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PROJECT-BASED LEARNING: APPLICATION TO A RESEARCH MASTER SUBJECT OF THERMAL ENGINEERING

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Abstract

The European Higher Education Area (EHEA) requires students to engage in more autonomous work. This autonomy is an outcome of the self-regulated learning process. Self-regulation involves a self-management skill set that can cope with any adverse contingency and requires both knowledge of the available abilities and personal control to put these skills into action. Learning the self-regulation process is a critical step in developing competences that enable the transformation of mental aptitudes into academic competences. However, it is necessary to modify the learning conditions to achieve self-regulation in an adequate way. Thus, the academic authorities should empower skills that facilitate autonomous learning and contribute tools to student proactivity. In this regard, problem-based learning is an effective method to facilitate the acquisition of transversal competences. This didactic methodology may be performed in terms of the individual or team-based learning (TBL) that is necessarily linked to a teaching-learning open system. An adaptation of Project – Based Learning (PBL) to the thermal engineering studies, i.e., the project-based learning model, was designed for the Research Master subject of 'Building Energetic Efficiency'.

Keywords *– european higher education area, project based learning, autonomous learning, transversal competences*

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1 INTRODUCTION

Measuring students' work is a key metric in determining the design of academic planning. The amount of work that a student has to perform to meet the objectives of the academic planning is measured objectively by the European Credit Transfer System (ECTS). The ECTS includes all of the theoretical and practical training that students should complete to achieve competency for their future professional status. Overall, three curricular models are distinguished: traditional, problem-based and system-oriented (Hernández & Lacuesta, 2007; Heylings, 2002).

The concept of 'problem-based learning' (PBL) can be defined in a variety of ways. Richard Felder, Howard Barrows and Ronald Woods, who were involved in the early stages of PBL development at McMaster University (Canada), defined this concept in terms of an active methodology that, along with knowledge attainment, facilitates the acquisition of several transversal competences such as team work, search and selection of information and synthesis and analysis abilities (Barrows, 1984; Felder, Woods, Stice & Rugarcia, 2000; Tseng, Chang, Lou & Chen, 2013). Learning is managed through the presentation and problem-solving of a complex task, i.e., a project, that is related to a future professional activity. It is not difficult to implement this methodology in engineering studies as a consequence of the methodology's applicability. Nevertheless, because students are not familiar with teaching-learning issues, it is necessary to establish clear steps to follow

early in the project-based learning process. PBL is perhaps one of the most ambitious options for promoting the development of competences in most tasks (Woods, 1996). Projects may be incorporated into a course in a variety of ways (Prince, 2004). Unlike other teaching-learning methods, the PBL methodology poses a problem (and/or project) before the students have acquired the knowledge needed to solve it (Dym, Agogino, Eris, Frey & Leifer, 2005). Once a project has been posed (or designed by students), different methodologies may be used to solve the problem: lecturing, instructor-facilitated discussion, guided decision making or cooperative learning (Garcia-Robles, Diaz-del-Rio, Vicente-Diaz & Linares-Barranco, 2009; Hsieh & Knight, 2008; Jaeger, Mayrhofer, Kuhlang, Matyas & Sihn, 2013; Rodrigues, Kuri & Casale, 2012; Steinemann, 2003; Stoll, 1996; Yadav, Subedi, Lundeberg & Bunting, 2011). 'Building Energetic Efficiency', a subject that belongs to the Thermal Engineering Research Master and consists of four ECTS credits, is taught in the second semester. This optative subject has an average of ten students per session. For the next academic year (2013-2014), a new project-based methodology plan will be established to fit this subject into the new demands of the EHEA. This methodology was implemented in other subjects in engineering studies (Villarroel & Herrera, 2004; Urraza & Ortega, 2009; Vasileva, Tchoumatchenko, Lakkala & Kosonen, 2011; Yasin, Mustapha & Zaharim, 2009; Zhou, Kolmos & Nielsen, 2012). The low number of students in this subject allows for an individual follow-up and the detection of potential deficits of the methodology, which may be critical for the continuous improvement of the teaching-learning process.

2 DESIGN/METHODOLOGY/APPROACH

2.1 The development of a project-based learning methodology

The implementation of a project-based learning methodology may cause difficulties for both students and teachers because of the change in roles compared with traditional learning (Stewart, Mast, Gross, Pellegrino & Rodriguez, 2013). Thus, the student has to play a leading role while the teacher performs a directive and supervisory role in the learning process. Contrary to what is presumed, the new role portrayed by the teachers is more complex and requires greater skills than does the traditional learning system (Hosseinzadeh & Hesamzadeh, 2012). Therefore, the teacher has to increase his knowledge of the subject to teach skills such as group dynamization and supervision, management of new technologies and leadership ability.

This learning strategy allows students to develop new skills to supplement their training and coaches them for their future professional performance. Figure 1 shows a scheme with the transversal and specific competences of the subject teaching guide. According to the Tuning project, project-based learning also stimulates other skills such as team work, researching capability and self-regulation (González, 2003).

The pedagogic aims of the project-based learning are as follows:

- To promote a strong theoretical basis of supervision and analysis for saving energy in buildings.
- To develop work schemes for an energy audit in buildings.
- To manage scientific searching tools and meet the requirements of scientific journals.
- To acquire other competences such as initiative, teamwork, communication, multidisciplinary focus, self-regulation, and compromising.

