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BIM Maturity Index: Analysis and comparison of architecture office's BIM performance in Porto Alegre

Evaluación de Índice de madurez BIM: Análisis y comparación del desempeño BIM de las oficinas de arquitectura en Porto Alegre

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This study evaluated the BIM Maturity Levels of architecture offices in Porto Alegre (Brazil) by adapting the method developed by Succar [1]. Capacity maturity models, such as the one proposed by Succar [4] identify a set of improvements, of processes that allow implementers to achieve significant business benefits. This methodology proves to be relevant for case studies, as it has the advantage of proposing an assessment of the maturity degree of organizations in the adoption and performance of BIM in its processes, operations and relations with other organizations. To achieve the objectives, theoretical research, case studies and analysis were performed. It was carried out by applying a questionary in face-to-face interviews and converting the qualitative data obtained into quantitative, ultimately generating the BIM Maturity Index: a percentage number that can be classified and compared. For example, with the BIM transition, there was a significant increase of the preliminary design phase, mainly due to the large amount of information that must be provided in the initial modeling stage. This leads to the resolution of a large part of the project in this phase and, consequently, the reduction of the time spent in the– final phases, such as executive project, documentation, budgets and etc., corroborating with the exposed by the MacLeamy Curve, which indicates how BIM workflow works in contrast to the traditional workflow. The results indicate a significant discrepancy in BIM competences between the case studies while reasserting challenges faced by them in a regional scope: the scarcity of external stakeholders appropriately inserted on the BIM process and the undersupplied BIM knowledge offered in academic courses. It is possible to trace similar characteristics and conditions in all case studies.

BIM; BIM Maturity; Project Managing; Case studies; Architecture offices.

Este estudio evaluó los niveles de madurez BIM de oficinas de arquitectura en Porto Alegre (Brasil) mediante la adaptación del método desarrollado por Succar [1]. Los modelos de madurez de capacidad, como el propuesto por Succar [4], identifican un conjunto de mejoras, de procesos que permiten a los implementadores lograr importantes beneficios comerciales. Esta metodología resulta relevante para los casos de estudio, ya que tiene la ventaja de proponer una evaluación del grado de madurez de las organizaciones en la adopción y desempeño de BIM en sus procesos, operaciones y relaciones con otras organizaciones. Para lograr los objetivos se realizaron investigaciones teóricas, estudios de casos y análisis. Se llevó a cabo aplicando un cuestionario en entrevistas presenciales y convirtiendo los datos cualitativos obtenidos en cuantitativos, generando finalmente el Índice de Madurez BIM: un porcentaje que se puede clasificar y comparar. Por ejemplo, con la transición BIM, hubo un aumento significativo de la fase de diseño preliminar, principalmente debido a la gran cantidad de información que se debe proporcionar en la etapa de modelado inicial. Esto lleva a la resolución de gran parte del proyecto en esta fase y, en consecuencia, a la reducción del tiempo empleado en las fases finales, como proyecto ejecutivo, documentación, presupuestos, etc., corroborando con lo expuesto por MacLeamy Curve, que indica cómo funciona el flujo de trabajo BIM en contraste con el flujo de trabajo tradicional. Los resultados indican una discrepancia significativa en las competencias BIM entre los estudios de caso, al tiempo que reafirman los desafíos que enfrentan en un ámbito regional: la escasez de actores externos adecuadamente insertados en el proceso BIM y el conocimiento BIM insuficiente que se ofrece en los cursos académicos. Es posible rastrear características y condiciones similares en todos los estudios de caso.

BIM; Madurez BIM; Gestión de Proyectos; Estudio de caso; Oficinas de Arquitectura.

1. INTRODUCTION

D espite all the studies developed in the area, the number of companies using BIM (Building Information Modeling or Building Information Model) technology and its teaching in brazilian universities are lower than those observed in european countries and the USA. As pointed out by Ruschel et all. [2] in a

study regarding the teaching of BIM in Brazil, only a few brazilian professionals are qualified to use it in its full function.

