies surveyed

The aforementioned survey was done in 13 (thirteen) architectural offices, users of the BIM technology, located in the cities of Rio de Janeiro (7 companies), São Paulo (5 companies) and Curitiba (1 company). These are small companies, with 69.23% of them having less than 15 employees (Figure 1). As to the implementation stage

of the BIM, as shown in Figure 2, at the time of the survey 46.15% of the offices used the technology in a pilot project or in a design team, 23.08% used it in most of the projects and 23.08% already used it in all of their projects.

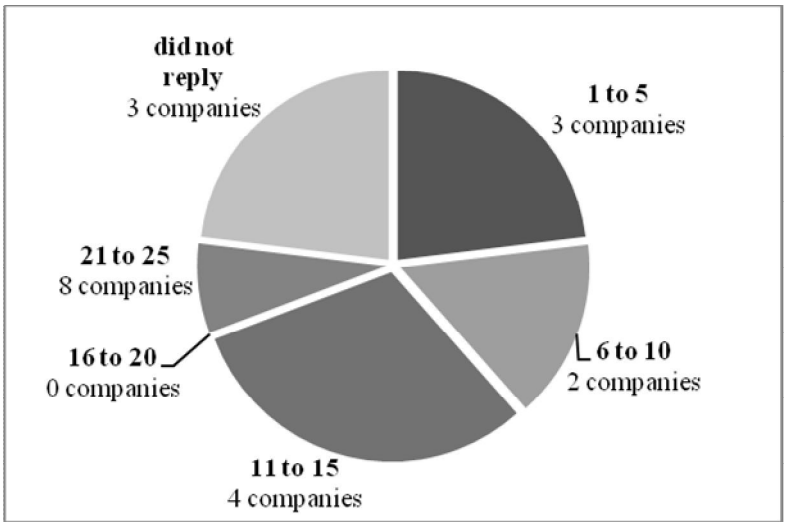

Figure 1: Number of Employees

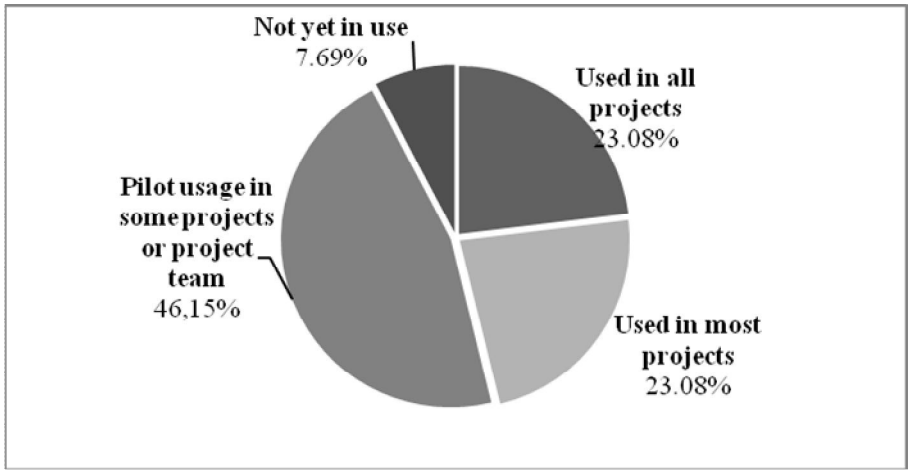

Figure 2. BIM software implementation stage

Figures 3 and 4 show the year for the acquisition of the software and the time the company had effectively used it for.

