TÉCNICO LISBOA

BIM e Arquitetura: da aprendizagem à prática

Extended Abstract

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1. Introduction

Investigation Issue

Higher education in Portugal includes a series of course units that aim to prepare students for a professional career in the area studied. However, technological advances and new forms of learning are not always considered and reviewed in the curricula of higher education courses such as Architecture and Engineering, where the paradigm changes affected by the emergence of new technologies are more prominent. Most recent graduates do not have the necessary training to meet the needs of employing companies, with a great gap between the university curriculum and the national paradigm, with regard, above all, to the appearance of BIM technology and its use.

The present work intends to evaluate and validate the offer of national training in BIM technology, at a university level as well as in the professional environment, in order to understand the advantages and disadvantages of its total implementation and what should be the changes in the paradigm of Architecture, for make this implementation possible. This theme comes after an exhaustive research on the current state of BIM technology at national level, which led to a desire to better understand the state of implementation and use of technology in the AEC sector. In addition, it was important to understand the main difficulties in implementing the technology, as well as the advantages and disadvantages that are inherent in its use. This in-depth research on the topic was essential to be able to take into account the relevance of BIM in the future of Architecture, serving as a basis for the structuring of this report.

The survey of existing training will be done mainly through the collection of information at the national universities of Architecture and Engineering. In addition, the collection will focus on the elaboration of a survey, taking as a sample the population of recent graduates in Architecture. The analysis of this survey will allow us to learn about the BIM training and knowledge of Architects, as well as the state of technology implementation in companies.

The central question of this dissertation is to understand the level of implementation of the technology in the international plan and extrapolate for the national context, realizing if this level can be enriched through a change in the learning of the technology and in the training or through an improvement in the offer formative. In addition, this work will seek to understand the current profile of the newly licensed architecture, in its relationship with the project development with digital tools, which responds to the needs of the construction companies and architectural offices. This last aspect may be the focal point for a future discussion of what changes will have to operate, in the higher education curricular units in Architecture, leading to a formation of integration of digital technologies in the design processes, but complete and oriented to the future.

Framework

The need to deepen the knowledge about BIM arose first in the discovery of the basic capabilities that technology can offer, with regard to three-dimensional modeling. Later, throughout my academic career, the growing desire to explore this area consolidated the idea that a change in training is necessary and that BIM can be a process that facilitates this change (Gu. N et al., 2012). Nevertheless, the transition from the use of traditional methodologies to BIM methodologies is a lengthy procedure, but one that will influence not only

Engineering and Architecture students, but will also allow a significant change in the construction industry, so it is necessary to find the best one. way of introducing BIM throughout this process.

The BIM teaching in universities is still far from reaching the level necessary to prepare students for the use of technology in the professional context. In the international context, although there are already some higher education establishments teaching subjects on BIM tools since 2003, many of the countries still use traditional tools to develop projects and presentations. (Barison, et al., 2011). Regarding the teaching of BIM at national level, the existing training at higher education level is scarce, with universities that integrate subjects dedicated to the introduction of BIM concepts in the curriculum, but only exploit the tool at a digital level, through knowledge and specific software modeling. (Bastos, et al., 2015)

Motivation

The development of this theme came up with evidence of the current growth in the implementation of BIM technology in Architecture. Based on this premise, the objective is to understand how the teaching of architecture adapts to this change. However, the implementation of technology requires much more than the change to new software, as mentioned by Hermund (2009), it requires a change of mentalities and the appearance of new jobs. In the national context, there are challenges to be overcome with regard to the total implementation of technology, both in the industry sector and in education. The aim is that this work can highlight the main differences between education and industry, based on international case studies and the survey that will be developed, with the aim of understanding the necessary changes in the formation of future generations, for a more integrated of them in the job market.

Goals

The main objective of this dissertation is to investigate the level of training in BIM technology, which national higher education institutions offer and compare the content with the needs and difficulties described by newly licensed areas. In short, when comparing these two points, it is possible to understand what changes must be made both in university education and in industry, to mitigate these problems. This point will be essential to understand if the profile of newly licensed architecture is capable of serving the current needs of the labor market. This work also aims to understand the difficulties of implementing bim in Portugal and contribute with measures to mitigate this situation, based on real case studies at an international level.

Methodology

In an initial phase, a survey and review of the existing literature on the BIM theme will be made. This literature will serve as a reference for the development of the various chapters. An exploratory analysis of national and international cases will also be carried out, focusing mainly on the analysis of existing university backgrounds and BIM companies. To understand the level of knowledge and use of BIM in Architecture, an online survey will be developed, aimed at a population of recent graduates in Architecture, which aims to

assess not only the relevance of teaching technology in universities, but also to understand its use in future of the profession, after entering the job market. By defining recent graduates in Architecture as a sample of this survey, it is possible to obtain information regarding the current teaching of technology, and also to understand the current implementation of BIM in companies and architecture offices. Finally, the results obtained in the survey will be analyzed and a comparative analysis will be carried out between the same results and the conclusions drawn during the development of the work.