In light of the above, and considering the difficulties of using BIM on a national scale, this article analyzes how BIM has been used by brazilian architecture firms in the city of Porto Alegre, in the state of Rio Grande do Sul, Brazil.

Furthermore, the contribution of this research lies in answering the following questions: (a) do architecture firms use the BIM platform? (b) how well do the offices know about BIM's features and potential?

This article transposes the method developed by researcher Bilal Succar (founder of BIMeInniative) to Porto Alegre reality, in order to obtain the BIM maturity among companies in the city and the consequent composition of a BIM maturity framework for architecture offices of Porto Alegre. The scope is to envision the real situation experienced by these offices and the perception of their leaders regarding the implementation of BIM. It is intended, therefore, to contribute to the architecture offices in overcoming barriers and in supporting the decision to adopt or not to adopt BIM, understanding that the platform may offer solutions both for the increase of quality and productivity of services, as for the reduction of waste and costs.

2. CONTEXTUALIZATION

In Brazil, BIM debuted in the early 2000s and has been gaining ground in several areas, like the academic one. However, the CAD (Computer Aided Design) to BIM transition faces difficulties. These challenges result mainly from the general incomprehension of BIM's integration forms with the design process.

According to Nardeli [3], in the last decade "several companies faced the challenge of managing hundreds of concomitant projects with continental distances between them, subjected to different urban laws and local rules for project licensing, as well as varied realities when it comes to material costs and labor, generating, undeniably, a complex governance and management scenario".

Twenty years have passed since BIM's introduction and the results still seem modests, when compared with the amount produced by the construction industry. In this sense, the question arises: would it be possible to assess the degree of maturity reached so far by the sector in its effort to implement BIM in Brazil?

Succar's methodology [4], addresses this question. Succar [1] developed a methodology that analyses, quantifies and qualifies the use of BIM in organizations and enterprises, considering eight variables: objectives, phases and milestones; reference publications; established guidelines and success cases; technical standards; regulation mark; performance indicators; training and capacity building systems; technological infrastructure. Based on these indicators, it is possible to establish a scale of BIM Maturity that consists in five levels, from initial to optimized, an issue addressed below.

2.1.BIM MATURITY

Capacity maturity models, such as the one proposed by Succar [4] identify a set of improvements, of processes that allow implementers to achieve significant business benefits. This methodology proves to be relevant for case studies, as it has the advantage of proposing an assessment of the maturity degree of organizations in the adoption and performance of BIM in its processes, operations and relations with other organizations. By establishing parameters to measure the BIM maturity stages, it allows not only to evaluate the status of the organization, but also to visualize future steps that lead to higher levels of maturity and, therefore, to a process of permanent performance improvement.

It is noteworthy that Succar develops this methodology to face the difficulties faced by organizations that, at some point, see BIM and/or its tools as good alternatives for the development of their work and choose to implement them.

The methodology consolidates in the BIM Maturity Matrix (or BIM³), which has two axes: BIM Capability Sets and BIM Maturity Index. The tables that guide the requirements assessment are divided into four parts: technology, processes, policies and stages & scales.

The technology section analyses performance and connections with BIM process in three areas: software (uses and products extracted from the software, as well as their implementation in the company's strategies), hardware (equipment) and network (storage and sharing). The processes section includes resources (physical and knowledge infrastructure); activities and workflow (roles, skills and dynamics); products and services (deliverables); leadership and management. The policies cover three aspects: preparatory (training, knowledge transfer); regulatory (codes, regulations and standards); contractual. The stages refer to those defined by the BIMeInnitiave method, with three in total. Finally, the scales (divided into micro, meso and macro) refer to the company's BIM processes range, related to the presence or absence of multidisciplinary exchange with external agents.