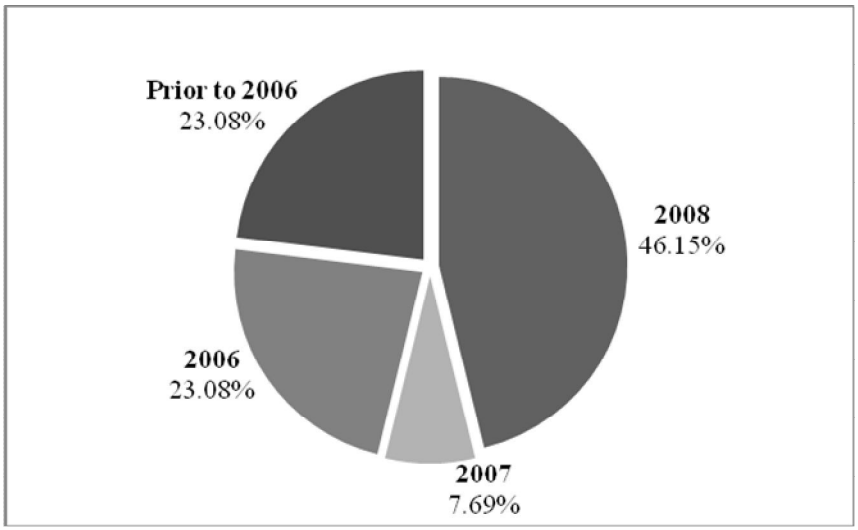

Figure 3. Year of software acquisition

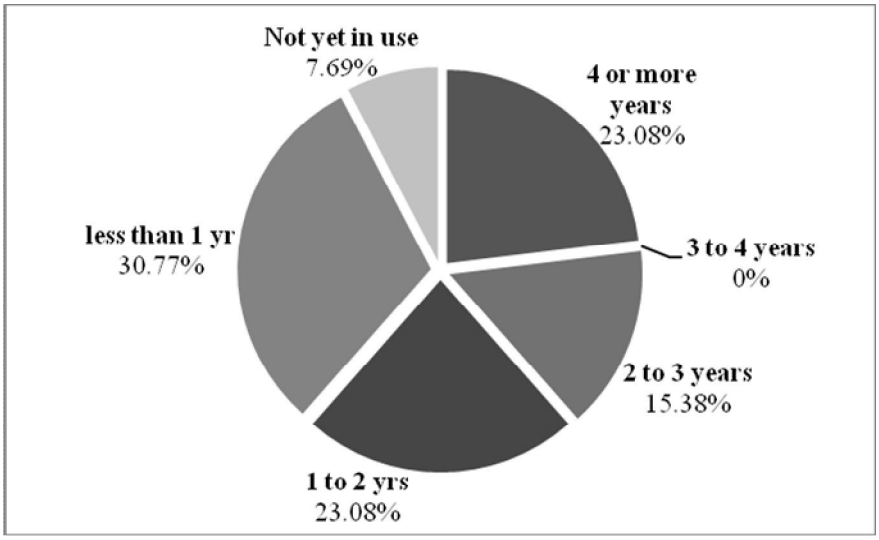

Figure 4. Time the company has effectively used the software for

As it can be seen in Table 1, the time between the acquisition of the programme and its effective implementation is relatively short; however, it is not possible to say that in most cases the use begins shortly after the acquisition of the software. On the contrary, there is a big number of companies that bought the software and still did not use it widely.

	SOFTWARE USED	ACQUIRED IN	TIME IN USE	IMPLEMENTATION STAGE
Company 1	Revit	2006	1 year e 6 months	Pilot use in 1 project or project team
Company 2	Revit	before 2006	4 years e 8 months	Use in all projects
Company 3	Revit	2007	1 year	Pilot use in 1 project or project team
Company 4	Revit	2008	8 months	Pilot use in 1 project or project team
Company 5	Revit	2008		Not yet in use
Company 6	Revit	2008	5 months	Use in most projects
Company 7	Revit	2006	1 year and 8 months	Pilot use in 1 project or project team
Company 8	Revit	2006	2 years	Pilot use in 1 project or project team
Company 9	Revit	before 2006	4 years	Use in most projects
Company 10	Revit	2008	7 months	Use in all projects
Company 11	Archicad	2008	2 years and 6 months	Use in most projects
Company 12	Archicad	before 2006	over 4 years	Use in all projects
Company 13	Revit	2008	3 months	Pilot use in 1 project or project team

Table 1. BIM software use characterization

4.3 Reasons for seeking the technology

The design offices point as reasons for the adoption of the BIM the aspects linked to the performance in drawing through the project and to the usual way of designing. The aspect most mentioned to seek the technology relates to the improvement in design quality (21.28%). Other factors pointed are (Figure 5): facilitating design modifications (17.02%), reducing delivery deadlines and work load per project (17.02% and 14.89%, respectively), and improving the presentation of projects (12.75%).

The use of the BIM allows design improvement with a reduction of errors as it anticipates the design definitions and this way it avoids problems in future stages, where the modifications usually generate bigger consequences. The ease of visualization through countless cross-sections, views and perspectives also contributed for the generation of more intelligent design solutions.

The BIM technology allows design modifications to be easily made through the parameterization of objects. Coupled with this, the automatic generation of views

and cross-sections points to a possible reduction of the work. With this, the offices expect to cut the delivery deadlines with the reduction of the work load spent in each project.

The presentation of projects can be improved in relation to the CAD, as the BIM facilitates the adjustment of scales, text size, and indications. Apart from that, it is possible to quickly generate perspectives and present them in a very professional way to the client.

The survey also indicates that some clients have already perceived the advantages of the BIM approach (2.13%); however, this number is still rather limited, which indicates that in the majority of the cases the decision for the implementation has come from the offices themselves, aimed at the improvement of their processes.

