HEALTHY BUILDINGS: INNOVATION, DESIGN & TECHNOLOGY

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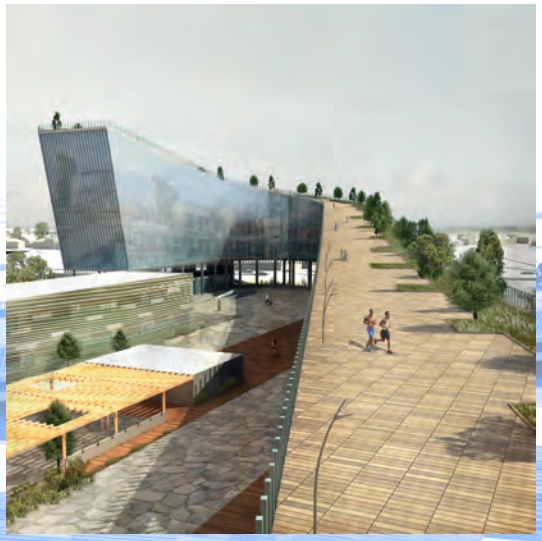

CONFERENCE PROCEEDINGS OF THE 6TH INTERNATIONAL CONGRESS OF ARCHITECTURAL TECHNOLOGY UNIVERSITY OF ALICANTE 12-14 MAY 2016

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International Marjal Healthy Chair

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HOW TO MEASURE HEALTHINESS IN BUILDINGS:

Experiences in teaching with BIM tools

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Abstract. Introducing teaching about healthy solutions in buildings and BIM has been a challenge for the University of Alicante. Teaching attached to very tighten study plans conditioned the types of methods that could be used in the past.
The worldwide situation of crisis that especially reached Spain and the bursting of the housing bubble generated a lack of employment that reached universities where careers related to construction, Architecture and Architectural Technologist, suffered a huge reduction in the number of students enrolled. In the case of the University of Alicante, students' enrolment for Architectural Technology reached an 80% reduction.
The necessity of a reaction against this situation made the teachers be innovative and use the new Bologna adapted study plans to develop new teaching experiences introducing new concepts: people well-being in buildings and BIM.
Working with healthy solutions in buildings provided new approaches for building design and construction as an alternative to sustainability. For many years sustainability was the concept that

applied to housing gave buildings an added value and the possibility of having viability in a very complex scenario. But after lots of experiences, the approved methodologies for obtaining sustainable housing were ambiguous and at the end, investors, designers, constructors and purchasers cannot find real and validated criteria for obtaining an effective sustainable house. It was the moment to work with new ideas and concepts and start facing buildings from the users' point of view. At the same time the development of new tools, BIM, has opened a wide range of opportunities, innovative and suggestive, that allows simulation and evaluation of many building factors.

This paper describes the research in teaching developed by the University of Alicante to adapt the current study plans, introducing work with healthy solutions in buildings and the use of BIM, with the aim of attracting students by improving their future employability.

Pilot experiences have been carried out in different subjects based on the work with projects and case studies under an international frame with the cooperation of different European partner universities. The use of BIM tools, introduced in 2014, solved the problems that appeared in some subjects, mainly building construction, and helped with the evaluation of some healthy concepts that presented difficulties until this moment as knowledge acquired by the students was hard to be evaluated.

The introduction of BIM tools: Vasari, FormIt, Revit and Light Control among others, allowed the study of precise healthy concepts and provided the students a real understand of how these different parameters can condition a healthy architectural space.

The analysis of the results showed a clear acceptance by the students and gave teachers the possibility of opening new research lines. At the same time, working with BIM tools to obtain healthy solutions in building has been a good option to improve students' employability as building market in Spain is increasing the number of specialists in BIM with a wider knowledge.

Keywords: *Healthy buildings, BIM, innovative teaching, project-based learning*

1. Background

Introducing building information modelling (BIM) tools as a vehicle for learning in the study of architecture and architectural technology has posed a challenge for the University of Alicante. The need to adapt curricula to the demands of the construction market has become a priority in order to improve the employability of future graduates. Furthermore, innovative teaching has become a necessity, and the use of tools that facilitate new approaches to concepts that improve the quality of life for the end users of buildings, an obligation.