The matrix is created through a score system. It results in a percentage index capable of comparing and classifying BIM users. This index indicates how advanced the case study is in the BIM process, obtaining the possibility of classification in different levels of maturity, defined in ascending order of progression [1]: maturity a (initial) - the BIM tools were implemented (modeling software or others), but there is no general strategy and BIM's processes and policies are not defined; maturity b (defined) - senior agents guide the use of BIM, there are documentation of processes and policies, as well as training manuals, guides and delivery standards, market possibilities are not yet explored; maturity c (managed) - the company has clear goals, with action and monitoring plans, the idea of BIM is shared with all team members, marketing takes advantage of BIM opportunities; maturity d (integrated) - functions and goals for BIM are part of the organization,

BIM is used to attract and retain customers, there is good collaboration with partners and project deliverables (model) are synchronized, productivity is predictable, the quality management system is associated with BIM standards and performance goals; maturity e (optimized) - proactivity for changes in processes or policies, innovative solutions for products, processes and business opportunities are relentlessly sought and followed, software utilization is constantly reviewed, there is a periodic review of delivery standards, using new software functionalities and reaching product and productivity improvements.

The five levels of BIM maturity are scored, from initial level, with 0 (zero) points, to the optimized level, with 40 (forty) points. The progression from lower levels to higher levels indicates improvements in the control of the BIM process, also evidencing improvements in the predictability of results, by minimizing variations in competences, performances and costs.

An example of the use of BIM maturity levels in Brazil is found in Catelani [5]. According to the author, in 2017 Brazil's BIM maturity level, regarding the leadership component, could be considered medium-low, which is described as: "there are one or more volunteer leaders and/or informal BIM boosters working in the country". "The main efforts to disseminate BIM in this period were carried out by software developers and by some specific and isolated companies, organizations or groups". In 2018, when ´BIM BR Strategy´ was developed, Brazil evolved to the level of ´medium maturity´, which is described as: "there is a unified working group or committee directing the implementation/diffusion of BIM in the country" [5].

3. METHODOLOGY

To achieve the objectives, theoretical research, case studies and analysis were performed (Fig. 1). The theoretical research addresses two main approaches: the use of BIM in Brazil [6]; [7]; [8]; [9]; [10]; [11]; [12]; [13]; [14]; [15] and the conceptual structure of Bilal Succar's work [1], [4], [16]. The concepts developed by the researcher Bilal Succar are based on the author's own texts, distributed in academic circles and online. Authors who studied the theoretical structure of Succar or used it to develop their work were also considered [17], [18], [19], [20], [21], [22].

3.1. CASE STUDIES

Case studies comprehend the following steps: offices selection; questionnaire elaboration; application of the questionnaire in interviews; data analysis; conclusions draw (Fig. 1).
The questionnaire is part of the semi-structured interview prepared by Rodrigues [20] based on Succar's methodology, being divided into five areas: company profile and transition to BIM; technology; processes and policies; predictability and variability; company's BIM goals and objectives.

The interviews were conducted in the actual offices, with at least one employee among partners, project coordinators or BIM managers. Autodesk and Graphisoft client offices were selected and invited to participate. Accepting the invitation, the scheduling of the interviews was formalized through letters sent to the offices.

According to brazilian's classification of establishments sizes by number of employees, most of the offices interviewed are considered micro enterprises (up to nine employees). Case studies 3, 6 and 7 are considered small enterprises (10 to 49 employees). Case study number 7 is the largest in terms of number of employees: around 20 people.

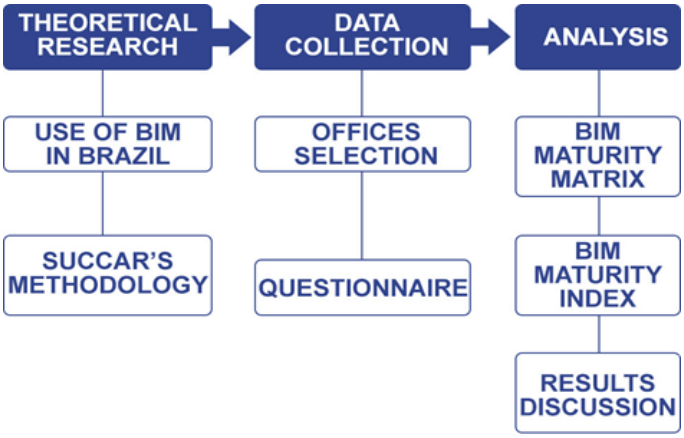

Fig. 1 Methodology graphic scheme.