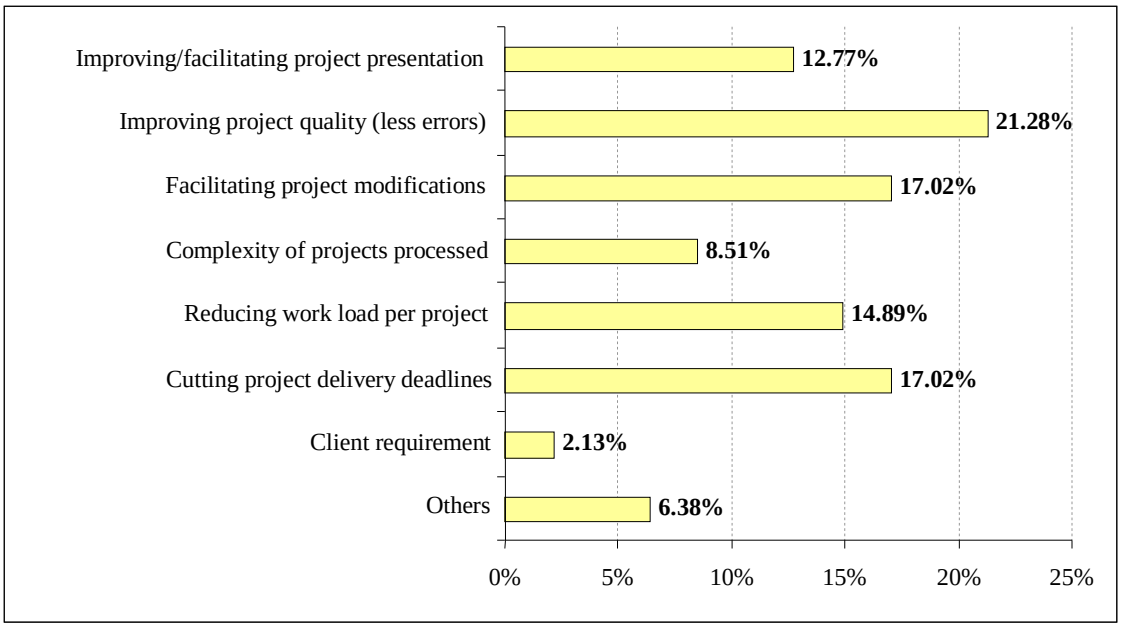

Figure 5: Reasons for seeking the technology

According to a report published in the Cadlyst site, two Brazilian architectural offices, Contier Arquitetura and Aflalo & Gasperini decided, for different reasons, to adopt the BIM (RUNDELL, 2006). Contier decided to optimize productivity, reducing the size of its office and maximizing its technological capacity, implementing the BIM in 2004, and becoming one of the first firms in Brazil to adopt the technology. This way it handles large projects with high performance and quality, managing to coordinate all the information in an integrated way. Aflalo& Gasperini, one of the first Architecture and Urban Planning firms in the

country, at the time with 25 architects, attends to a large project demand all over Brazil and say they constantly invest in technology to reduce the 'gap between design and construction'.

4.4 Difficulties in implementation

One of the biggest difficulties pointed by the offices refers to the lack of time to implement the technology (25%). The scarcity of professionals with a command of the software leads the offices to offer training that demands time and investment. Some 85% of the companies surveyed provided training to their employees. Apart from that, working with the BIM demands not only the learning of new skills but especially demands from the professional a new way of thinking the design process. Thus, the resistance to change software by the team (25%) ends up being another hurdle to be overcome in the implementation of the software.

The incompatibility with design partners was also a frequently mentioned item (16.67%). The fact is that the revolution is beginning in Architecture offices and the BIM technology still is little used by other designers (installers, calculation engineers).

There is some preoccupation in the offices with the investment in equipment to support the software (8.33%). In general the files generated by BIM software are quite large and demand much processing power.

Some offices said that the software does not fit the work developed (8.33%). This point was made by companies that said they did not work with projects that follow an even 'pattern'. This way, architects end up taking much time modelling components that are exclusive to that particular design and that may not be used in other work. This aspect can also be related to the low level of industrialization in Brazilian construction, with few pre-assembled or pre-fabricated elements. From this stems the scarcity of products offered in BIM libraries that obliges the designer to supply this deficiency of the industry. Figure 6 shows the main difficulties identified by the companies:

