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Implementation of the BIM Methodology in the Architecture Degree: Experience of the Architecture School of San Sebastian

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Abstract

The emergence of the Building Information Modelling (BIM) methodology in the design, generation, maintenance and data management of any type of building has meant the most important advance in decades in the construction sector. Moreover, current European and Spanish regulations require its mandatory use. In this context, the university degree studies related to construction must challenge this new reality. The aim of the project conducted in the University of the Basque Country (UPV/EHU) School of Architecture of San Sebastian, is the implementation of the BIM methodology in its Architecture Degree. The intention of this research is to implement the BIM methodology without subtracting competencies or content from the current Syllabus. This methodology should be gradually integrated into the different courses and intertwined with the contents of different subjects, in order to train Architecture graduates on BIM and preparing them to join a professional market that demands this knowledge. The purpose of this communication is to report the current status and the level of development of this study.

Keywords: *BIM; architecture; degree; university; teaching.*

1. Introduction

The construction sector is bearing a change in its traditional paradigm. The emergence of a new methodology based on digital technology, BIM methodology or Building Information Modelling, is going to change the way buildings are conceived, designed, constructed and used. The European Directive 2014/24/EU on public procurement (European Parliament, 2014) urges Member States to consider the use of technology to update public procurement processes. This Directive has been transposed into the Spanish 9/2017 Law on Public Sector Contracts (Jefatura del Estado, 2017), which allows public procurement bodies to require digital BIM tools for public works contracts, works concessions, services and project tenders.

In this sense, the university degrees linked to this sector will have to adapt to this new reality in a relatively short period of time. If future graduates must have enough technical skills to practice their profession, they must have sufficient knowledge of the subject. At present, BIM methodology is hardly implemented in the teaching content of university degrees. However, there are specific postgraduate and master's degree courses on the subject.

Something similar happens in the case of the university degree in architecture. At the moment, everything related to the acquisition of knowledge of BIM methodology is predominantly linked to postgraduate Masters, specific Masters and courses. Although there are specific experiences of implementation of the methodology in the Bachelor's Degrees, there is no known case where the BIM methodology structures a whole Syllabus in Architecture Degree. Hence the urgent need to implement BIM methodology in the Bachelor's Degrees in Architecture.

2. BIM methodology

BIM is a working methodology. It is a process of generating and managing building data during its life cycle, using dynamic 3D building modelling software in real time. It also reduces the waste of time and resources in the planning, design, construction and operation phase. It is not just about creating 3D model but also about generating a virtual building that contains additional information about elements and materials. In fact, it is a 3D database that enables tracing of all the elements that constitute the building. This database improves the operational management and maintenance of the building throughout its life cycle, making asset management much easier (Building SMART, 2020). The centralised digital data model allows recording all the modifications and processes that are carried out in the buildings during their life. Furthermore, the collaborative nature of the BIM methodology makes it an ideal tool for linking the various disciplines that take part the design-construction process.

3. Implementation of BIM proposal in the Architecture Degree

The University of the Basque Country (UPV/EHU) Architecture School of San Sebastian launched a project in 2018, together with the Basque Government, in response to the need to implement BIM in the Bachelor's Degree in Architecture. A Collaboration Agreement (ETS Arquitectura - UPV/EHU, 2018) was signed between the Basque Government and the University of the Basque Country with the purpose of promoting research in architecture, urban planning and construction. The project was presented and accepted and developed during the period of 2018-2021. The aim of this project is to implement BIM within the Bachelor's Degree in Architecture so that the graduates, once they have completed the Degree, get the BIM skills demanded by the construction sector labour market.

One of the fundamental premises established by the Management of the Architecture School of San Sebastian was that the BIM methodology should be taught as an integrated part of the Degree and not as a learning process in parallel to it. This will allow the integration of closely related subjects, which are closely related and which in traditional teaching are studied apart. Therefore, it will help students to have a global vision of all the design and construction process related to architecture and urban planning.

3.1. Current Syllabus

The current Syllabus for the Degree in Architecture at the UPV/EHU was approved on 24 March 2015 (ANECA, 2015). This Plan is based on the Orden EDU/2075/2010 (Ministerio de Educación, 2010) regulation, where the distribution of ECTS is established and structured on the basis of Competences and Modules that determine the learning objectives of the graduates. These competences are acquired through Basic Branch Subjects, Compulsory Subjects, Optional Subjects and a Final Degree Project (Figure 1).

DEGREE IN ARCHITECTURE - Currents Syllabus						
Type	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	Total
Basic Branch Subjects	36	24				60
Compulsory Subjects	24	36	60	60	21	201
Final Degree Project					9	9
Optional Subjects					30	30
TOTAL	60	60	60	60	60	300

Figure 1. Current Syllabus and distribution of ECTS on the Architecture School of San Sebastian, UPV-EHU. Source: UPV/EHU Architecture School of San Sebastian (2015).