3.2. ANALYSIS

The way that data were analysed and transferred to the matrix followed the methodology proposed by Succar [1] [4] and adopted by Rodrigues [20] in a study conducted with Brazilian offices. In the analysis, the responses obtained in the interview were transformed into numerical values, using BIM Maturity Matrix, to generate the BIM Maturity Index. By obtaining the Index, it is possible to classify each case study (initial to optimized level) using the BIM Maturity Degree table (Fig. 2) and sequentially determining the maturity level. It is important to notice that the maturity levels serve both to classify BIM Maturity Index for each study, as well as the BIM Capability Sets and their subdivisions found in the BIM Maturity Matrix (Fig. 3). In this case, each level includes a score range and a definition according to each item of the assessment. The correlation between definitions and scores of each level is what turns qualitative data into quantitative data

BIM MATURITY LEVELS			
	Maturity Level	Textual Definition	Numerical Rating
a	Initial	Low maturity	0-19%
b	Defined	Mid-low maturity	20-39%
c	Managed	Medium maturity	40-59%
d	Integrated	Mid-high maturity	60-79%
e	Optmized	High maturity	80-100%

Fig. 2 BIM Maturity Levels.

BIM MATURITY MATRIX							
Granularity level		a (0)	b (10)	c (20)	d (30)	e (40)	
TECHNOLOGY	software						
	hardware						
	network						
PROCESS	resources						
	activities & workflows						
	products & services						
	leadership and management						
POLICY	preparatory						
	regulatory						
	contractual						
STAGE 01	modelling						
STAGE 02	colaboration						
STAGE 03	integration						
SCALE	micro						
SCALE	meso						
SUBTOTAL		0	0	0	0	0	
TOTAL						0	
MATURITY SCORE						0,00	
MATURITY INDEX						0,00%	

BIM CAPABILITY SETS — MATURITY LEVELS AND ITS MAXIMUM SCORES

Fig. 3. The BIM Maturity Matrix – Adapted from Rodrigues (2018)

BIM MATURITY MATRIX (CASE STUDY 01)							
Granularity level		a (0)	b (10)	c (20)	d (30)	e (40)	
TECHNOLOGY	software				30		
	hardware				25		
	network				30		
PROCESS	resources					35	
	activities & workflows				30		
	products & services					35	
	leadership and management				30		
POLICY	preparatory				25		
	regulatory				30		
	contractual				30		
STAGE 01	modelling				30		
STAGE 02	colaboration					40	
STAGE 03	integration			20			
SCALE	micro				30		
SCALE	meso				30		
SUBTOTAL		0	0	20	320	110	
TOTAL						450	
MATURITY SCORE						28,13	
MATURITY INDEX						70,31%	

Fig. 4. The BIM Maturity Matrix – case study 1

4. RESULTS AND DISCUSSION

At the moment, seven case studies (EC) have been carried out, among the predicted ones, presented below and following the order in which the interviews were conducted.

4.1. CASE STUDY 01

The office designated as the first case study was founded in 2008. Currently, it works with two main typologies: real estate and authorial projects, including architectural contests. In addition, they report a third typological line that emerged with the implementation of BIM: the coordination of BIM projects for other companies and institutions. In the BIM implementation process, Archicad was the chosen software and two pilot projects were carried out. There was no previous development of templates and libraries, that was done concurrently with the actual production.

Furthermore, initial investment was considered low, and the hardware was judged to be the most expensive element. In the Maturity Matrix (Fig. 4), it is observed that, in most aspects, the fourth case study's score reaches the integrated level. In stage 1, the score fully reaches optimized level, which reveals a constant review of BIM technologies, processes and policies, seeking innovation and high levels of performance. In closing, the first case study reaches a BIM Maturity Index of 70.31%, being classified in the Integrated level (medium-high maturity).