However, the complexity of the Spanish education system has hitherto presented a barrier to meeting these needs, and over time it has resulted in very rigid architecture curricula characterised by a lack of adaptability to the changes that society has required at various points in time.

1.1. THE HOUSING CRISIS AND ITS IMPACT ON UNIVERSITIES

The Degree in Architecture has traditionally been one of the most popular degree courses on offer due to the almost guaranteed professional openings it provides. Indeed, a number of new Schools of Architecture were created in response to the high rate of construction activity during the property bubble.

However, when the housing bubble burst in 2008, the construction market collapsed and work prospects deteriorated, leading to a fall in the number of enrolments in degree courses associated with this market.

Figure.1. Map of Spain showing the existing Faculties of Architecture. Red circles (12) – public universities established before 2007. Green triangles (8) – Private faculties established before 2007. Yellow circles and blue triangles indicate public (7) and private (6) faculties established after 2007. Construction bubble exploded in 2008, Total 33. (Consejo Superior de Colegios de Arquitectos de España (CSCAE) 2015)

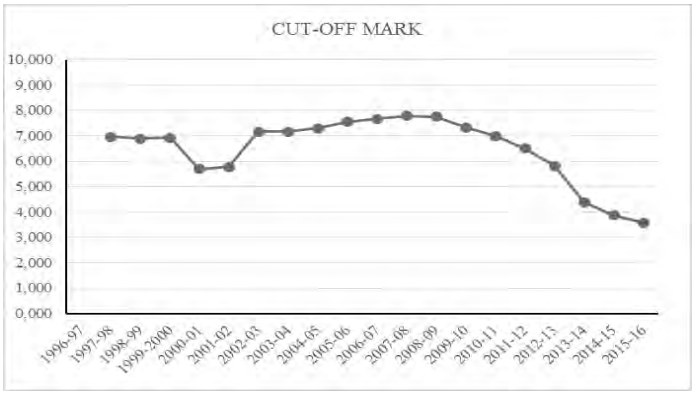

Figure 2. Graph comparing the cut-off mark. (University of Alicante (UA), 2015)

1.2 CRISIS IN THE CONCEPT OF SUSTAINABILITY

Improving the employability of architecture students, and therefore increasing enrolment applications, requires the development of innovative teaching strategies that will provide future graduates with added value and thus facilitate their rapid entry into the labour market.

Providing an expert education in the concept of sustainable construction could a priori represent the most direct strategy that a university could implement. Nevertheless, although the Spanish construction market demands building solutions primarily based on sustainability, economy and clean or zero energy, to name just some of the concepts that could be used as tools to mitigate environmental impacts and assess the sustainability of contemporary architecture (Acosta & Cliento, 2005), sustainable construction has not received sufficient attention in education. The concept of sustainability is grossly manipulated according to the interests of the agent employing it, and the threshold of sustainability depends, among other factors, on climatic conditions and a tradition of adopting environmental policies (Galiano, A, 2013).

The difficulty in carrying out educational activities focused on assessing the sustainability of buildings stems from the Spanish technical building code (Spanish initials: CTE) (codigotecnico.org, 2006), which among its basic documents includes the procedure for assessing the energy performance of buildings and the tools to use for this purpose. A wide variety of scientific studies have reported the ambiguity of these tools and the difficulties entailed in interpreting the results obtained (García Casals, X., 2004).

2. Objective

Consequently, in the light of the situation described above, universities must propose innovative actions that will improve the employability of

their students and provide them with added values that facilitate a more rapid entry into the labour market.

The creation in 2013 of the International Marjal Healthy Chair at the University of Alicante provided the opportunity for conducting novel, wide-ranging research focused on the well-being of building users. The possibility of working on healthy solutions and materials presents itself as an opportunity for student education in a multidisciplinary environment that encompasses the latest technologies in the field of design and construction (Villa and Poblete, 2007).

3. Teaching tool

3.1. DESIGN OF THE ACTIVITY

This educational activity revolves around course work in a subject that forms part of the standard curriculum, and is complemented by two short workshops at the beginning and end of the project. Teaching is complemented with an international competition known as the Healthy Housing Award, in which a jury of teaching staff awards a prize to the best work at the end of the academic year. Thus the award becomes an international and multidisciplinary forum for the exchange of good practices, in which teaching staff and students share the knowledge acquired during the academic year.