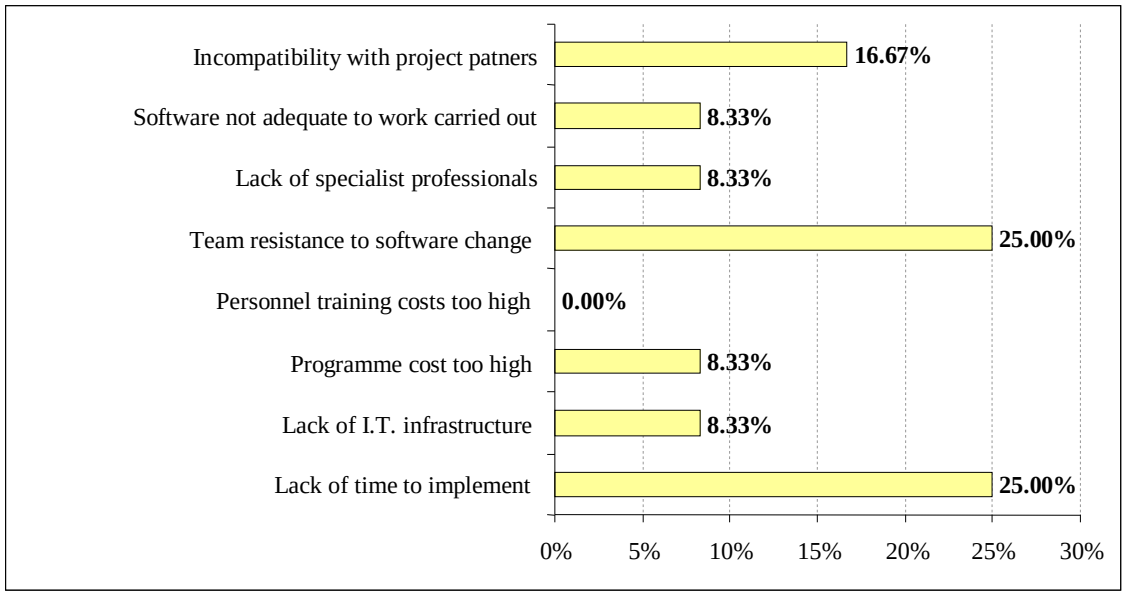

Figure 6: Difficulties to implement the BIM technology

4.5 Advantages of the BIM

It is possible to see in Figure 7 that the main advantages identified by the interviewees were the reduction of drawing errors (14.28%) and the ease to implement design modifications (14.28%). These aspects can be related to the parameterization of objects that allows the automatic correction of cross-sections, views, and other elements. The facilitated 3D visualization (14.28%) allows improving the understanding of the design by those involved and facilitates design solutions. The improvement in the exchanging information was not identified as an advantage by the participants in the survey as the supplementary designers (calculation engineers and installers) still are not using the BIM technology. It is possible to see that, despite the offices developing the Architectural project in a BIM model, the file ends up being passed on to the supplementary designers in DWG, losing much information and all the potential of the BIM in the parameterization of the data. At the same time it is difficult to incorporate the information from the designers as passed on in DWG to the BIM model. This way, one can see that the full creation of the model is not taking place, being restricted to the domain of architectural data.

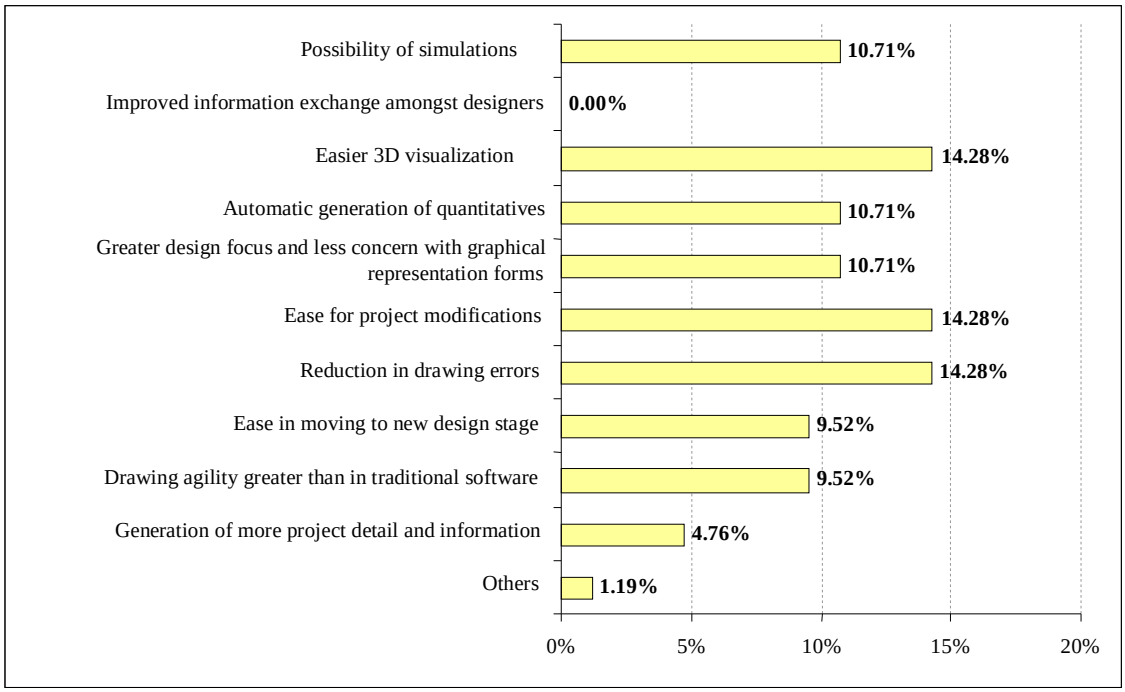

Figure 7: Advantages of the BIM

4.6 Difficulties of the BIM

The biggest disadvantages pointed by the interviewees (Figure 8) refer to the high cost of the software (25%) and to the time needed for personnel training (18.75%), which coincide, in their majority, with the views of Ito (2007). According to this author, although the technology exists to improve the efficiency and efficacy in the handling of multi-disciplinary data that involve the construction of a building, the industry resists adopting it due to its long learning curve and the costs involved in implementing the system. This author adds that the software on offer is still deficient, which is confirmed in the survey where the offices revealed they had difficulties in software (12.60%) apart from the preoccupation with the size of the files generated (15.63%).

Another factor identified was the lack of compatibility with other programmes (9.38%). The companies said that there is an immense difficulty in exchanging files between the several programmes and even in the conversion of the BIM file to DWG. Some offices pointed as handicaps the lack of adaptation of the software to Brazilian constructive standards (9.38%). It was at first believed that this would be one of the big problems identified by the offices in the BIM technology; however, the research showed that the companies have no sizeable concern with this point.

