

Strategic Plan of Graphic Expression to implement BIM on a Degree in Technical Architecture

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Abstract

Architectural and engineering studies in Higher Education Institutions face the challenge of modifying their teaching programmes, so that students acquire the competences linked to the new methodological techniques of Building Information Modelling (BIM) during their academic training. The experience of its adaptation at the Higher Polytechnic School of the University of Burgos is described in this paper, where the implementation of this methodology on collaborative work and integral project management has begun in the Knowledge Area of Architectural Graphic Expression with the teaching of its disciplines. The project has the strategic end-purpose of transferring these experiences to the other subjects on the Degree in Technical Architecture. A preliminary analysis of the human and material resources available in the Knowledge Area was performed and a Strategic Methodological Plan was drafted, to ensure the success of its implementation, establishing the lines of action to implement BIM methodology within a time period of eight semesters following its start-up.

Keywords: *Building Information Modelling, Strategic plan, Graphic Expression, Higher Education Institutions, Digital graphic tools*

1. Introduction

In 2016, a program report was presented at the Conference of Directors of the Schools of Technical Architecture and Building Engineering. The report contained a proposal to adapt the Degree Programmes in Technical Architecture-Building Engineering to the new competences in design, construction, maintenance, and management of buildings that are defined in the Building Information Modelling (BIM) methodology. The document had as its main reference the Doctoral Thesis of Professor Inmaculada Oliver, entitled: "Integration of the BIM Methodology in the curricular programming of the Degree studies in Technical Architecture / Building Engineering. Design of a proposal", the defence of which took place at the Technical School of Building Engineering at the Polytechnic University of Valencia, in December 2015 (Oliver, 2015).

In her Doctoral Thesis, she proposed the strategic modifications that should be introduced in the Degree Program in Technical Architecture-Building Engineering, to guarantee the training competencies of the graduates in BIM Methodology. Thus, it was argued that the future Technical Architects and Building Engineers should be able to apply the BIM Collaborative Methodology to all the objectives defined in ECI Order ECI/3855/2007, for the verification of the University Degrees that accredit the professional status of Technical Architects in Spain (Gobierno de España, 2007)

The implementation of BIM Methodology in all the disciplines of the Degree in Technical Architecture-Building Engineering must be done from the First Year (Sacks and Barak, 2010), because it constitutes in itself a competitive advantage to guarantee the successful employment of graduates. In this way, new professionals come on stream for companies who are capable of successfully confronting modern-day technological challenges (Arbués, 2016). Moreover, the implementation of BIM will create numerous opportunities for academic and research collaboration, the offer of services, and technological transfer that improve University indicators of competitiveness (CODATIE, 2016).

The modification of the degree programmes is a challenge for the universities that is not without its difficulties, such as having teaching staff with acceptable training in BIM Methodology, and material and technological resources that guarantee the success of its implementation (Gallego and Huedo, 2015) (Pomares et al., 2017).

The Higher Polytechnic School of the University of Burgos, with proven experience of over fifty years in the training of Technical Architects-Building Engineers, has assumed the commitment of implementing BIM Methodology in the Technical Architecture Degree. It has done so by drafting a Strategic Methodological Plan in the Area of Architectural Graphic Expression, the experience of which will be transferred to the other subjects on the Technical Architecture Degree and, subsequently, to all the Degrees of the Polytechnic School.

2. BIM Strategic Plan and selection of the Teaching Organizational Unit

Within the teaching structure of the Technical Architecture Degree, the field of Architectural Graphic Expression has its own identity, directly related to the disciplines of representation. It is therefore a reference area to become the Teaching Organizational Unit responsible for the process of implementing BIM Methodology. The subjects imparted in this Knowledge Area are directly focused on the application of digital tools for graphic design in two and three dimensions and are, in addition, distributed over the eight semesters of the Degree course.

2.1. Development of the Strategic Plan in Architectural Graphic Expression

The implementation of Digital Tools and Information and Communication Technologies is one of the main improvement actions in the new university context of the European Higher Education Area (Esteve, 2016), both for administration and management and for its inherent functions, such as teaching, research, and knowledge management (Becerik-Gerber et al, 2011). However, the integration of these tools is not always supported by a Strategic Plan that ensures the proper functioning and the achievement of the changes that its authors might wish to promote in the universities (Ángeles, 2012).

