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Architectural Draughtsmanship

From Analog to Digital Narratives

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Preface

The book presented here is a compilation of articles collected under the title*Architectural Draughtsmanship: EGA (Architectural Graphic Expression) From Analog to Digital Narratives*. It is the result of the International Congress EGA (Architectual Graphic Expression)16 held in Alcala de Henares in June 2016 with the subheading: "Teaching and researching in architectural graphic expression."

This was the 16th edition of the Congress, and it was again centered on the exchange of knowledge of what is taking place within the arena of architectural graphic expression inside and outside of our country.

The implementation of a successive curriculum over a short period of time (BA in Architecture, BA in Fundamentals of Architecture, Master of Architecture and Ph.D.) has led to the necessity of restructuring all areas of study within this field, and for that reason, it seemed the right moment to turn our attention to the work of professors and researchers. As the last Doctor Honoris Causa of the University of Alcala Kenneth Frampton said in his acceptance speech, we have to reclaim innovation by starting from tradition, both in terms of architecture and educational disciplines attached to it.

This book is organized into two major parts:

A/ Research into the field of architectural graphic expression, including related areas of education, in which innovative experiences have been presented in the new curricula,

B/ and how to teach research methods that are essential to the work and experiences found in the field of postgraduate studies.

The editors have grouped the articles into four major chapters, according to their individual subjects:

1. Innovation Teaching Strategies (Teaching experiences applied in EGA).
2. Design and Education (General education concepts in EGA).
3. Design and Architecture (Design issues related to current architectural practice).
4. History and Cultural Heritage (History of a particular designs and/or the design's application within the architectural heritage).

Blind pairs reviewed all articles as a guarantee of quality in order to obtain the recognition of the scientific community.

All the works are in English, although they may have originally been written in one of the languages of the Congress, either Spanish, Italian, or Portuguese, with the goal of emphasizing their respective international characters.

We believe this compilation of articles could be the trigger to start a new collection of books about the international relevance of architectural graphic expression. It is the result of the important contributions taken from the congresses dedicated to the subject that have been held regularly for over thirty years, with the participation of a large number of researchers from European and Latin-American countries.

Alcalá de Henares, Spain

Enrique Castaño Perea
Ernesto Echeverría Valiente

Contents

Using BIM and GIS to Research and Teach Architecture

Francisco Pinto Puerto, Roque Angulo Fornos, Manuel Castellano Román, José Antonio Alba Dorado and Patricia Ferreira Lopes

Abstract This paper describes the use of BIM and GIS in our research of architectural heritage and the experience gained from their implementation from Year 1 to Year 5 in the subjects "Drawing and Machine" and "Drawing 3, Graphical Analysis" taught in the Department of Architectural Graphical Expression of the Seville School of Architecture during the academic years 2014/2015 and 2015/2016. We propose a transition towards a teaching model that integrates analogue and digital with a gradual and coherent approach based on an understanding of architecture itself as a complex system made up of various elements and attributes, both visual and alphanumeric, which allow the "graphical" to transcend the visual and incorporate different types of information.

Keywords Building information modelling · Geographic information systems · Research and teaching at the school of architecture

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1 Introduction

In the late 1960s, the exhibition entitled *Cybernetic Serendipity* (Reichardt 1968) at London's Institute of Contemporary Art launched the debate on the use of computers and digital tools in the creative processes of diverse fields ranging from literature to the graphic arts. Rather than achieve a specific aim, the *Cybernetic Serendipity* artists set out to experiment with the different ways of using machines, undertaking a series of activities that straddled both science and art. The creative process therefore generated a new dynamic in the modes of production, visualisation and interaction, not only because of the media used but also the new agents involved. Since then, and especially since the late twentieth century, the frenetic evolution and refinement of technological advances has made digitisation such an important part of our reality that we now talk about a "digital culture".