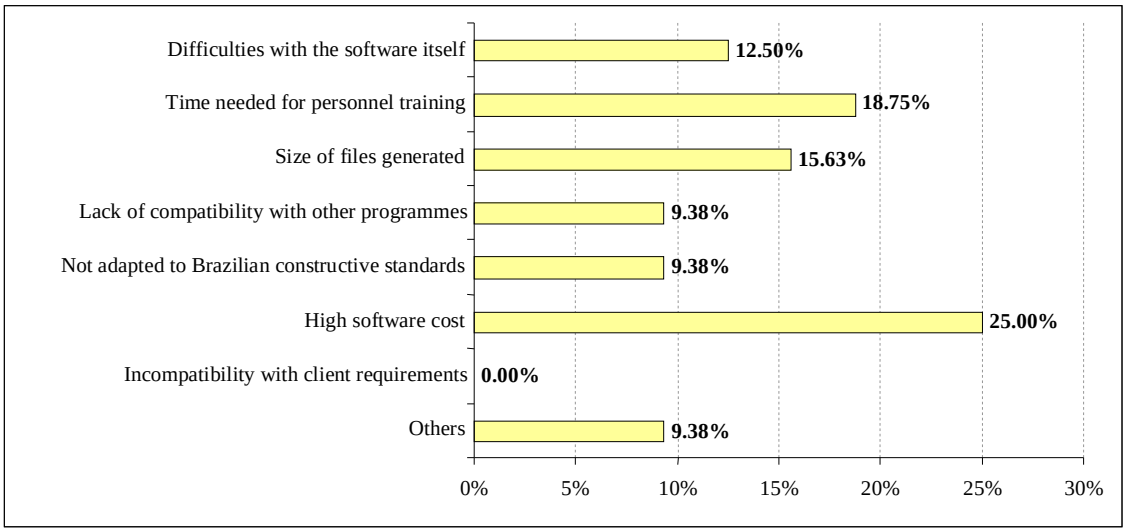

Figure 8: Difficulties of the BIM

4.7 Software use and design information exchange

The research showed that the companies adept of the BIM continue to use CAD software as support tool. Many offices work using the already created CAD drawing library which can be imported into the BIM software, producing lighter files. Table 2 shows software use according to the design stages as developed by the offices:

SOFTWARE USE					
Project Stages	**Does not usually execute this stage**	**BIM**		**Others**	**Other frequently used software**
		Uses	**Does not use but intends to in the next 6 months**		
Feasibility study	**11%**	**37%**	**11%**	**42%**	Autocad Sketchup
Preliminary Studies	**0%**	**53%**	**6%**	**41%**	Autocad Sketchup
Pre-Project	**0%**	**50%**	**11%**	**39%**	Autocad Sketchup
Legal Project	**0%**	**56%**	**11%**	**33%**	Autocad
Executive Project	**0%**	**47%**	**18%**	**35%**	Autocad

Table 2. Software use according to design stages

As regards the exchanging of design information (Figure 9), the offices say that a large part of the files are saved in the DWG (44.44%) format, facilitating their opening by the other intervening parties of the process that still have not adopted the technology (supplementary project players and the client itself). PDF and DWF files received respectively 25.93% and 14.81% in the mentions. IFC files did not get mentioned. It is believed that with the growth in the use of the programmes and their possibilities there will be an increase of the use of this standard in Brazil.

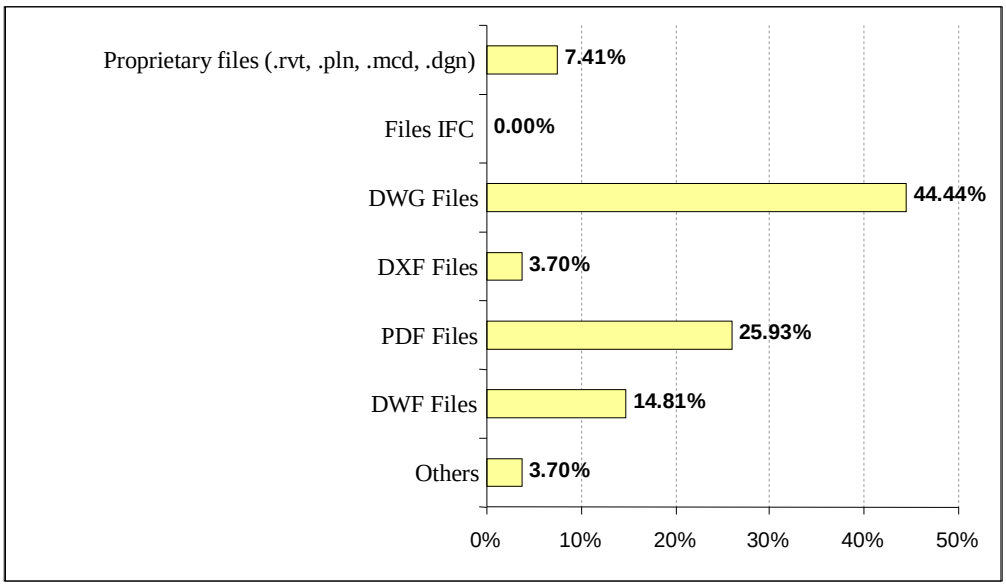

Figure 9. Formats used in the exchange of design information

4.8 Changes identified

The absolute majority of those interviewed in the survey (72.73%) state they did not attain a reduction in relation to the design deadline (Figure 10) and 66.67% of the interviewees reported that there was no reduction in the team for the same design work load (Figure 11). This is probably due to the restricted use of the BIM. It is believed that changes can become evident from their more intensive use and from the understanding of the benefits of the BIM to real estate promoters and to offices with a demand for large or complex projects. Some offices say that there really was no reduction in design deadline but the BIM provided a time gain in the conception stage and in the generation of new products and services previously not offered to the client.