The drafting of a Strategic Plan offers us a standardized working document with a vision of the future in the medium to long term (Martelo, 2015). In it, the current situation is analysed, the objectives are defined, resources are assigned and the strategies to achieve them are programmed over time (Fuster, 2008). In addition, a Strategic Plan is a living document that has control and feedback systems that ensure compliance with its contents. In this sense, the academic managers of the Higher Polytechnic School of Burgos considered the drafting of a Strategic Plan in the Area of Architectural Graphic Expression as an opportunity to discover its potential and to understand both its strengths and weaknesses, as well as to assess the strategic position of the School before assuming responsibility for the start-up and implementation of BIM methodology.

The educational strategy developed by the Professor Antonio Fernández Coca (2012), widely disseminated in conferences and publications, was in fact a precedent in the academic field of Technical Architecture, and more specifically in the disciplines of Graphic Expression.

Finally, the Strategic Plan must be the result of the collective commitment of the Professors of the Graphic Expression Area involved in its development. In order to reinforce its effectiveness, it was decided the need for its approval by the Board of Graphic Expression Department in the 2016-2017 academic year and its monitoring and follow up by the Management of the Higher Polytechnic School.

3. Diagnosis of the current situation of teaching

The first development stage of the Plan consisted of preparing a diagnosis of the intrinsic characteristics of the Area of Architectural Graphic Expression and a comparative study of its situation with respect to the other Knowledge Areas that teach on the Degree in Technical Architecture. For that purpose, a situational analysis was performed using the SWOT (Strengths, Weaknesses, Opportunities, and Threats) diagnostic procedure, in order to establish improvement strategies and competitive positioning, thereby guaranteeing the success of the plan (Ponce, 2007) (Mata, 2007).

3.1. Internal analysis: strengths and weaknesses

For the study of strengths and weaknesses, the human and material resources assigned to the course were separately analysed. The main characteristic of its teaching staff is the heterogeneity of qualifications and academic training. Only four of the nine teachers hold doctoral degrees and their training is very diverse, as among them there is an Agricultural engineer, three Architects, four Technical Architects-Building Engineers, and an Architect with a Bachelor of Fine Arts.

In business organizations, heterogeneity can constitute a competitive advantage for a multidisciplinary approach to strategic actions, so this diversity of academic and professional profiles is in itself a great strength and at the same time a weakness of the Area. These differences can be very beneficial if the synergies between colleagues are adeptly harnessed, so that the diversity of teaching profiles will not create imbalance and lose the unity of the group.

Regarding material resources, Graphic Expression Department has fully equipped computer rooms, but not all of them have the hardware required by the BIM software. Therefore, it is necessary to program a Computer Equipment Renewal Plan, a circumstance to be considered in future annual investments for the renewal and replacement of equipment.

3.2. External Analysis: opportunities and threats

The aim of implementing BIM modelling in a pioneering way in the Area of Architectural Graphic Expression was assumed by the professors as a challenge and an opportunity to lead the process of a paradigmatic shift in the teaching of Computer Aided Design (CAD) towards BIM Methodology. An innovation that reminded the most veteran teachers of the upheaval that took place twenty-five years ago when moving from hand-drawing to CAD.

On the other hand, this goal was not considered as an isolated Innovation Line, but it is interrelated with the Teaching Innovation Lines of the other Departments of the School. It was considered so, given that once BIM was incorporated in the subjects of Architectural

Graphic Expression, the experience would be transposed to the other subjects of the Technical Architecture Degree and, subsequently, to the rest of the Degrees of the School.

A critical element of the process is the diversity of learning itineraries available to students in the Study Plan of the Degree Program in Technical Architecture, which sometimes do not correspond to continuous sequential learning of BIM Modelling Methodology.

4. Action lines and sequential distribution of BIM learning

The implementation of the BIM Modelling Methodology has provided an opportunity to organize and to establish the most suitable schedule for instruction in the other digital tools applied in graphic expression subjects, such as 2D and 3D Graphic Design software, the software of Infographics and Virtual Reality, and the specific software of Topography and Photogrammetry. Table 1 shows the list of subjects of the Area according to the natural learning sequence of digital graphic tools, taking the year and the semester in which they are taught as a reference.

Table 1. Teaching schedule of Graphic Design software including BIM modelling.