2. BIM and Architecture

BIM Context

"BIM technology is one of the most promising developments in the Architecture, Engineering and Construction industry, enabling the development of accurate digital models that, when complete, can contain exact geometries and data necessary to support construction, manufacturing and all activities essential to construction of a building. In addition, BIM technology also accommodates functions related to the modeling of the life cycle of a building, providing the basis for new construction and design resources, as well as changes in the relationships between the various actors in a project "(Eastman, et all., 2011). In spite of this, it is still a technology under development for a wide diffusion of the AEC sector, and one of the main reasons for its little use is due to the lack of qualified professionals to face the changes that BIM brings to the sector.

In order to understand the state of implementation of BIM in Portugal, it is frequent to take as reference the most developed countries in the sector of construction and BIM implementation. Although its emergence occurred for the first time in the United States of America, in the 1970s, through a digital model created by Charles Eastman, the development of technology has dissipated all over the world, and currently, the United States United, the United Kingdom and the Scandinavia region lead its implementation, through coordination between government support and the mandatory use of technology in the construction sector (Smith, 2014).

International overview of the State of BIM in the AEC industry

Currently, the construction industry faces a gradual change in the process of elaborating a project, which changes from being based on two-dimensional documentation (plans, elevations and sections), to a 3D digital model, made from collaborative processes (Eastman *et al.,* 2011). Although CAD (*Computer Aided Drawing*) is the precursor to using the computer to produce graphical representations of Architecture and Engineering projects (Nunes, et al., 2018), it is currently known that its functionalities are flawed and not avoid design inconsistencies. In addition, with the increase in the complexity of the projects, the production of the design elements results in costly processes. For this reason, there is a clear need for the introduction of a more developed technology, which allows to face the problems and crises of the sector.

Despite the inherent advantage over previous technologies, the development and introduction of BIM in companies is gradual and does not progress in the same way worldwide. In countries such as Denmark or the United Kingdom, the implementation of the technology is already at a more advanced stage and with a global perspective, largely due to government initiatives for mandatory use of BIM in the construction sector (Carvalho, 2016). Also according to Carvalho (2016), other countries such as Brazil and China, are beginning

to show interest in BIM technology, but its implementation in the industry sector is still in a little mature phase, therefore, there are several obstacles to overcome to a full implementation of BIM. In the specific case of China, the development of BIM tools by companies is still quite incomplete (Li, *et al*., 2018).

"The implementation of BIM requires a complete change from a linear system to a parametric model, which is normally based on the use of new software, which requires initial costs related to the acquisition of software licenses and training of professionals, but also maintenance costs, for license renewal " (Krystallis, et all., 2019). In addition, the scarcity of professionals equipped with in-depth knowledge of BIM theory and practice, capable of moving the industry to the full use of technology and its capabilities, is yet another obstacle to the full implementation of technology (Hartmann *et al*., 2008).

BIM Nacional Implementation

"Portugal is one of the countries where the implementation of BIM, both in industry and in academia, is still at a very preliminary stage. The country's tradition of teaching architecture, the scant financial and governmental support and the work culture of the architect are reasons often cited as being at the origin of this gap "(Pepe, et al., 2018). The main constraints to the introduction of BIM technology in the industry are mainly due to the economic crisis that this sector has experienced in recent years, contributing to a decrease in public tenders and support for construction, which has led to an increase in unemployment in this area (Bridges , 2016).

For an introduction of BIM technology in the industry, it is necessary to have favorable conditions for its implementation, such as government support and professional training initiatives. In addition, the initial investment to start the technology introduction process is quite high, mainly due to the acquisition of hardware, software and training of human resources (Carvalho, 2016). Despite this, according to Gil (2015), the crisis in the sector has subsided over the years, making it possible to foresee a more encouraging environment with regard to the future of the sector. In the national context, several initiatives have been developed that reflect a clear intention to promote knowledge of BIM technology and the desire to deepen and dynamize this approach among professionals.

3. BIM Education

Although BIM technology is considered a positive change in the construction sector, the challenges that arise, related to it, will only be able to be properly overcome when educational institutions incorporate their learning into their curricula (Khemlani, 2006). According to Hamid, et all., (2016), the adoption of the teaching of fundamentals and skills related to BIM, by universities, is an asset for the AEC sector, since it reduces the costs of future technology adoption, as well how it significantly improves the career opportunities of recent graduates. However, despite the advantages of BIM learning, there are still few educational institutions that offer opportunities related to the learning of technology, and, according to Sacks, *et al.* (2011), "there is still no common understanding about what skills are needed to teach students, or what should be the content, principles and methods of education in these areas "

Despite the heterogeneity of approaches, with regard to teaching BIM, there is no “standard formula for designing and implementing BIM curricula, since each academic program is different, having a unique approach to BIM interpretations and practices” (Gu, *et al.,* 2012).

