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BIM AS A TOOL TO DEVELOP COLLABORATIVE CAPACITIES IN MASTER´S STUDENTS

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***Abstract**. During the last years, engineering projects of buildings and infrastructures make use of a new methodology, based on the 3D simulation of the elements of the project. It is the BIM (Building Information Modeling) methodology. In some countries it is already a common practice in large projects. Europe countries are developing legislation for public initiative projects to be prepared and presented in this format.*

However, in University education the use of these systems is still performed at a low level, perhaps because one of the fundamentals of the methodology is collaborative work, which hinders the individual evaluation of the student. This limitation may be justified in undergraduate studies, of a more generalist nature, but in no way should it be in the Master's, where the student must be trained in a specialized manner and in the latest and most advanced technologies, and also should be able of team work.

For this reason the BETI Innovation Group (Biosystems Engineering Teaching Innovation) of the Technical University of Madrid is trying to implement teaching based on challenges using BIM methodology. The students of different Masters and courses will develop a collaborative engineering project using BIM methodology and procedures. In this way the students develop very diverse competences: collaborative work, organization and planning, leadership, management of ICT technologies, non-verbal communication, etc.

Master students must organize themselves following the professors' guide to jointly achieve the challenge of developing a project that the professors propose to them. As many challenges as necessary will be proposed, so that 10 to 20 students collaborate in each project.

Students will be assigned roles and tasks, following the guidelines of the professors, will establish their deadlines and milestones, which must be met so as not to harm others. The project will cover a complete academic year, since in one of the Masters the students will work on the project in two courses, one belonging to the first semester and another to the second semester. The grades will be based on the work done by the students, not being so important the final result.

The BIM methodology allows building the virtual model with different levels of development (LOD), which makes it easier for students to work on this model in diverse courses with progressive specialization..

Keywords: 3D objects, collaborative work, Challenge Based Learning, team work, Collective intelligence

1. Introduction

In the last few years, engineering projects comprising buildings and infrastructures have been developed using a new methodology, based on the 3D simulation of the elements of the project. It is the BIM (Building Information Modeling) methodology. In some countries it is already common practice in large projects. In Europe most countries are incorporating legislation for public initiative projects to be presented primarily in this format (Porwal & Hewage, 2013).

However, in University education the use of these systems is not as common as should be, perhaps because one of the fundamentals of the methodology is collaborative work, which hinders the individual evaluation of the student and partly its integral formation. This limitation may be justified in undergraduate studies, of a more generalist nature, but in no way should it be in the Master's, where the student must be trained in a specialized manner and in the latest and most advanced technologies (Wu & Issa, 2013; Sacks & Pikas, 2013).

For this reason, a group of professors from three Schools of Engineering at the Universidad Politecnica de Madrid (Spain) have decided to join the BETI Innovation Group (Biosystems Engineering Teaching Innovation) to implement teaching based on challenges and 3D reality so that their students can develop a collaborative project of engineering using BIM methodology and procedures. In this way the students develop very diverse competences: collaborative work, organization and planning, leadership, management of ICT technologies, non-verbal communication, etc. (Clevenger et al. 2010, Singh et al. 2011)

BETI research group have made some previous contributions to the advance learning on projects for engineering studies (Garcia et al. 2009, Fuentes et al. 2011, Fuentes et al. 2014)

Therefore, the immediate purpose of the project is to develop the guides and the teaching material necessary to help the students in the achievement of the challenges, prepare the computer systems for the development of the challenges, obtain the licenses that were necessary and prepare the first challenges for next academic year, so that this teaching could be implemented at the beginning of the next academic year. Upon completion of the project, a first evaluation based on student surveys on the opportunity and acceptance of the experience could be made.

The ultimate goal of the project is to get the students of five different Masters of three engineering Schools (Design Engineering, Building and Agricultural Engineering) to become familiar with the BIM methodology, through a teaching system based on challenges, in which they develop some competences: collaborative work, organization and planning.

2. Methodology

The objectives of the project are:

- Prepare challenges for the collaborative learning of the students of five University Masters of three UPM Schools using the BIM methodology
- Prepare the teaching material and the necessary aids so that the students can successfully develop the challenges.
- Start in the next academic year this new learning methodology and make a first evaluation at the end of the project.
- That Master students become familiar with a new and emerging technology, essential for their professional future
- That students improve their skills in collaborative work
- That students improve their skills in organization and work planning
- That students improve their skills in the use of ICT technologies and non-verbal communication

- That the students know the competences and knowledge of their classmates from other degrees and collaborate with them in a common challenge.

Masters' students of the different degrees and Schools participating in the project, must organize themselves following the professors' guide to jointly achieve the challenge of developing a project that the professors will propose to them. As many challenges as necessary will be proposed, so that 10 to 20 students collaborate in each project. Considering the present number of students, three challenges are intended, starting at different levels of definition.

Students will be assigned roles and tasks, following the guidelines of the professors. They will establish their deadlines and milestones, which must be met so as not to harm others. The project will cover a complete course, although in one of the Masters the students will work on the project in two courses, one in the first semester and another in the second semester. The grades will be based on the work done by the students, not giving so much importance to the result itself. A rubric will be developed for each challenge, considering the different starting level.

The BIM methodology allows building the virtual model with different levels of development (LOD), which makes it easier for students to work on this model in diverse courses and progressive specialization.