The debate about analogue and digital, which in the field of architectural graphical expression has been raging since the year 2000, has evolved from a certain rejection of the "graphical machine" to processes designed to integrate drawing strategies and digital media. In recent years, this debate has been coupled with major changes in the practice of architecture, where the "Albertian paradigm" of the "author-architect" has begun to flounder, giving way to a new idea of the architectural project in which "the vertical integration of computer-aided design and manufacturing is creating new forms of digital craftsmanship, blurring the Albertian distinction between designer and producer". (Carpo 2003, 23) Meanwhile, the potential that digital media offer for working in collaborative environments is facilitating the architect's participation in multi-disciplinary teams, challenging the notion of authorship that prevailed in the modern age. (Carpo 2003, 112) The compensation for this foreseeable loss is a profound renewal of architectural practice, which has broadened the debate on its complexity to encompass much more than its formal condition. Nowadays, that debate embraces the interaction of multiple situations and conditions which range from determining its physical and material reality to managing its sustainability and economic and social responsibility. In short, digital media are not only fuelling the demands for the architectural renderings that have become so common in our insatiable visual culture, but are radically transforming all the processes related to the conception, research, production and management of architecture. (Catalá 2005, 41; Pinto 2010)

The aim of this paper is to demonstrate how all of these issues are being incorporated into our research and teaching. In the field of research, they enable us to explore the potential for integrating the multiple disciplines that are involved in the guardianship of architectural heritage: identification, including mapping and analysis, research, protection, conservation, dissemination and management. In the field of education, they enable us to plan and adapt research and professional experience to the teaching and learning contemplated in the new syllabuses, thus meeting the demand for more transversal training that integrates the various disciplines involved. The integration of traditional drawing—which we call analogue—as the source on which the digital interfaces are built, and digital drawing,

observed and practised in a critical, thoughtful manner, provides a means for addressing both the need for innovation in research and the actual aims of the new syllabuses. Within this set of new resources, Building Information Modelling (BIM) and Geographical Information Systems (GIS) encompass the various scales of matter and space, offering powerful tools for the analysis, design, production and management of architecture.

2 In the Field of Research

Most of the authors of this paper are investigating the same themes as the research group HUM799 (http://grupo.us.es/ecphum799), focused on heritage knowledge strategies. The project we are currently undertaking is based on the hypothesis that it is possible and indeed necessary to use the new technologies to combine the scattered and disjointed data from the different fields of knowledge which, each in its own way, impact on the architectural models of our historical and cultural heritage that stem from numerous increasingly specialised disciplines (archivism, archaeological, architectural, visual, analytical, economic, etc.). This convergence (basically, inter-related or inter-connected heterogeneous information) requires the design of a specific IT tool, which must be complete and flexible enough to significantly optimise decisions regarding this heritage (conservation, maintenance, restoration, renovation, management and dissemination). We are therefore exploring ways of modelling architectural heritage, understanding this model as a mental construct that entails more than reproducing its present form or formulating hypotheses about the possible state of earlier forms. Indeed, we view this model as a vehicle for thinking about these forms and integrating them into the aforementioned disciplines (Pinto and Guerrero 2013, 137). The use of BIM in this field, even if specifically focused on new-build architecture, is proving to be extremely useful for addressing the challenges posed. One reason for this is its capacity to manage vast quantities of information, visualise relationships, and investigate a crucial issue in the heritage field: time, a contemporary value that makes it much more difficult to understand this type of architecture (Fig. 1).

The advances in this respect have led to complex models which in addition to the usual material characteristics and the hierarchisation of the building processes now include the sequencing of the various states, alteration and destruction processes, and the classification of spaces by defining their precursory elements, be these formal or pathological. Our project began by modelling and managing the information associated with an archaeological ruin, the Hylas House at the archaeological site of Itálica, (Angulo 2012) which emerged following the architectural analysis and diagnosis of the remains prior to the definition of a master plan. As the next stage in our project, we used digital models and databases to plan and develop the case for the legal protection of the church of San Pedro in Arcos de la Frontera, Cádiz province Castellano (2013). More recently, we have modelled the chapel of La Virgen de Antigua in Seville Cathedral, which offers an example of Late Gothic