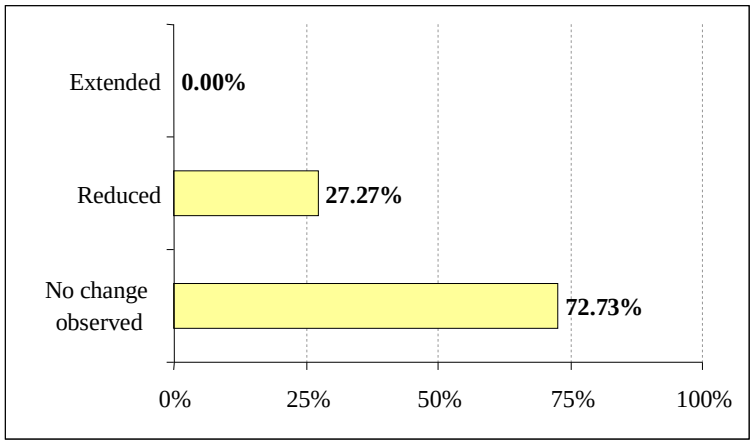

Figure 10: Changes identified – Design deadline

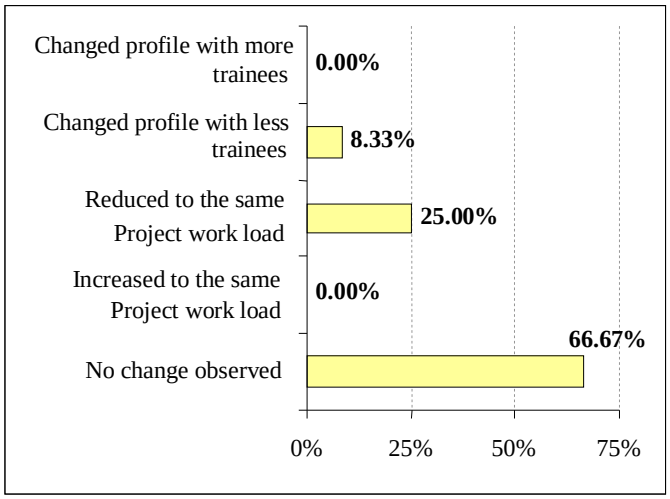

Figure 11: Changes identified – Design team

In the items "Design Quality" (Figure 12), and "Presentation Quality" (Figure 13), the replies indicate that the offices noticed an increase in the level of design quality with the possibility of pre-emptying problems, ease of compatibility and reduction of project errors. Apart from that, there was improvement in the organization of the information, with a greater understanding of the design by designers and clients.