4.2. CASE STUDY 02

The second case study started its activities in 2004. Currently, it is dedicated to single-family residential buildings and also commercial ones.

According to the interviewee, the client's profile is increasingly projecting to real estate developers. BIM was implemented in 2014 and the chosen software was Archicad.

In this process, there were no consultancies, but instead an informal assessment of pros and cons. There was a pilot project and the development of templates and libraries took place gradually.

The initial investment in BIM was considered average, with the software cost being considered the highest.

By analyzing its BIM Maturity Matrix (Fig. 5), maximum scores are observed on resources (processes) and on the meso scale. This means that the physical factors of the work environment are reviewed to ensure personal satisfaction and productivity, as well as indicating high levels of collaboration on projects, which are carried out by interdisciplinary teams, including the majority of stakeholders.

With an index of 47.66%, case study number 2 reaches Managed maturity level (medium maturity).

BIM MATURITY MATRIX (CASE STUDY 02)						
Granularity level		a (0)	b (10)	c (20)	d (30)	e (40)
TECHNOLOGY	software			20		
	hardware		10			
	network				25	
PROCESS	resources					40
	activities & workflows				30	
	products & services			20		
	leadership and management			20		
POLICY	preparatory			20		
	regulatory			20		
	contractual		10			
STAGE 01	modelling				30	
STAGE 02	colaboration		10			
STAGE 03	integration		10			
SCALE	micro			20		
SCALE	meso			20		
SUBTOTAL		0	40	140	85	40
TOTAL						305
MATURITY SCORE						19,06
MATURITY INDEX						47,66%

Fig. 5. The BIM Maturity Matrix – case study 2

BIM MATURITY MATRIX (CASE STUDY 03)						
Granularity level		a (0)	b (10)	c (20)	d (30)	e (40)
TECHNOLOGY	software					35
	hardware			15		
	network				30	
PROCESS	resources					40
	activities & workflows					40
	products & services					35
	leadership and management				30	
POLICY	preparatory				30	
	regulatory				25	
	contractual				30	
STAGE 01	modelling					40
STAGE 02	colaboration					40
STAGE 03	integration					40
SCALE	micro					35
SCALE	meso				30	
SUBTOTAL		0	0	15	175	305
TOTAL						495
MATURITY SCORE						30,94
MATURITY INDEX						77,34%

Fig. 6. The BIM Maturity Matrix – case study 3

4.3. CASE STUDY 03

The third case study starts its insertion in the market through architecture visualization business in 2007, inaugurating its actual architectural production in 2009. It is the largest case study among the interviewees, with about 20 employees.

Commercial and residential typologies represent the main activities of the company, in addition to production for contests and interior architecture.

The transition to BIM platform included training, consultancy and a pilot project, besides the gradual creation of a BIM manual for internal use and the provision of online courses for new staff. The initial investment was considered very high, being the purchase of licenses considered the most expensive element of the transition process, the software chosen was Revit (Autodesk).

The Maturity Matrix (Fig. 6) shows that most values remain at the integrated and optimized levels, reaching maximum score in five items. This indicates that the firm strongly aligns to strategies that link architectural production process in BIM with performance and productivity review practices, interdisciplinary collaboration, standardization and documentation of solutions related to the company's BIM process and goals. The third case study finishes its assessment with an index of 77.34%, thus reaching an Integrated maturity level.

4.4. CASE STUDY 04

The fourth case study came from the work of two architects who started designing during their graduation using CAD, and the transition to BIM was made in 2009. The company was officially established in 2011 and today is dedicated to interior architecture projects from small to middle and upper middle -class customers. Since the transition to BIM took place when the office was not yet formalized, their work was made autonomously, relying on their individually acquired BIM knowledge, without a more in-depth assessment of pros and cons. In order to choose the software, the members took courses to learn both Revit and Archicad, ultimately choosing Archicad. The initial templates and libraries used were the original ones from the software, adding and creating more elements over time. There were no returns to CAD, except file exchanges with third parties, which was argued to be something still necessary, given the limited number of external agents working in BIM. The software was considered as the most expensive element of the BIM transition, with the initial investment being seen as high cost. At sum, in all aspects, the score reaches levels between defined and integrated (Fig. 7), and its maximum score is found in the contractual item, inside Policies section, which indicates that the organization is aligned through mutual trust and dependence, going beyond contractual barriers. Its BIM Maturity Index is 40.63%, ranking the study at the Managed level.