3.1.1. Modules and Competences

Four types of competences are established within the Degree: Basic Competences, Degree Competences, Transversal Competences and Specific Competences. All these competences are distributed in 10 modules which in turn contain the Basic Branch Subjects, the Compulsory Subjects, the Optional Subjects, as well as the Final Degree Project.

3.1.2. Compulsory Subjects, Optional Subjects and Integrated Workshops

As the current Syllabus stands, the acquisition of competences by the students of the Bachelor's Degree in Architecture is based on the subjects. Compulsory Subjects (201 ECTS) are the ones that prevail over Optional Subjects (30 ECTS). Implementing BIM methodology is among these subjects where the main emphasis should be done. The Optional Subjects can be used to complete the learning process. As stated in the current Syllabus, in Integrated Workshops various subjects participate so that the student can acquire transversal knowledge by integrating various subjects in a single Studio or Workshop. These Workshops could become one of the most interesting platforms to implement BIM as one of the main objectives of this methodology is to work transversally with several subjects at the same time.

3.2. Review of the Syllabus

At present, the UPV/EHU Architecture School of San Sebastian has begun the revision of the Syllabus where it is foreseen that based on the present study, the Implementation of the BIM methodology in the Degree will be included. It should be noted in this regard that, although the study is based on the current Syllabus, the modifications that could be introduced in the future are foreseen and proposed, so that the assessments and conclusions derived from this research are taken into account from the outset.

3.3. BIM Competences, Tasks and Uses

There is not enough experience to establish the correct pathway for acquiring BIM knowledge at the same time as acquiring degree regular competences. In order to establish the learning objectives of the BIM methodology, it is necessary to set a series of parameters that serve as tools to develop teaching. For this reason, and based on the research conducted to date, to establish what BIM contents are, the study stands on three basic concepts: BIM Tasks, BIM Uses and BIM Competences. BIM Competences are related to teaching, while BIM Tasks and BIM Uses are related to the professional field. These three parameters that are considered fundamental to implement the methodology in the Degree are presented below.

3.3.1. BIM Competences

BIM Competences are those linked to the ability to perform a BIM activity or provide a BIM result (Succar, Shed, et al., 2013). When defining BIM Competences, a list was prepared by selecting those that would allow greater interaction and compatibility with the Competences of the different Degree modules. The BIM competences proposed (Figure 2) must be related to the specific competences of subjects when implementing BIM (Barison & Santos, 2011).

	Basic and Advanced Architectural Design Module
BIM - E16	Analyse and use a BIM architectural design model
BIM - E17	Create and design a BIM architectural model
BIM - E18	Modify a BIM architectural design model
BIM - E19	Analyse and use an existing or planned urban model according to BIM methodology, for medium- and large-scale review
BIM - E20	Create and design an urban planning model using BIM methodology
BIM - E21	Modify an existing urban model using BIM methodology

Figure 2. BIM Competences established for the Degree in Architecture.
Source: Authors (2020).

3.3.2. BIM Tasks

The BIM Tasks refer to the way in which the methodology can be worked and developed. These Tasks focus on the use and development of the virtual building that is the object of design, analysis and subsequent construction and operation phase. All the tasks are grouped into five blocks: Visualization and Information, Modeling, Analysis and Calculations, Documentation and Graphics, Project Management (Messner, Anumba, et al., 2019).

3.3.3. BIM Uses

Finally, BIM Uses depict the different uses given to a BIM project throughout the life cycle of the building. A classification of 28 BIM Uses (Figure 3) has been proposed based on the research developed so far (Kreider & Messner, 2013).

BIM Uses	
01 CURRENT TERRAIN MODELLING	15 DRAWING PRODUCTION
02 COST ESTIMATION	16 INTERDISCIPLINARY 3D COORDINATION
03 PHASE PLANNING/ SCHEDULING	17 CONSTRUCTION SITE PLANNING
04 SPACE DISTRIBUTION	18 DESIGN OF BUILDING COMPLEXES. VR.
05 SITE ANALYSIS	19 DIGITAL FABRICATION
06 DESIGN REVIEWS	20 DIGITAL SITE LAYOUT
07 DESIGN MODEL	21 CONSTRUCTION QUALITY CONTROL
08 STRUCTURAL ANALYSIS	22 AS-BUILT MODEL
09 ENERGY ANALYSIS	23 FACILITY MANAGEMENT MODEL
10 LIGHTING ANALYSIS	24 ASSET MAINTENANCE SCHEDULING
11 HVAC ANALYSIS	25 ASSET PERFORMANCE ANALYSIS
12 SUSTAINABILITY ASSESSMENT L	26 ASSET MANAGEMENT
13 TECHNICAL CODE VALIDATION	27 SPACE MANAGEMENT AND MONITORING
14 OTHER ENGINEERING ANALYSIS	28 CONTINGENCY PLAN

Figure 3. BIM Uses proposed for the Degree in Architecture.
Source: Authors (2020).