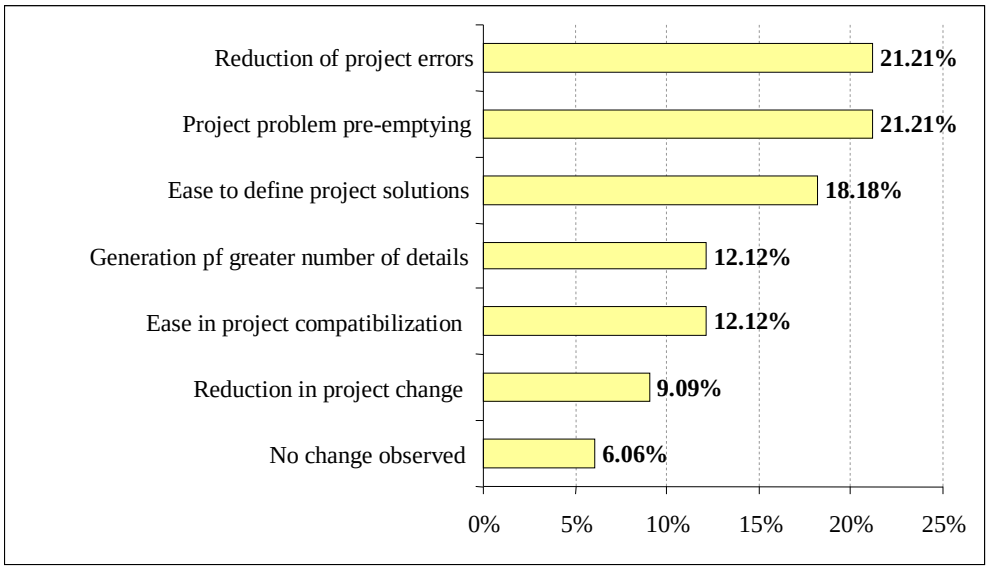

Figure 12: Changes identified – Design Quality

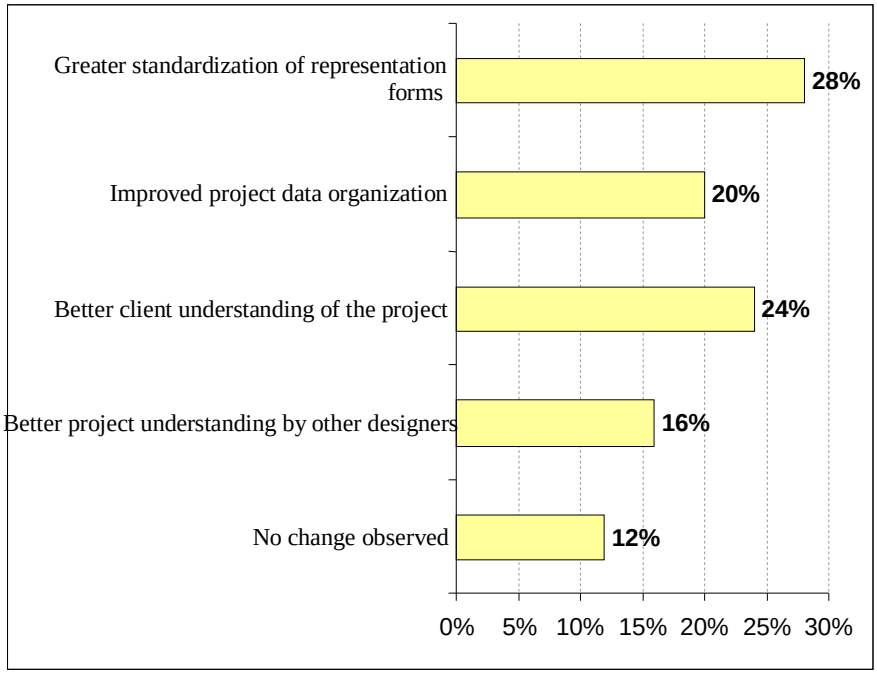

Figure 13. Changes identified – Presentation Quality

As regards the "Final Products" (Figure 14) it is possible to see an anticipation of the design solutions, the providing of a larger volume information in each stage and the generation of new products that had not been previously generated by the office. Thus, the offices provide the client with services to survey quantitatives, images, videos, amongst others. This diversifies the work of the company, covering its field of activity.

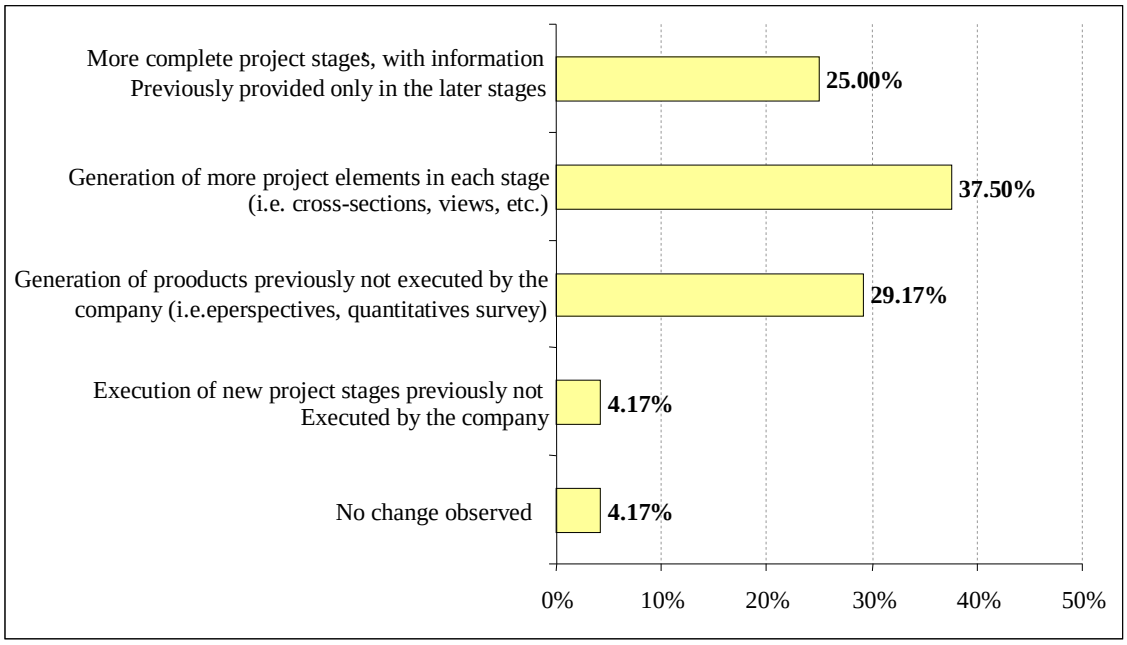

Figure 14: Changes identified – Final Products

	TIME IN USE	PROJECT TEAM	PROJECT DEADLINE	FINAL PRODUCTS GENERATED
Company 1	1 year and 6 months	No change observed	No change observed	More information
Company 2	4 years e 8 months	Reduced	Reduced	More information and New products
Company 3	1 year	No change observed	No change observed	No change observed
Company 4	8 months	Did not reply	Did not reply	Did not reply
Company 5	starting implementation	Did not reply	Did not reply	Did not reply
Company 6	5 months	Reduced	No change observed	More information and New products
Company 7	1 year and 8 months	No change observed	No change observed	More information
Company 8	2 years	No change observed	No change observed	More information and New products
Company 9	4 years	No change observed	No change observed	More information and New products
Company 10	7 months	No change observed	No change observed	More information
Company 11	2 years e 6 months	Reduced	Reduced	More information and New products
Company 12	over 4 years	No change observed	Reduced	More information and New products
Company 13	3 months	Did not reply	Did not reply	Did not reply

Table 3. Relation between time of use of the BIM and main changes identified

It is possible to see in Table 3 that some of the companies that have used the software for more time (Companies 2, 11 and 12) have attained a reduction in the design deadline which is not unanimous given that Company 9 has already used the BIM for 4 (four) years and did not attain this reduction.

One possibility is that the reduction of the deadline is not applied but a reduction of work load is applied. The non reduction of the deadline can be attributed to the change of scope, with the designers aggregating new products (perspectives, 3D views, etc.) or it can also be explained by the demand for object modelling as previously pointed.