3.2. INTERNATIONAL APPROACH

One strategy for improving students' work prospects once they have finished their studies is to adopt an international approach. Many University of Alicante graduates go to work as architects in other countries (Sindicato de Arquitectura (SARQ) 2013), and consequently the exchange of good practices and exposure to working protocols abroad are very useful tools that enable students to learn about work under other conditions. Hence, it is considered of prime importance that the project to carry out

should be located in another country, and that a comparative analysis should subsequently be conducted of implementing an architectural project locally and abroad.

Students' work is enriched by learning about approaches to project execution in three European partner universities, Hogeschool van Amsterdam (HvA), Beuth Hochschule für Technik (BHFT) and København Erhvervsakademi (KEA). Thus, it is not only teaching staff at the University of Alicante who are responsible for the design of the activity: professionals from Holland, Germany and Denmark have also offered their vision of the subject under study.

3.3. CHOICE OF SUBJECT

Work at the University of Alicante on activities related to a building education with added value is not new. The creation in 2007 of the Sustainable Building Awards constituted the start of a relationship between the Marjal Foundation and the University of Alicante in the field of architecture studies. This collaboration is based on a mutual interest in offering society an alternative to the usual solutions found on the property market.

The combination of stagnation in the housing market and a distortion of the concept of sustainability have created a need to rethink the concept of environmentally friendly housing. There is much more to sustainable housing than energy saving. The concept should encompass a broader scope, including people's way of life. Any building that in addition to maintaining a satisfactory relationship with the environment promotes healthy lifestyle habits and enables appropriate relations with the local urban environment and its residents can be considered healthy housing.

Thus, in the light of the experience garnered over four academic years, the Marjal Foundation and the University of Alicante have opted to modify the educational activity by widening the scope of research to encompass healthy building. The activity is now entitled the Healthy Housing Project

and has also acquired an international scope. Modifying the subject taught has entailed the participation of teaching staff from other areas, reinforcing involvement in collaborative, multidisciplinary work.

3.4. PROJECT DESCRIPTION

The project that students are given concerns a detached house with an approximate floor area of 200 m^2. This house must be located in a singular environment and must be adapted to it and integrated within it in such a way that it generates the least possible impact on the environment. Students can choose the site, although they are given a housing development around a golf course in the southeast of the province of Alicante as a possible location. The suggested occupant of the housing is a European citizen who has settled on the Mediterranean coast.

The premise underlying the design process is that the housing must possess healthy solutions that improve the quality of life of the occupants and it must respect the surrounding environment.

4. Working methodology

The proposed methodology has been developed over the course of several academic years, achieving a satisfactory balance in 2014/15. It is based on learning through collaborative work at various levels, on project-based learning and on the use of computer tools such as BIM tools.

This working structure contrasts with the usual approach taken in the curricula, which are normally structured around completely isolated materials, and has been made possible by modifying the curricula and adapting them to the context of Bologna.

The possibility of achieving an award at the end of the educational activity provides an especially important incentive for students. Participation in architecture competitions forms a significant part of the profession of architect. Therefore, tailoring this type of activity to students has drawn their education closer in recent years to the professional reality.

Lastly, providing the collaborative work with an international scope generates a series of advantages for participant students and teaching staff (Cuseo, 1996). Given the need for internationalisation resulting from the crisis in Spanish construction, the possibility offered by cultural exchange of learning in a different climate and cultural environment represents a very attractive added value for students. Learning in a new environment with a different culture and climate is a very valid tool that complements those used in officially recognised architecture studies.

Figure. 4. Tutored work. International groups with teaching staff from different countries.

5. BIM tools

The use of BIM in construction-related work is an unstoppable revolution that has gradually spread throughout Europe, although the degree of implementation is uneven. Greater use is made of these tools in northern European countries than in the south. The use of BIM tools in Spain is

completely new, and there is much demand among university students for courses on the subject.

However, it is difficult to incorporate BIM tools in the architecture curriculum unless they are introduced in the initial years. Sometimes, the complexities entailed in using a computer application mean that a lack of knowledge about its functions limits the acquisition of knowledge.