Challenges of BIM Education

The main objective of the introduction of BIM education in academic institutions is to enable recent graduates in the AEC sector with the necessary skills to meet the industry's demand (Barison, *et al.,* 2011). “Universities have an important role to play in the transition to the next generation of professionals who understand the use of BIM as a process that supports collaborative work” (Lockley, 2011).

According to Young, *et al.,* (2008) the necessary support for the expansion of BIM comes from the existence of professionals trained according to the BIM approach and in general, this type of support has been scarce in recent years. In addition to these difficulties, the lack of time or resources to prepare a new curriculum, the lack of space in the curriculum for the inclusion of new curricular units and the lack of appropriate materials for teaching BIM, are also some of the challenges pointed out by Barison, *et al.,* (2011). In contrast to the inadequacy of existing BIM instructors at universities, there is an increasing number of professionals in the industry sector, who have a strong practical knowledge in BIM, who can become potential technology instructors in educational institutions (Chen, *et al*., 2020).

Another factor is related to the learning of BIM tools, since the majority is difficult to learn according to conventional teaching methods, since the generated BIM models (in software such as Autodesk Revit or Archicad), are great complexity and contains several components with different properties. Thus, it is difficult for the teacher to be able to cover all these subjects during the limited time of classes (Tsai, 2019).

BIM Education in national universities

In Portugal, there is an increasing number of institutions integrating content related to BIM areas. In some courses in Architecture and Engineering, at the Architecture Universities of Lisbon and Porto, as well as at the University of Minho, there are course units that introduce technology learning, promoting only intra-disciplinary content, software exploration, parametric modeling and creation of families (Bastos, *et al.,* 2015). Despite the conscious growth of the importance of BIM in the future of the sector, according to Poças (2019), the lack of training on the part of the faculty and the scarcity of certification of training carried out, continue to define obstacles to the introduction of BIM in Portuguese education.

4. BIM in the teaching and practice of Architecture in Portugal

The survey

In order to analyze the level of knowledge and training in BIM technology, which recent graduates acquire, both undergraduate and postgraduate, a survey was prepared, in view of this target audience. The main objective of this survey is to understand the existing BIM training at academic level, as well as the

relevance of introducing its teaching in the curriculum of national architecture courses. In addition, the analysis of the survey made it possible to understand the state of technology implementation in national companies, understanding the importance that BIM training can have in the future of the AEC sector.

Methodology

Following the research carried out, the survey was then developed in order to reach the largest possible number of recent graduates in Architecture, in order to obtain a wide and varied spectrum of responses. With regard to the means of dissemination, so that the survey reached the largest number of respondents possible, it was decided to send the same, via email, to the dissemination department of each university, in order to reach all the alumni of each educational institution. A request was also made for disclosure on social networks, on pages related to Architecture in Portugal, in order to expedite the achievement of results in a shorter period of time.

Survey Structure

After the elaboration of the survey guide, which defined the main themes for which results were wanted, the final survey was prepared, following the premises of this guide.

- The initial phase of the survey aims to understand the background of the inquiry, characterizing the respondent according to their age, the educational institution in which they graduated and in which year the course ended, what was their basic training (Architecture, Urbanism or Architecture of Interiors) and, currently, in which area he develops his professional activity.
- This section aims to ask the BIM knowledge of the inquiry, through the understanding of the software that he knows and the fundamentals that he associates to the approach of technology. In order to understand where this knowledge had been acquired, questions were developed to obtain results related to the use of BIM software and tools during the respondent's academic career.
- For this group of questions, the main objective was to understand whether the competencies of the inquiry were enough to exercise the current position they occupy in the company and whether there was a need to acquire graduate education. It is also important to understand whether the company in which you work has implemented the BIM methodology and whether it uses software related to it. The questions in this group were also intended to ascertain what the respondents' BIM knowledge was at the entrance to the company, and whether it felt the need to participate in training related to BIM technology (software, methodological instruments and fundamentals). The last questions in this section intend to understand the importance that the respondent gave to the knowledge obtained in an academic context, in a postgraduate context and within the company where he works
- The last section of questions was of a more personal nature and of opinion, in order to understand if the respondent has notion of the importance that technology may have in the future of their profession, what are the advantages that technology believes it can bring to the what will change in your profession with the introduction of this technology.