3.4. Strategic implementation guidelines

In order to implement the BIM methodology, four strategic guidelines are established.

3.4.1. Main Objectives

Firstly, based on the duration of the Architecture Degree studies and taking into account the assignment of Modules and Competences, a series of Main Objectives are established (Figure 4). These objectives are linked to the BIM Competences, Tasks and Uses.

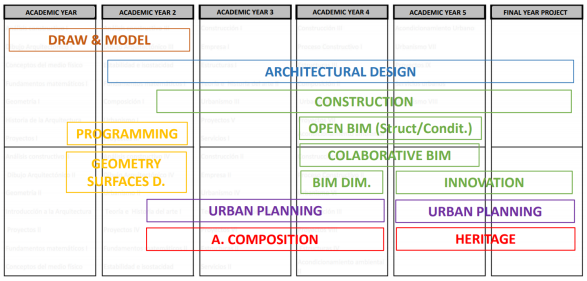

Figure 4. Summary table of the Main Objectives of BIM for the Degree in Architecture. Source: Authors (2020).

3.4.2. Compulsory Subjects

Based on the distribution of Compulsory Subjects in the Degree, a curricular path of BIM teachings is established. This distribution is carried out in three Learning Levels (Figure 5). Depending on the content of each subject, the knowledge of the methodology is taught in a Main Level, a Secondary Level and a Complementary Level.

ACADEMIC YEAR 1	ACADEMIC YEAR 2	ACADEMIC YEAR 3	ACADEMIC YEAR 4	ACADEMIC YEAR 5
Semester 1	Semester 1	Semester 1	Semester 1	Semester 1
Architectural Design I	Architectural Design III	Architectural Design V	Architectural Design VII	Architectural Design IX
Constructive Analysis I	Constructive Analysis III	Construction I	Construction III	
Architectural Drawing I	Architectural Drawing III	Business Administration I	Construction Process I	
Geometry I	Urban Planning I	Urban Planning III	Urban Planning V	Urban Planning VII
Physical Medium Concepts	Stability and Isostasy	Structures I	Structures III	
Math Fundamentals I	Math Fundamentals II	Services I	Enviromental Conditioning I	Urban Conditioning
History of Architecture	Architectural Composition I	Theory and History of Art II	Architectural Composition II	

Figure 5. Partial distribution of the curricular pathway based on 3 Learning Levels. Source: Authors (2020).

3.4.3. Optional Subjects

The contribution of the Optional Subjects distributed throughout the Degree can help to complement BIM knowledge. These subjects, although not fundamental for the acquisition of minimum knowledge of the methodology, can provide additional learning value.

3.4.4. Workshops and/or Seminars

To complement all the BIM training, the existing Integrated Workshops in the current Plan should be maintained and even increased. Workshops are the most suitable BIM implementation environments as they promote collaborative work. We must not forget that architecture degrees incorporate "project-based learning" from their very conception, and that group work occupies a substantial part of the teaching activities developed. This ability to work in groups will be one of the aspects that can benefit most from BIM methodology (Egea, 2016).

3.5. Experience gained

During the period of the project, training has been included for students who are currently studying for their degree, so that they can also acquire this knowledge without waiting the implementation to be completed. On the other hand, teaching staff is being trained so that those who are not initiated in the BIM methodology acquire the skills to implement the BIM methodology in the content of each subject after a period. This whole process is being carried out together with experts in the methodology at national level and in collaboration with the administration, specifically with the Department of Territorial Planning, Housing and Transport of the Basque Government, which is funding this project.

4. Conclusions

In the three years since the project began, several conclusions have been drawn so far. The first is that there is an urgent need to embark on the path to be able to implement BIM Methodology as soon as possible in the Bachelor's Degrees, in this specific case in the Bachelor's Degree in Architecture. To this end, the Syllabus must be revised and BIM Competences must be added to it. It should not be forgotten that, as stated in the European Directives and Spanish Regulations, public procurement, and consequently private procurement, should be promoted through technological advances.

On the other hand, it is an obligation of the university to prepare future professionals with the skills to develop the profession. In this sense, the experience acquired so far at the San Sebastian School of Architecture has been very positive. Several surveys have been conducted among students to assess the effectiveness of the proposed Plan. More than 350 surveys have been conducted among the students of the different courses of the Degree between 2018-2021. 90% of the students surveyed consider it important to acquire BIM knowledge for their professional future, while 97% would like to learn the BIM methodology. To this end, it is essential to integrate the methodology into existing subjects. However, the incorporation of these BIM Competences should not leave aside the current Degree Competences.

Finally, it must be said that a period of time will be needed before the BIM methodology can be fully implemented in the Degree. At the moment, neither the awareness of the importance of the methodology, nor the necessary infrastructures to develop it at the university, nor the current training of the teaching staff, indicate that it can be implemented immediately. A medium-term period will be needed to become this project a reality.

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