BIM MATURITY MATRIX (CASE STUDY 04)						
Granularity level		a (0)	b (10)	c (20)	d (30)	e (40)
TECHNOLOGY	software			20		
	hardware		10			
	network			20		
PROCESS	resources			20		
	activities & workflows			20		
	products & services			15		
	leadership and management			15		
POLICY	preparatory		10			
	regulatory		10			
	contractual				30	
STAGE 01	modelling			15		
STAGE 02	colaboration			20		
STAGE 03	integration			20		
SCALE	micro			15		
SCALE	meso			20		
SUBTOTAL		0	30	200	30	0
TOTAL						260
MATURITY SCORE						16,25
MATURITY INDEX						40,63%

Fig. 7. BIM Maturity Matrix – case study 4

BIM MATURITY MATRIX (CASE STUDY 05)						
Granularity level		a (0)	b (10)	c (20)	d (30)	e (40)
TECHNOLOGY	software				30	
	hardware				30	
	network			20		
PROCESS	resources				30	
	activities & workflows					35
	products & services					35
	leadership and management			20		
POLICY	preparatory				30	
	regulatory			20		
	contractual			20		
STAGE 01	modelling				30	
STAGE 02	colaboration					35
STAGE 03	integration					40
SCALE	micro					35
SCALE	meso					35
SUBTOTAL		0	0	80	150	215
TOTAL						445
MATURITY SCORE						27,81
MATURITY INDEX						69,53%

Fig. 8 BIM Maturity Matrix – case study 5

4.5. CASE STUDY 05

The office representing the fifth case study started its activities in 2004. Today it is recognized in the market for its BIM production, and that is for having carried out some important projects at regional level.

Its main clients are real estate market developers, with residential, commercial, mixed or institutional types being the most usual building typologies. BIM debuted in this company in 2010, being Archicad the opted software. During BIM transition, hardware and software costs were the highest.

Besides, there was a pilot project and templates and libraries were gradually made by the office, as the need for new elements arose.

Through its Maturity Matrix (Fig. 8), it is possible to see that the highest values refer to processes, stages and scales. In stage 3 - network-based integration - the maximum score was reached, which indicates that the integration of models and workflows is continuously reviewed and optimized.

New efficiencies, alignments, and results are actively pursued by a tightly united interdisciplinary project team. Integrated models contribute to many agents involved throughout the production chain.

With a Maturity Index of 69.53%, the fifth case study is classified at the Integrated level.

4.6. CASE STUDY 06

The founder architect of the sixth office started its work in 1984. However, the office with the name and the partnership as it is known currently was opened in 2012. This is a particularly interesting case study, having its work started in the 80's, the founder architect witnessed several technological transformations, from paper and ink, to CAD, and finally reaching, today, BIM.

The firm's most usual typologies are residential, commercial and mixed buildings, with main clients being real estate developers. The transition to BIM began in 2014, main reason being the desire to increase the control of preliminary phases of the project, with the main goal of reducing rework.

The firm take two different courses to learn Archicad and there wasn't a pilot project in this transition process. However, the interviewee comments that there were no returns to CAD. They consider the transition to BIM to be of average cost.

In the BIM maturity matrix (Fig. 9), it is noted that the lowest values are found in the policies, indicating a lack of training, especially a lack of alignment with possible company strategies. There are limitations in documentation and standardization regarding BIM processes. This case study reaches an Index of 50.00%, therefore, reaching the Managed level.