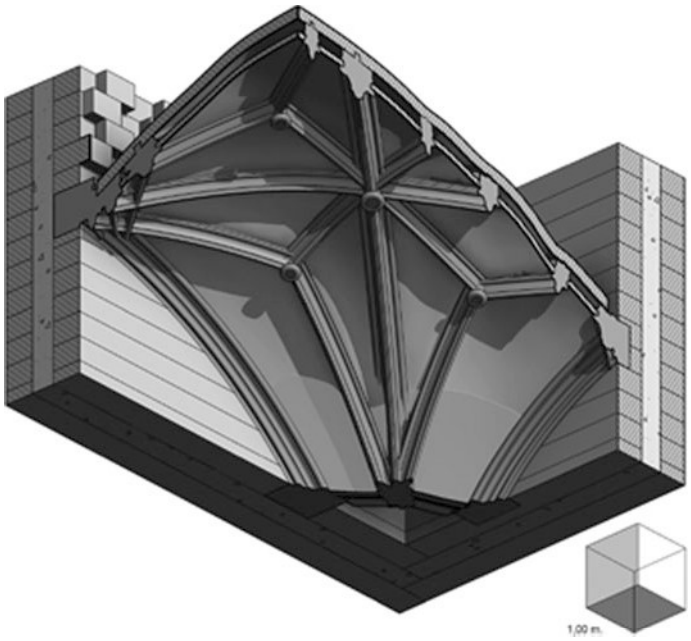

Fig. 1 Chapel of La Virgen de Antigua in Seville Cathedral. BIM Model. Author Roque Angulo Fornos

architecture subjected to a complex sequence of transformations through the ages and whose interpretation though the digital model is shedding crucial light on how it reached its current state (Angulo 2015; Pinto and Angulo 2015). In all of these cases we used BIM, adapting the models as necessary to incorporate heritage considerations. To build the models we either used existing plans or digital photogrammetry and laser scanning, according to the aims of the project in question. Since we had obtained our data from different types of records and analyses, we systematised all potential input data for the BIM models, classifying the modelled objects according to numerous properties and attributes, which can be edited, in order to visualise relationships that had previously gone unnoticed. One of the principal advantages of BIM models is that they evolve with the actual analysis of the heritage object in question: in other words, from the moment its merits are recognised and protected under the aegis of some form of legal regulation and it is included in a catalogue or inventory of protected assets, to its profound study, restoration or formulation of plans for its future conservation. This evolution is in line with the LOD (Level of Detail) specifications that have become a standard component of BIM systems applied to new buildings, not only facilitating the ongoing amortisation of the time and financial investment in creating them but guaranteeing their efficiency in accordance with the aforementioned principles of combining scattered and disjointed information from different fields of study (Figs. 2 and 3).

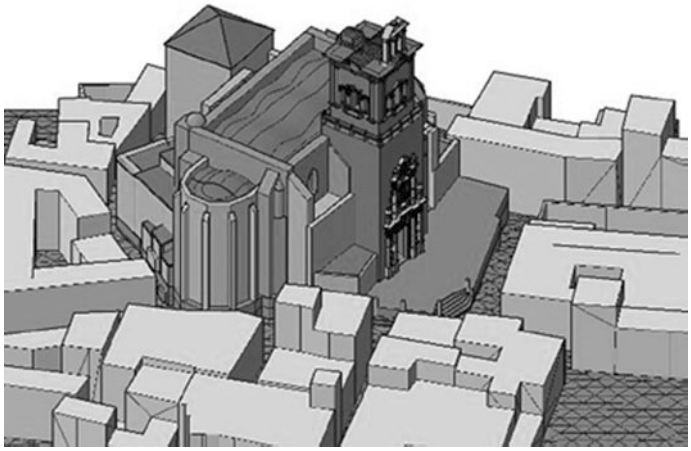

Fig. 2 Church of San Pedro in Arcos de la Frontera (Cádiz) Heritage Information Model. Author Manuel Castellano Román

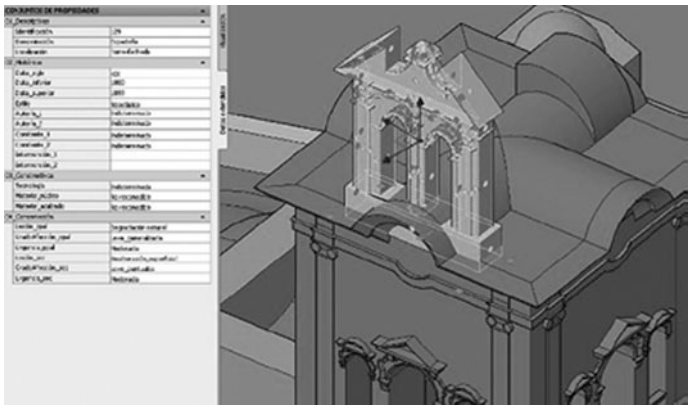

Fig. 3 Church of San Pedro in Arcos de la Frontera (Cádiz) information about the bulrush on the tower in the heritage information model. Author Manuel Castellano Román