	Teaching software
	Software application in teaching

Technical Architecture Degree										
Architectural Graphic Expression			Software							
Year	Semester	Subjects	Graphic Design 2D-3D	BIM Modelling	Modeling 3D - Infography	Video-Virtual Reality	Graphic Design 2D-3D Advanced	BIM Advanced	GIS	SFM-Structure from Motion
1°	1°	Descriptive Geometry								
	2°	Architectural Drawing I								
2°	3°	Architectural Drawing II								
	4°	Architectural Drawing III								
3°	5°	Topography								
	Optional	Graphic Representation Techniques								
	6°	Technical Projects I								
	Optional	Interior Design								
4°	7°	Technical Projects II								
	7°	Photogrammetry								
	8°	End-of-degree Project								

BIM teaching began in the second semester of the 2016-2017 academic year, in the Architectural Drawing I programme, with the introduction of the basic theoretical and practical concepts of this methodology, guiding the students through the intuitive study and the philosophical knowledge of BIM techniques and processes (Sacks and Barak 2010).

The temporary sequence of training continues over the following two semesters, in the 2nd year. In this year, the students will be trained in architectural modelling, applying the potential offered by the tool for the development of building constructions.

In the fifth semester, students have the opportunity to choose the optional subject of Graphic Representation Techniques as part of their curricular training, where advanced BIM modelling is taught in architecture, structures, and mechanical, electrical, and plumbing engineering design (MEP). Students who do not choose this optional subject can study advanced BIM modelling in Technical Projects I and Technical Projects II, in the sixth and seventh semesters, respectively.

Following this learning sequence, it is guaranteed that students will reach the End-of-Degree Project in the eighth semester equipped with the skills to develop a Building Project using BIM Methodology.

5. Intervention strategies to achieve the objectives

The timeline for BIM Methodology implementation established in the Strategic Plan has set the pace of change and adaptation the subject Syllabuses. The professors assigned to each subject, in coordination with the drafters of the Strategic Plan, are responsible for defining the specific theoretical contents that should be introduced in the Syllabus and the practical supporting exercises, so that the students can acquire the skills that are detailed in them. In parallel, the academic managers were specifying the measures that, according to the initial diagnosis, should be put into action to reinforce the strong points, to face the threats, to correct the weaknesses, and to exploit the opportunity of actively leading the implementation of BIM Methodology.

The internal improvement actions were aimed at correcting the differences in training among the teaching staff, which was one of the weaknesses detected in the diagnostic phase. The academic managers of the Strategic Plan asked the Institute for Educational Training and Innovation of the University of Burgos to organize BIM Training Modules, to improve teaching skills in BIM. There was massive participation on these training modules among teachers, not only from the Area of Architectural Graphic Expression, but from other Knowledge Areas with training competences in the Technical Architecture Degree.

Moreover, as evidenced in the analysis of the external situation, the process of implementing BIM Methodology represented a great opportunity for qualitative improvement, both in terms of the qualifications of the human team and the availability of technological resources. Hence, the commitment was assumed from the very beginning, to transmit the work done to the University Community, disseminating the actions taken and the results in the different management areas, both at the University of Burgos and the

Higher Polytechnic School and, in addition, at Conferences and Teaching Innovation Congresses, and through specific publications.

6. Monitoring and control for continuous improvement

The monitoring of compliance with the schedule in the Strategic Plan is done annually at the Board of the Graphic Expression Department at the time of approving the Syllabus for the following academic year. Two years into the implementation process that began in 2016/17, we are currently working to adapt the contents of Graphic Representation Techniques and Technical Projects I, in the Third Year of the Degree. The complete integration of BIM Methodology in Architectural Graphic Expression is foreseen in the 2019-2020 academic year, at which time its transversal implementation will begin in the other disciplines of the Degree in Technical Architecture.

Once this stage of the Strategic Plan has been completed, the methodological objectives established in it will remain in force, as they will serve to provide feedback to the system on its practical application to the teaching-learning process, because teaching excellence can only be achieved through the process of continuous improvement (Rodríguez 2003).

7. Conclusions

The imminent need for graduates of Technical Architecture-Building Engineering to acquire professional competences in BIM requires the adoption of specific measures to guarantee their integration in higher level Degree studies. The Strategic Plan of Graphic Expression has been an effective instrument, which has made possible to organize the teaching of the Knowledge Area and establish synergies among its teachers. We are now working on transferring it to other Areas. The success of this experience has encouraged the drafters to develop other Innovation Lines through strategic plans because, in addition, this methodology has achieved the involvement of many people during the process.

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