BIM MATURITY MATRIX (CASE STUDY 06)						
Granularity level		a (0)	b (10)	c (20)	d (30)	e (40)
TECHNOLOGY	software			15		
	hardware			15		
	network				30	
PROCESS	resources			20		
	activities & workflows				25	
	products & services			20		
	leadership and management				25	
POLICY	preparatory		10			
	regulatory		10			
	contractual			20		
STAGE 01	modelling				30	
STAGE 02	colaboration				30	
STAGE 03	integration			20		
SCALE	micro				30	
SCALE	meso			20		
SUBTOTAL		0	20	130	170	0
TOTAL						320
MATURITY SCORE						20,00
MATURITY INDEX						50,00%

Fig. 9 BIM Maturity Matrix – case study 6

BIM MATURITY MATRIX (CASE STUDY 07)						
Granularity level		a (0)	b (10)	c (20)	d (30)	e (40)
TECHNOLOGY	software				30	
	hardware				30	
	network				30	
PROCESS	resources			20		
	activities & workflows				30	
	products & services					35
	leadership and management				25	
POLICY	preparatory			15		
	regulatory				25	
	contractual				30	
STAGE 01	modelling				30	
STAGE 02	colaboration				30	
STAGE 03	integration			20		
SCALE	micro					35
SCALE	meso			20		
SUBTOTAL		0	0	75	260	70
TOTAL						405
MATURITY SCORE						25,31
MATURITY INDEX						63,28%

Fig. 10 BIM Maturity Matrix – case study 7

4.7. CASE STUDY 07

The seventh case study was founded in 1985 as a joinery, gradually shifting its focus to ephemeral architecture projects. Around the year 2000, the office turned entirely to residential architectural production - single and multifamily - and commercial buildings. BIM was implemented in 2011, using Archicad.

There was training and consultancy. During the transition, the firm was divided into strategic groups for creating templates, libraries and remodeling old CAD projects. In Figure 6, it is noticeable that the highest scores refer to products and services.

This indicates that the company extracts a satisfactory range of BIM products, such as quantities, schedules, budgets, etc. It partially reaches optimized level in stage 3, demonstrating that the integration of models and workflows is continuously revised and optimized.

The values achieved by this case study is shown in the table below (Fig. 10).

The index of 63,28% of this office configures an Integrated maturity level.

4.8. DISCUSSION

Case studies 1, 3, 5 and 7 are the highest maturity indexes, reaching the Integrated level. Cases 3 and 7 went through similar BIM transition processes: besides consulting and training, the offices created pilot projects, libraries and templates in a well-defined structure and well-integrated with the implementation strategies. However, there is a difference of 14% in the BIM maturity index, which is mainly explained by the processes, stages and scales. It can be seen that, in case study number 3, there was more performance monitoring and reviewing of BIM processes, as well as more defined BIM partnerships with third parties involved in the design and/or execution process.

Case studies 2, 4 and 6 show maturity indexes below 60% and above 39%, which classifies them at managed level. There are some similarities, mainly regarding to the BIM transition process: all of them went through informal transition processes, without consultation or training; the creation of templates and libraries took place gradually, as needed, without a predefined strategy; there were no well-defined pilot projects or in any way aligned with the implementation strategy. In general, there is an approach in these case studies that still tends to emphasize modeling, but still there are advances in BIM's procedural and political factors and BIM vision is shared by the entire team. In these cases, there is a greater gap between the company's BIM goals and what is actually possible

to do in practical work than the other case studies.

It is possible to trace similar characteristics and conditions in all case studies. For example, with the BIM transition, there was a significant increase of the preliminary design phase, mainly due to the large amount of information that must be provided in the initial modeling stage.

This leads to the resolution of a large part of the project in this phase and, consequently, the reduction of the time spent in the – final phases, such as executive project, documentation, budgets and etc., corroborating with the exposed by the Mac-Leamy Curve, which indicates how BIM workflow works in contrast to the traditional workflow (Fig. 11).

In this article, the MacLeamy Curve supports and strengthens the verifications made through the reports collected from the case studies regarding the time allocated in the project phases and the transition from the CAD system to BIM [23].