However, the scale of the problem is larger than the building itself because many of the explanations for its forms and the vicissitudes it has undergone are rooted in the territorial aspect and its relationship with contemporary works, often scattered across a vast region or the whole country. In order to address this new framework, we have used Geographic Information Systems (GIS). One of the first issues to consider in relation to GIS is that this technology has traditionally been associated with geography and the use of a set of techniques and methods in the various aspects of this discipline, ultimately transforming this field of study. In the field of architecture, GIS was initially used for urban development, especially as regards

transport and mobility, before being extended to urban planning and management. Today, following major advances and improvements in digital tools, coupled with their enormous data processing and analysis capacity, we use GIS in different ways to understand architecture in all of its complexity, connecting it to the cultural, social and historical aspects of a spatial environment. Our experience has enabled us to confirm the usefulness and vast potential of GIS for analysing and managing heritage. Since heritage demands a multi-disciplinary yet coherent vision, GIS offered us a "point of union" for relating information in different formats (images, plans, maps, tables, texts, etc.) and of a diverse nature (historical, economic, architectural, geological, anthropological, etc.). As part of the aforementioned research project currently under way, we are trying to create a digital model of information on the structural organisation of Western Andalusia in the post-Reconquest, Late Gothic context when the foundations for the modern territory were laid, since these largely explain its structure today. Our ultimate aim is to examine the spatio-temporal networks generated by the building enterprises (civic and religious buildings, infrastructure and roads), with a special focus on the professionals and artists involved (Ferreira and Pinto 2015). Accordingly, our premise is the digitisation and processing of graphical documents and alphanumeric data which, processed in the GIS environment, can be cross-referenced and situated in space and time to generate visualisations and analyses, thus creating new images and interpretations that not only provide answers but also pose new questions about the built object.

By inter-relating both systems, BIM and GIS, we can move freely between seemingly very distant scales whose common mission is the construction of info-graphics (inter-connected alphanumeric and graphical data) to obtain and actively manage knowledge, preserve values and facilitate the conservation of heritage (Fig. 4).

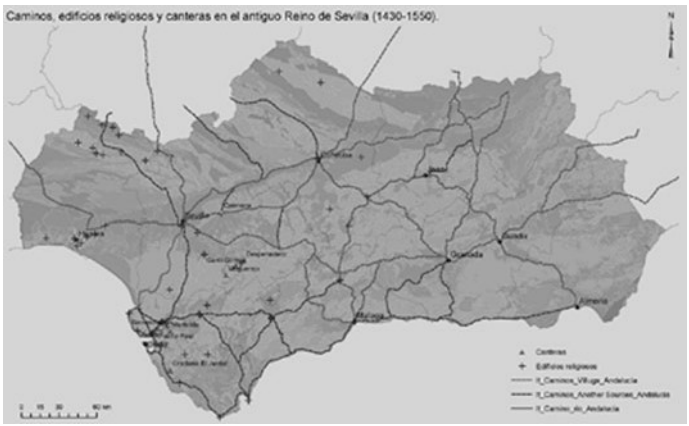

Fig. 4 Digital model of information on the structural organisation of Western Andalusia in the post-reconquest, Late Gothic context. Author Patricia Ferreira Lopes

3 In the Field of Education

With regard to the teaching and learning process of architectural drawing, we have gradually incorporated the contents contemplated in the 2010–2012 syllabus and the common subject programmes taught in the Department of Architectural Graphical Expression at Seville University. However, we do not believe that architectural drawing can be taught in isolation, without reference to the nature of the graphical media used in the teaching process. In other words, the teaching of digital drawing cannot be seen as a mere adaptation of analogue drawing processes to the digital graphical environment, simply choosing between one or the other as a form of acquiring expertise in different techniques. Rather, we have encouraged the integration of the analogue with the digital, so the choice of the graphical tool is not determined a priori but is dependent on the purpose of the graphical constructions proposed.