5. QUESTIONS RAISED / NEEDS IDENTIFIED

5.1 Creation of a standard for the use of the BIM

One of the needs highlighted by the companies surveyed is the establishing of a standard to use the BIM, covering not only materials libraries and current products in our market, as usual stages of the design process and the modelling of their respective products. It is believed that a standard could be created to be used by all the offices, and provided by the companies that develop the software. This standard should be constructed in a cooperative way with the participation of the entire productive chain. Specialists believe that software companies may adapt their products when they realize there will be financial return. Thus, a template with Brazilian standards and nomenclatures may be created based on the demand, with the increase of the number of users in the country.

5.2 Project authorship

With the BIM an idea rises where a model would be provided to the client who could then insert new information throughout the life cycle of the building. With this, it is necessary to find a manner of work where the rights of the architect on the design are safeguarded throughout the life cycle of the product and not only as intellectual property rights on the conception, as the model will be explored for a long period of time by several specialists. Another issue raised relates to the responsibility for the design. When inserting a family with detailed information of the system, for an object (a door, for example) it becomes necessary to identify the

responsibility for each associated information item, whether it was originated in the designer or if it came from the manufacturer. One should also establish the set of data that should form its 'property sets' (sets of properties) for the different component families.

5.3 Level of Design Information

The information needed on components varies according to the design stage, which leads to the need of different versions of the same object. The ideal situation would be to have several drawing levels for the same object, one with all the information and details and other more simplified versions. Another point studied relates to the contribution of the manufacturers in terms of information in these new modelling standards. It is believed that the manufacturers will develop the components according to the needs identified by the architects. Apart from that, the research found that several attributes found in the software are not being used (price, for example).

5.4 How to gain more with BIM-based projects?

One of the issues put by the offices is how to have the client acknowledge the quality of the projects developed with the BIM and how to be paid for this aspect. Some offices state they profit with the supplying of new products (images, quantitative survey, amongst others). It is interesting to note that the offices did not point to gains in productivity or deadline reductions in services. However, this is probably due to the relatively long time to incorporate advantages of this kind or to the use of the hours gained as a consequence of a supposedly higher efficiency resulting from the use of the BIM in activities to improve design quality.

5.5 Teaching of the BIM

The university, as cradle for technological innovation cannot stay still before the revolution we are witnessing and should contribute towards the formation of professionals qualified for the future job market. Today the curricula are outdated as regards the technological and methodological aspects, still bound to a sequential or linear mode for project development.

6. CONCLUSIONS

Amongst the main results obtained in this work one could highlight the formulation of a diagnosis for the implementation of the BIM technology in Brazilian architectural offices, from the analysis of companies in Rio de Janeiro, São Paulo and Curitiba. Although the sample looks small, we believe it is representative of the offices that use the technology as this universe is still quite limited.

The main reasons pointed in the search to use the BIM technology relate to the reduction of design errors and quality improvements. The research indicates that these results are being obtained by the Architecture offices surveyed.

The majority of the offices did not point a reduction in design deadline with the use of the BIM, in opposition to several international studies. It is believed that this reduction will only be possible with the experience in the use of the technology, with the better adapting of the professionals to the software and with the effective insertion of the other project players and agents in the process as a whole. However, as the contents of a project carried out with the use of this technology is clearly greater than what is commonly provided in the projects, the comparison of men-hours between projects carried out with the CAD and with the BIM is maybe inadequate in the Brazilian case.

It is possible to see in the research that the BIM provided an increase in the volume of information available in the projects that were executed. Apart from that, there was the generation of new products that had not previously been offered to the client, such as quantitative surveys and 3D images.

Another point to be highlighted is that the use of the BIM is still very much limited to Architectural offices. The compatibility of projects that could be facilitated, assisting in the reduction of errors and facilitating design solutions, in reality still occurs in the traditional ways of the CAD. The technology is being used more as conception tool and as a facilitator of the design process in the Architectural design offices, not directly reaching other processes linked to the production of the building. It is necessary that there is bigger participation of the suppliers and clients in the process so that more sizeable advantages are obtained with the

technology. It is clear that the issue of integration of the projects needs to evolve so that a guarantee for biggest time gains and still more design quality can be provided.

The software still needs to evolve as related to interoperability. Much design information is lost with the execution of file exchanges in several formats. The effective implementation of IFC files can be a path to minimize these issues.

The use of the BIM leads to the re-definitions as regards the management of the design process and the discussion of yet unexplored possibilities by Brazilian design offices. The results of the survey as carried out in this indicate that the transition from the use of the CAD to the BIM demands a series of adaptations in the working process of the offices that present themselves as hurdles for the adoption of the software.

Although it is not the sole motivation to adopt the BIM, the promotion of real estate enterprises is a space of use for the BIM to be explored and known. It is important that the vision of an architect and the resources of the constructor share the same weight and responsibility on the quality and performance of the building. And it is in it that this integration commences.

The contracting companies as yet do not require the use of the BIM technology on the part of Architectural offices. The constructors are only starting to see the real advantages offered by BIM-developed projects and its positive influence on the remaining construction processes. With the more intense demands by these clients, the offices will not be able to avoid this evolution. At this time companies the companies that are venturing in the implementation of the BIM will be ahead in the market.

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