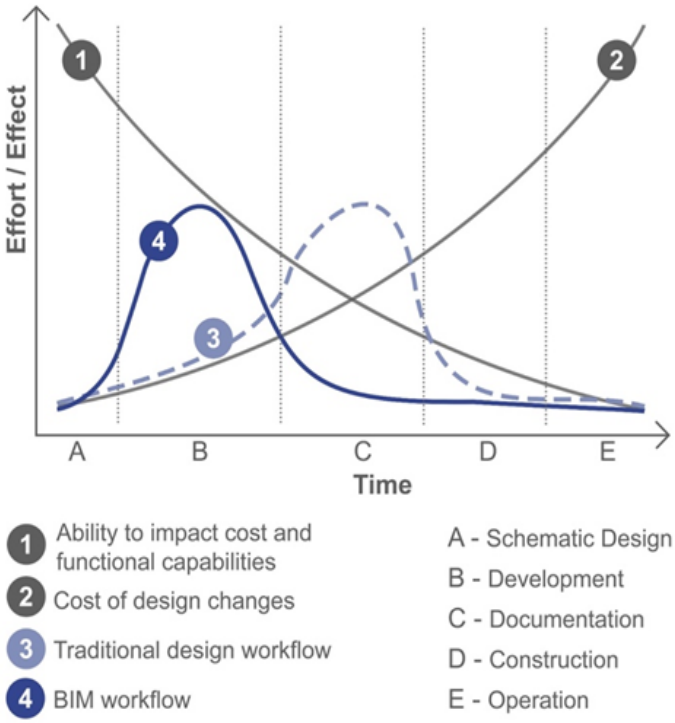

Fig. 11. Title of the Figure.

Despite this and the vast majority of respondents considering the use of BIM as a factor of competitiveness in the market, all of them reported that there was no increase in the amount of fees for using the platform.

It is interesting to note that none of the case studies' BIM Maturity Indexes reached the Optimized level, mainly because the score to reach optimized levels depends directly on a wide network of external agents inserted in BIM that does not match the regional reality - as noted by the offices' reports - nor with the Brazilian context [2] [24] [25], especially if we compare it with the United States and European countries (Fig. 12).

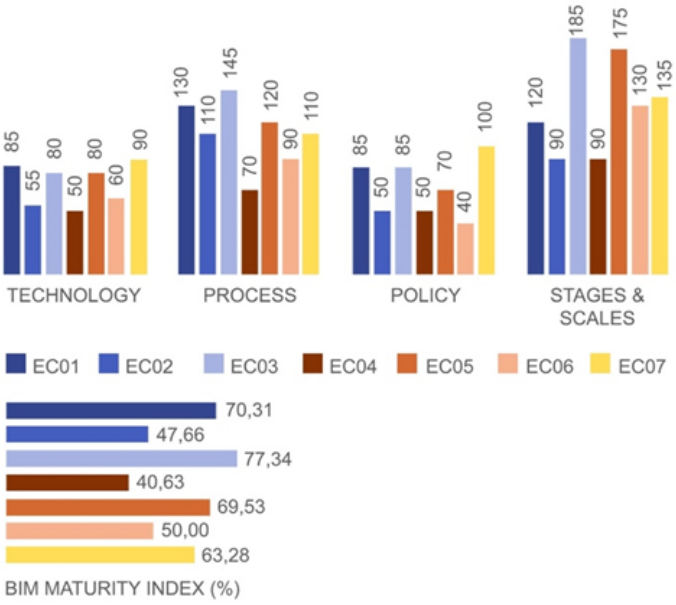

Fig. 12.

6. CONCLUSIÓN

In line with the preliminary results, it is concluded that, even though there is a disparity between the offices' BIM competences, some challenges are faced by all of them. Consequently, the common difficulties to be transposed in the regional and national scenario are accentuated: low availability of third parties inserted in the BIM process, mainly in the area of complementary projects; lack of knowledge of the entirety of the platform by agents from the AEC realm; shortage of disciplines in universities dealing with the subject. It is also observed that there are internal factors to be worked on in order to increase BIM capacities of companies, institutions and users of the platform, especially with regard to the awareness that the BIM platform involves procedural and political factors that can be improved.

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