Nevertheless, the wide variety of tools available makes it possible to select those which are simple to use but very good at delivering results that help students understand the consequences of certain decisions for the final strategy adopted during the design process, thus allowing the educational activity to focus more intensively on the process followed and the final result obtained.

The activity presents useful tools such as the Autodesk programs: Vasari now replaced by Autodesk FormIt, Lighting and Ecotect. In addition, we have obtained good results using the Climate Consultant program. At the other extreme, use of Revit has caused problems due to lack of knowledge about the program, and students have lost valuable time in learning how to perform certain actions (Blanco, 2006).

6. Marks

Consistent with the above, student marks are based on the process followed to achieve the result rather than the final result obtained (Brown and Glasner, 2003). Student marks must reflect a satisfactory balance between the three parts entailed in the project: analysis, implementation and outcome. Thus, an information presentation structure is defined based on the use of three A1 panels that display the required information as described.

7. Implementation of the activity

7.1. FORMAL EDUCATION

The core of the proposed educational activity is course work involving the design of a healthy building in accordance with the project description given above. With the objective of providing students with the knowledge necessary to obtain satisfactory results, we have designed a series of theoretical sessions and some introductory exercises using various BIM tools.

7.1.1 Theoretical sessions

The theoretical sessions focus on different aspects related to the design and construction of buildings with added value, and encompass issues such as the crisis in the concept of sustainability, the design of healthy buildings and the importance of the user in the proportion of architectural spaces.

7.1.2 Exercises with BIM tools

The theoretical sessions are complemented by a series of short exercises using BIM tools. These are based on the use of simple tools that provide a wealth of information. Students are responsible for processing this information and applying it to the exercise in hand.

7.1.2.1 Climate Consultant

This is a free software tool developed by the UCLA that uses climate data files. Once the climate data has been processed, students obtain a climograph showing the comfort zone for that location throughout the year, and a table is generated indicating the extent, expressed as a percentage, to which design and building factors influence this comfort zone. Finally, it gives design recommendations to achieve solutions that allow the building to offer architectural spaces within this comfort zone.

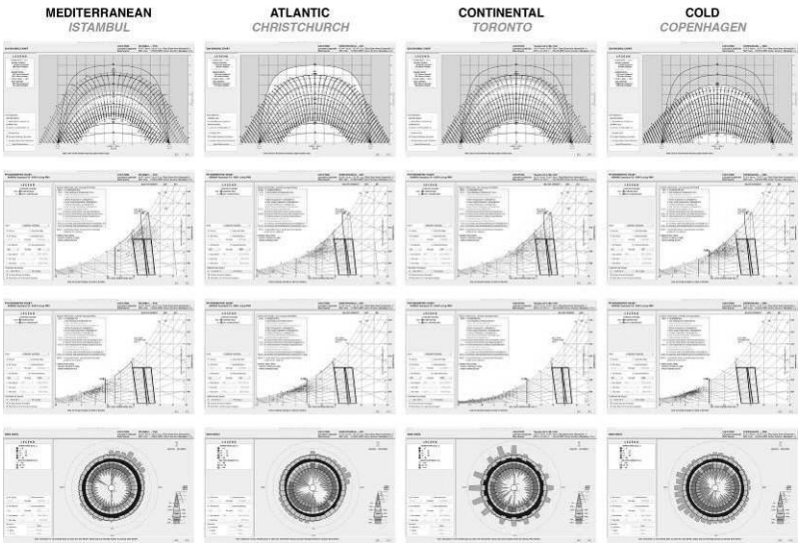

Figure. 5. Tables showing Climate Consultant results.
(Ege Balcil, Jorge Ballester and Jonas Hveen)

One drawback of this program is its simplicity. Students must possess a considerable capacity for critical thinking and abstraction. They must be able to draw conclusions from the results offered and subsequently apply them in their design.

7.1.2.2 Autodesk FormIt 360

This program has been developed as a substitute for Autodesk Vasari. It is proposed as a tool for preliminary analysis of various aspects of building behaviour. Drawing and modelling is very simple, and these phases are complemented with an analysis of sunlight and energy performance. These analyses can also be performed with more complex BIM programs such as Revit, but less time is required to learn how to use Autodesk FormIt 360.