In previous syllabuses, a subject like Assisted Drawing at the Seville School of Architecture took its name and established its contents exclusively on the basis of the fact that the work was conducted on a computer. It was an urgent response to the need to address the learning and critical knowledge of digital drawing tools which, in the professional realm and even the students' practice, were not contemplated in the syllabuses. At the conceptual level it did not represent a profound alteration because, in general, it was merely the transposition of the processes used in analogue drawing to the digital medium, and almost exclusively to Vector CAD. Even so, some innovations were gained from the increased graphical capabilities: 3D modelling, the dynamic manipulation of volumes and surfaces, and 2D vectors encoded as the final documentation of a graphical process conducted in 3D. In this academic context, only a handful of teaching plans incorporated parametric CAD and BIM, allowing students to experience the material nature of architecture, the potential of parametric creation and editing, and the coordination of the various encoded representations. Therefore, the representation of an architectural organism was not limited to the use of abstract graphical signs like points, lines and blobs, but required a global understanding of the organism and the recognition of each and every one of its building elements and systems.

In light of this experience, our teaching plan for the current syllabus was underpinned by the consideration that it was crucial to stop viewing the digital architectural drawing as a homogeneous set of processes and results, usually associated with digital vectors in CAD programs or, at most, with rasterised digital drawings of renderings. Today, the digital architectural drawing offers a vast repertoire of devices and programs which share a digital nature in common but can nevertheless vary dramatically in their approach to the graphical question. We therefore need to consider how appropriate they are for the various teaching plans and the academic development of students, and also to take an overall view of the role that the Department of Architectural Graphical Expression can play in this.

In this respect, there is a certain consistency between the evolution of digital architectural graphics programs and the objectives, competencies and

teaching-learning processes defined for the subjects taught in this department at the Seville School of Architecture. This consistency is founded on the adaptation of each computer program to the conceptual contents of the subjects, which as a matter of principle avoids any assimilation to a specific course on a given program. Accordingly, we have defined a series of categories for the digital architectural drawing programs and introduced them in what we believe to be the most appropriate year and subject. In any case, we must remember that this is cumulative knowledge and that the use of a specific digital drawing program does not exclude the use of analogue drawing or any other digital drawing programs with which students are already familiar.

In the analytical CAD vector, the graphical objects are defined as independent geometric elements, characterised by their spatial coordinates (x, y, z) and classified with abstract codes (colour, line type, layer) whose meaning is interpreted by the user and which facilitate the logical organisation of the graphical information, visualised using cylindrical or conic projection systems. The geometric dimensions of the architectural form can be specifically addressed with these types of programs, which have the advantages of precision, accuracy without detriment to the support, and the unlimited reproduction offered by the digital environment. We therefore regard analytical CAD to be a particularly appropriate graphical tool for achieving the objectives of the subject *Drawing 1: Geometry and Perception* in the first year of the course.

That same year, as a continuation of *Drawing 1*, we teach *Drawing 2: Expression and Communication*. To address these aspects, we can extend the possibilities of the CAD programs already used since they normally include specific functions for documenting models and generating renderings to explore the visual attributes of architectural forms. This is also an appropriate point to introduce the possibilities afforded by raster image processing programs, either to increase the communicative potential of digital architectural drawings or even as a medium for creating mixed images obtained from digital photographs, digitised analogue drawings and exclusively digital drawings.

We have already described the characteristics and potential of BIM programs, as discovered by our group when they have been used in the field of architectural heritage. We regard their incorporation in the teaching of architectural drawing as particularly appropriate in Year 2, specifically in the subject *Drawing 3: Graphical Analysis*. Year 2 students have already used drawings as a means of representation and have discovered, if only through the name of the subjects, the convergence of concepts that transcend the mere geometric characterisation of architecture. In our proposal, BIM modelling complements analogue drawings, CAD vectors and the processing of raster images, increasing –though certainly not exhausting– the possibilities afforded by analysing architecture with digital graphics. The BIM methodology offers a specific graphical medium for integrating into a single model architectural dimensions such as the environmental parameters derived from its geographical location, its volumetric and spatial attributes, its technotherefore be expressed in alphanumeric tables, and which cannot be measured and require other forms of graphical expression.