Survey Results

After preparing this survey and analyzing the responses obtained, it is possible to highlight:

- the evidence that BIM technology is not yet widely known to all Architects and that teaching technology in universities is far from ideal;
- curricular units related to technology learning, existing in educational institutions, only focus on the introduction of aspects related to modeling and practice in BIM software

On the other hand, it is also possible to infer that, within the scope of the survey sample, that:

- few companies with an implemented BIM methodology

The vast majority of companies that were surveyed still do not develop work exclusively performed on BIM software, with a well-defined methodology and in which their workers know the technology in depth.

Finally, regarding the respondents' training needs, it can be seen that:

- few have felt the need to enter post-academic training in relation to the BIM approach.

This further highlights what was said earlier, regarding the small number of companies where the BIM methodology and uses are implemented

5. Conclusion

To conclude, I emphasize that although this survey shows that the knowledge related to the BIM approach, both in companies and in universities, is far from ideal, the change has been progressive and has shown to be growing. More and more ideas and concerns are emerging regarding the need for change, which is expected to be implemented over the next few years. It is up to the educational institutions to reformulate the formation in Architecture, so that the new architects can face the changes made in the industry sector. On the other hand, it is up to companies to promote the implementation of the BIM approach in their projects, in order to give a future to those who finish their academic training, allowing the change to be general and significant.

With regard to BIM education in Portugal, it was possible to conclude that the training related to technology is still underdeveloped, compared to the international panorama, where there are already several initiatives to introduce BIM in the curricula of the Architecture and Engineering courses. In spite of this, the knowledge related to 3D modeling with proprietary software is the concept that proved to be more known and developed, according to the researches carried out and the elaborated survey.

Also, regarding the implementation of BIM technology as a work methodology in companies, it was possible to observe that there are still few companies that work according to this methodology. However, it was found that the introduction of work processes in BIM may be the way forward, in order to improve the AEC sector in Portugal, reducing project times and costs.

Despite the commitment to the insertion of BIM curricular units in universities, external training can also serve as a complement to specific content of technology, and it is up to each student to understand the concepts and tools he intends to develop in more depth. In this way, the basic knowledge of a recent graduate in Architecture should pass through content learned in an academic context, in a course focused mainly on learning methodology and BIM concepts, and these contents should meet the main needs of the construction

industry. In order to complement this basic training, to learn a specific concept, tool or software or for a specific position within a company (especially at the BIM Manager level), postgraduate training is essential to move from meeting the possible gaps in academic training, deepening knowledge and focusing specifically on a deep learning of technology. In this sense, it is up to the recent graduate to understand which BIM areas he intends to deepen his knowledge in, despite having already had contact with technology in the academic environment.

In the case of the current profile of the newly architect and the way he adapts to the job market, it is evident that there is a discrepancy in relation to the needs of the industry. On the one hand, the AEC sector has had a gradual growth in the implementation of technology as a working methodology, constantly looking for professionals who can deal with issues related to projects, developed in a BIM environment. In contrast, university education related to technology still needs to be improved, namely through the introduction of mandatory curricular units on BIM uses, theoretical concepts, not only focusing on the learning of modeling concepts and software. In this way, students are able to understand the various uses of developing collaborative projects between specialties, while also learning the BIM work methodology. Despite the existence of training outside the educational institutions, it is the duty of universities to adapt to the change in the AEC sector, in order to educate future professionals in the field on topics that will be useful to them in the future.

Only when this change is general and when universities work in parallel with companies and studios, will the BIM approach be useful in generating more economical and easy-to-manage projects, allowing maintenance over time.

Future Work

The development of the present work and the elaboration of the survey of recent graduates in Architecture, allowed not only to draw well-founded conclusions, but also to pave the way for new issues to be developed in future works.

One of the obstacles to the development of BIM projects is the lack of knowledge related to technology, coupled with the costs that change can have within companies. However, most players in the construction sector believe that BIM technology is the future of the sector. In this way, it could be interesting to develop a survey, aimed at companies in the AEC sector, to understand what are the main reasons for the lack of technology implementation, as a working method.

Another issue, especially in terms of education, is the fact that there is no method to follow, with regard to how to teach BIM concepts and tools, and how these contents should be introduced in the curriculum of university students. Despite this, at international level, there are several courses and courses related to BIM technology, which develop both theoretical and practical concepts related to technology. One of the points that could be relevant to develop, after the analysis made to the existing BIM curricular units in national education, would also be to define a guide for the implementation of curricular units in educational institutions, namely the contents to be taught and the evaluation methods to be followed.

Although a long work is still needed, with regard to the implementation of the technology of the Portuguese industry, the questions raised and the way in which they will be answered, may serve to promote the change in the implementation of BIM technology in Portugal, both in companies and on education.

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