The Masters and subjects involved are:

In the School of Agricultural, Food and Biosystems Engineering:

- Master's Degree in Agricultural Engineering
  - Course: Project engineering (1st semester, 30 students)
  - Course: Construction and Rural Infrastructures (2nd semester, 30 students)
- Master's Degree in Agricultural Systems Engineering
  - Course: Projects in Agricultural Systems Engineering (1st semester, 15 students)
  - Course: Structural design of buildings in Agricultural Systems Engineering (1st semester, 5 students)

In the School of Industrial Design and Engineering:

- Master in Industrial Design Engineering
  - Course: Eco-efficiency and eco-innovation (2nd semester, 40 students)

In the School of Building:

- Master in Technological Innovation in Building
  - Course: Research and innovation in Building (1st semester, 20 students)

The project will be developed in five phases, planning of the challenges, generation of supporting documentation, verification and adjustment of the necessary tools, implementation of the experience in the first semester, preliminary evaluation of the experience with the first participating students.

The actions will be the following:

1. Approach of the challenges. The first action will be the search for information about similar or applicable experiences of other universities or institutions. There will be meetings of the professors of the subjects to propose an initial draft, defining object, capacity, location, levels of detail in each phase and deliverables. This draft will be discussed with some students from previous years and their representatives. A final meeting will be held with the coordinators of other subjects or the academic commission of the degree as the case may be.

2. Generation of supporting documentation. The existing documentation that may be useful for students will be consulted. Those documents that do not exist and are considered necessary for the students to carry out their work will be produced by the professors. All this documentation will be available in a Moodle space of each of the courses involved.

3. Verification and adjustment of the necessary tools. The group of professors will discuss the needs for the development of the experience, classified by different levels (admissible, desirable, optimal...). An inventory will be made of the software and hardware available for the different degrees and a strategy of acquisition or shared use, always considering the possibility of free software if it exists.

4. Implementation of the experience in the first semester. The academic guides will be adjusted to include this experience. The evaluation rubrics for each of the courses will be modified to incorporate what is related to the experience. A presentation of each course will be prepared to explain to the students the details of their work.

5. Preliminary evaluation of the experience with the first participating students. Two surveys will be prepared before the start of the semester - the first to be delivered before the start of the course to find out the level of BIM knowledge and basic tools by the students. A second survey will be developed to deliver to the students before the end of the project and to check the degree of satisfaction with the experience and the problems detected in this preliminary phase.

3. Results

The implementation of such an ambitious project has faced many difficulties and issues that should be considered by other professors trying to go the same path. The first difficulty is to integrate existing programme of studies, changing some courses or adding new subjects. Even when all the professors of the courses were involved in the proposal and made a compromise in that sense, it cannot be avoid that coordination and administrative rules should also be taking into account. For these reasons in the first project meeting was decide that the implementation of the project would be made progressively.

For example the Master's Degree in Agricultural Systems Engineering was planned to be approved by the Spanish government in March 2018, but was delayed until July 2018, so it was decided by the University to postpone the beginning of the courses to September 2019. For our project this meant that one of the Masters and two courses would not be available.

On the other hand the Master in Industrial Design Engineering and the Master in Technological Innovation in Building found difficulties to implement so quickly these teachings and asked for more time. So, eventually, it was decided to start only with the Master in Agricultural Engineering, see what happens and incorporate the other Masters in the next academic year. That was not the aim of the project and compromise one of the objectives, multidisciplinarity, but considering the different bachelor background of the students of this Master it could be acceptable as a first step.

After a search on previous similar experiences in other Universities and having conversations with the professors involved, it was clear that a number of at least 10 to 15 hours contact teaching were necessary to give the students enough basic knowledge of the BIM methodology and tools.

The next decision was to use commercial software, because the University could provide student licenses for free, and a number of self-learning tutorials were available for students. The University promotes the use of open sources in all software tools, but in this specific area this option was not possible.

A set of nineteen guides for the students were developed during summer for the use in the teaching sessions and as didactical material.

It was also decided that there will be three challenges for the students (a group of around forty students). Each of them (a winery, a pig grower farm and a greenhouse) would be at a different start level. In the case of the greenhouse the students would begin from scratch, in the case of the pig grower farm, the students would have the sketch, and in the case of the winery they would have a BIM project.

Each group of students would be composed with members with different Bachelor backgrounds, crop production, animal production and food engineering and incorporating students with knowledge of structures and facilities. From this moment they will have to organize the tasks, roles and time schedule.

Evaluation of the work will be made base on the differences from the beginning to the final project, the compliance of deadlines and partial deliveries and the level of team work detected by the professors, interviews and questionnaires.

At the moment of preparing this paper we are starting with the experience and no more results can be shown but even at this initial stage some conclusions can be proposed.

4. Conclusions

The project is at the first phase and only few conclusions can be presented. Nevertheless we consider them interesting for the readers and the conference assistants:

- It is possible to combine different programme of studies to develop a collaborative common project, but it should be considered that many issues and difficulties can arise, and be flexible with the time to implement the whole thing.
- It is important to prepare common didactical guides and select common software.
- At this moment the use of commercial software simplify very much the work and its preferable when possible
- In Spain, even at the Master level in a technical University, the students have a lack of tools relative to BIM projects, and some classes must be used to get them to the initial level.

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