The next category we establish are programs that facilitate visual programming environments for parametric design. The graphical entities of BIM programs are parametric objects, but we are referring here to parametric design as a process of computer-aided design in which the graphical entities can be defined according to open variables (parameters) and certain conditions of association between them, expressed in terms of a logical sequence of geometric-mathematical operations. Consequently, a parametric design does not produce just one solution but a range of solutions, as wide as the defined parameters allow. Although initially used to design machines, its applications for architecture are providing a constant source of formal investigation, supported by the ease of connection with rapid prototyping processes and digital manufacturing using numerical control machines. We therefore believe that it would be interesting to explore the unique contributions of these programs in certain architectural conception processes examined in the Year 3 subject *Drawing 4: Conception* (Fig. 5).

The unique teaching experience derived from the *Architecture Workshops*, where teachers of different subjects converge, reinforces the appeal of BIM programs for providing a common platform of graphical integration, without detriment to any other graphical operation or medium that may prove useful. Indeed, logical and building dimensions. It also facilitates discussion about which aspects of architecture are measurable and can this is endorsed by the results of the research experience described above.

In Year 5, the elective subject *Drawing and Machine* is proposed as a synthesis of the relationship between architecture and the digital graphical technologies (drawing with machines), and as a reflection on architecture as a built device that constitutes a complex system (drawing of machines). This synthesis requires the student to re-examine all the graphical resources used, with BIM retaining its pride

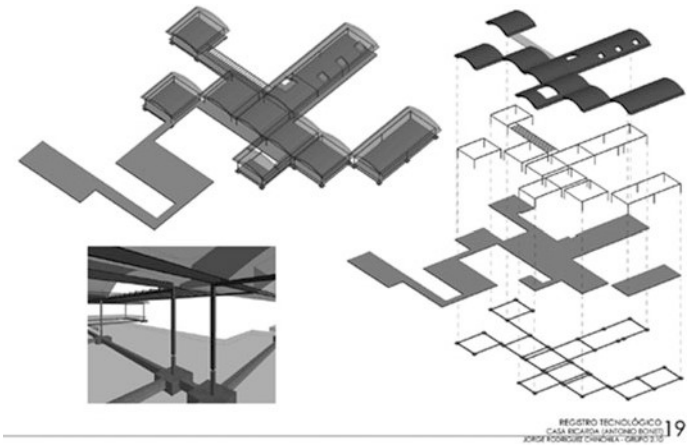

Fig. 5 Exercise in the subject drawing 3 graphical analysis, developed with BIM methodology. Student Jorge Rodríguez Chinchilla. Professor Manuel Castellano Román

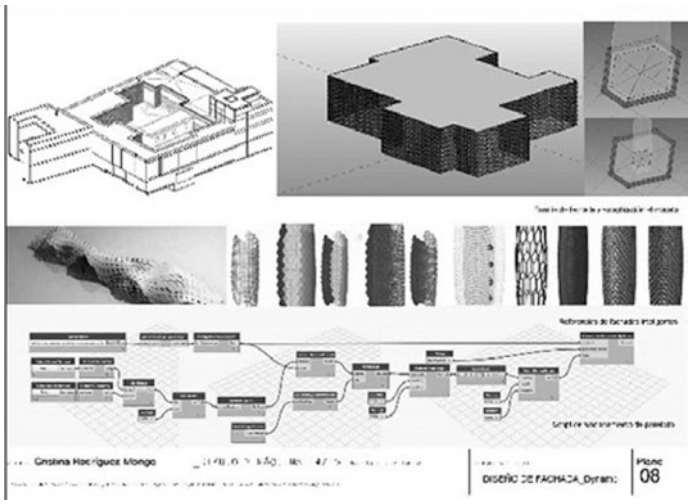

Fig. 6 Exercise in the subject *Drawing and Machine* developed with BIM methodology and parametric design software. Student Cristina Rodríguez Monge. Professors F. Pinto, R. Angulo, M. Castellano, J. A. Alba, P. Ferreira

of place, precisely because of its quality as a nexus. A new characteristic is added in this year of the course: the possibility of generating collaborative work environments and re-thinking the role of the architect in society and in the production of architecture (Fig. 6).