Figure 6. Pictures showing Autodesk FormIt 360 results (Esteban Monteagudo and Ignacio Ramos)

Despite the amount of data that the program offers, its level of performance is not as good as the Autodesk Vasari program. It is an online tool that occasionally does not work properly.

7.1.2.3 Autodesk Ecotect

This is a more complex tool used to assess the comfort of an architectural space. Modelling requires more time, but it yields very valuable data on the environmental comfort of a room in a building or even of an entire building. In this case, students have used it to assess sunlight, indoor daylight levels and cross ventilation behaviour in living spaces.

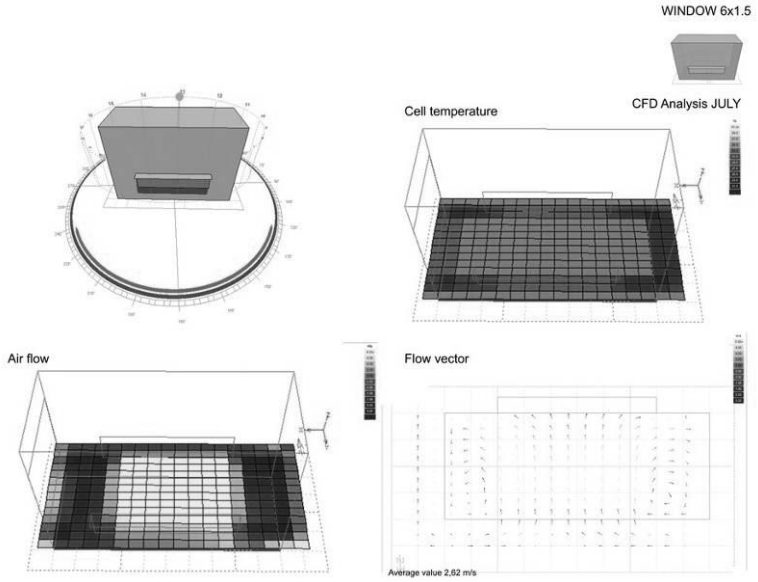

Figure 7. Pictures showing Autodesk Ecotect results
(Pablo Martinez, Eddit Mester and Alicia García)

This is possibly the tool that requires most time to understand how the program works in order to acquire sufficient ability to interpret the results.

7.2. INITIAL WORKSHOP

To complement the teaching involved in each of the subjects and in order to coordinate the tasks to perform, we have designed an international workshop that takes place at the beginning of the semester.

The workshop, which lasts one week, is divided into two parts. The first of these focuses on an analysis of new BIM tools in international groups. Each group consists of one student from each of the partner universities. Once this period is over, students return to their own university group and share the knowledge acquired from the exercises carried out, and then

subsequently apply it to their projects with the possibility of receiving corrections from teaching staff from other universities.

7.3. FINAL WORKSHOP

The educational activity concludes with a final workshop in which all students present their work. Students share and compare their experiences, and discuss the impact that the knowledge of each of the students, which varies due to their origin, exerts on the project carried out. The influence of the tools is highlighted, examining the extent to which they have facilitated or hindered the project.

The workshop concludes with the Healthy Building Awards ceremony, where an international jury decides on the project that has best achieved a healthy solution through the use of BIM tools.

Figure 8. Photo of the awards

8. Results and conclusions

The complexity of the BIM tools used is crucial for the success of the educational activity. The use of very complex programs is only viable

where basic prior knowledge exists. The use of more simple and intuitive tools is more appropriate to ensure a satisfactory learning process. This situation can be offset by teaching the basics of these programs on courses delivered prior to this activity.

The use of BIM tools reinforces project-based learning, and makes it possible to trace the decisions taken during one phase of the project and measure the consequences they have for the result. These tools also make it possible to assess the factors that define comfort solutions and achieve healthy architectural solutions.

An analysis of the results and of student satisfaction questionnaires indicates a high degree of acceptance and motivation on the part of the students as regards participating in the activity. There has also been an increase in the demand from enrolled students for training courses on more complex BIM programs such as Revit.

In sum, BIM tools are being introduced into the curriculum at the University of Alicante, generating a greater level of coordination between subjects than ever before achieved. For future years, we envisage the possibility of implementing collaborative work structures and multidisciplinary projects.

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