Finally, in *Drawing and Machine* we introduce geographical information systems. When one looks at GIS teaching in architecture schools, it is immediately evident that little work has been done on this subject, and most of it has been focused on teaching the applications of GIS for urban management. Interestingly, the courses developed examine territory in the light of recently gathered data, with alphanumeric information linked to spatial entities providing a fundamental element. The teaching experience conducted at the Seville School of Architecture is focused on developing and augmenting skills for thinking about space in a non-linear and interdisciplinary manner. The proposal consisted in demonstrating the various possibilities that GIS technology offers by examining case studies and conducting practical exercises in the classroom to enable students to create historical theme maps, adding information to their entities and comparing them with the present situation. This entailed viewing the production of territory as the result of different forces (economic, cultural, social) by juxtaposing layers from different periods, which enabled us to merge historical and current data and show students that GIS has applications not only in the field of urban management but also—possibly mainly—in the field of heritage.

4 Conclusions

The use of BIM and GIS systems in the heritage field opens up new avenues for researching and interpreting architectural heritage. In addition to providing systematisation and flexibility, their ability to process vast volumes and types of data mean that not only architects but historians, archaeologists and geographers as well can contribute information from complementary disciplinary approaches, since the BIM-GIS graphical model offers a common medium. In our case, the methodology applied to the context of Late Gothic architecture can be transferred and adapted to other heritage contexts and objects, which in the short to medium term will enable us to extend our field of study, both spatially and temporally.

In relation to the teaching experience with the two systems, the results obtained during the pedagogic intervention and their subsequent systematisation bring home to students the diversity of the records that converge within a work of architecture, and the need to integrate them rationally, maintaining a critical attitude to the mechanical requirements of the system, which must always be underpinned by theoretical reflection. The construction of the BIM model is a way of thinking about that architecture, of creating mental maps. In these maps design can interact with the value and cost of the solutions adopted in real time, which reinforces the responsibility for the decisions made. In the field of GIS, students have learned how to view territory as a dynamic space that lends itself to reflection on the infinite relationships between its elements, be these topological, spatial or alphanumeric. The use of maps, projection systems and GIS databases not only enhances students' repertoire of graphical tools but offers them a new way of thinking about and understanding architecture, from its object-based scale to its insertion in the territory.

Based on these experiences, we therefore propose a transition towards a teaching model that gradually and coherently integrates the analogue and digital across the various modules and subjects that students must complete during their degree course. This will not only enable them to understand architecture as a complex system made up of different elements and attributes, both graphical and alphanumeric, but will ensure that the "graphical" transcends the visual to incorporate heterogeneous types of information.

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Francisco Pinto Puerto He has a degree in Architecture from the Seville School of Architecture (1988) and he was Senior lecturer in the Department of Architectural Graphical Expression at Seville University since 1999. He divides his time between teaching, restoration and research in the heritage field. He is the author of several research works on the art of stonework and its application to stone vaults. He is currently the lead researcher of project HAR2016-78113-R of the National Research, Development and Innovation Programme focused on the Challenges of Society, funded by the Ministry of Economy and Competitiveness and FEDER funds.

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Manuel Castellano Román He has a degree in Architecture from the Seville School of Architecture (1998) and a Master's degree in Architecture and Historical Heritage (1999). He has been an associate lecturer in the Department of Architectural Graphical Expression at Seville University since 2003. He combines his teaching duties with his professional practice, where he is

engaged in new builds as well as architectural renovation. As a researcher, he has undertaken projects related to the guardianship of historical heritage and BIM methodology, currently crystallised his doctoral thesis entitled "The Carthusian Monastery of Nuestra Señora de la Defensión in Jerez de la Frontera: A digital information model for the custodianship of immovable cultural heritage".

José Antonio Alba Dorado He has a degree in Architecture from the Seville School of Architecture. He completed his studies courtesy of the Dragados First Prize 2001/02 for his final year project at the Environmental Research Centre at Isla de las Palomas in Tarifa (Cádiz). He combines his professional practice as an architect with his research and teaching at the Department of Architectural Graphical Expression at Seville University, where he has been teaching subjects related to BIM methodology applied to architecture since 2008.

Patricia Ferreira Lopes She has a degree in Architecture and Urban Planning from the Federal University of Pernambuco in Brazil and the Porto School of Architecture (2009) and Master's degrees in Building Pathologies from the Polytechnic University of Madrid and in Architecture and Historical Heritage from the University of Seville. She has been a trainee teacher and researcher at the Seville School of Architecture since 2014, where she is involved in the R&D&I project HAR2012-34571 and HAR2016-78113-R. She is currently writing her thesis on new digital tools in the field of architecture, territory and society, applied to heritage and based on information technology, GIS and data visualisation.