Considering the number of students enrolled in the master's program in previous years (an average of 10 students per year), three working groups are required. Each working party (3-4 students) should develop and report a unique and original project. The projects may be proposed by the students or selected from lists set out in a virtual platform. In this study, the instruction method selected was cooperative learning. The reason for selecting cooperative learning methodology was to ensure that the students would acquire the competences contained in the syllabus (Figure 1).

At the beginning of the subject, the student receives information about the group's working techniques: conflict resolution and management, group goal setting and effective communication. At the subsequent working session, the academic methodology is introduced to the students. A role-playing technique is used to recreate a professional context in the field of energy efficiency consulting, in which the students serve as engineers and the teachers as customers. In addition, role-playing techniques are used to encourage student participation. Subsequently, the tools to be used for the group's follow-up are detailed to the students as follows:

- Project folder: the project folder hosted at the virtual platform collects all of the project information.

- Project follow-up: weekly group meetings, project progress, register of individual dedication time, individual responsibility and task registration.

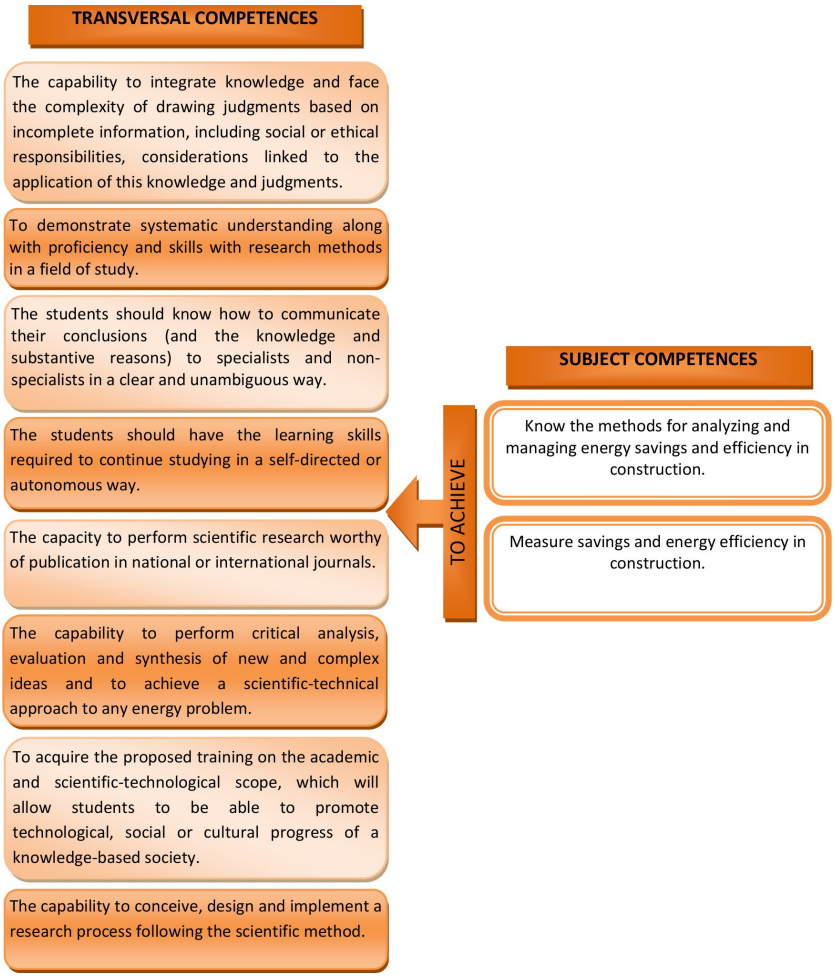

Figure 1. Transversal and specific competences that will be developed following a project-based learning methodology

- Group norms: each group is encouraged to establish its specific functioning rules, especially those for conflict management and resolution.

Each project is described by a file summarizing the objectives, materials to use and the teacher's and students' weekly workload. Thus, the teacher, besides giving the material to the students, should spend time giving detailed definitions of unexplained issues during theoretical classes. Keeping in mind the initial information of each project, the groups can freely choose from among these issues For example, a project could be as follows:

Energy audit of a resort with the following objectives:

- Optimization of the energetic consumptions and costs.
- Diversification of the energy sources.
- Introduction of an energy management system under the UNE 216301 rule.

Moreover, each group should provide a paper review of the state-of-the-art in energy efficiency in buildings. This review will familiarize the students with database management and with locating scientific knowledge in journals. The maximum length and format of the project will be provided by the lecturer beforehand. The final report of the project, together with a daily record of the group's activities (e-portfolio), must be delivered to the teacher during the last week of the semester. The e-portfolio will contain the documents used during project development. The documents will be classified and archived at folders located in the virtual platform, which will allow the teachers to analyze and evaluate the group activities effectively. Additionally, this report will be presented and defended by the group during class in front of the teacher and their colleagues. After the

public exposition and defense are completed, the project will be assessed. For the evaluation, the teacher will assess both group and individual performances. In complement, each student will provide a self-evaluation and a co-evaluation of their peers, i.e., an evaluation of each member of the group. As a result of this participative evaluation, self-criticism and teamwork abilities will be empowered to the students (Rizo, 2004).

It should be noted that the project-based learning requires more resources than does the traditional method. For example, physical space will be provided for the teacher assistant and group meetings.

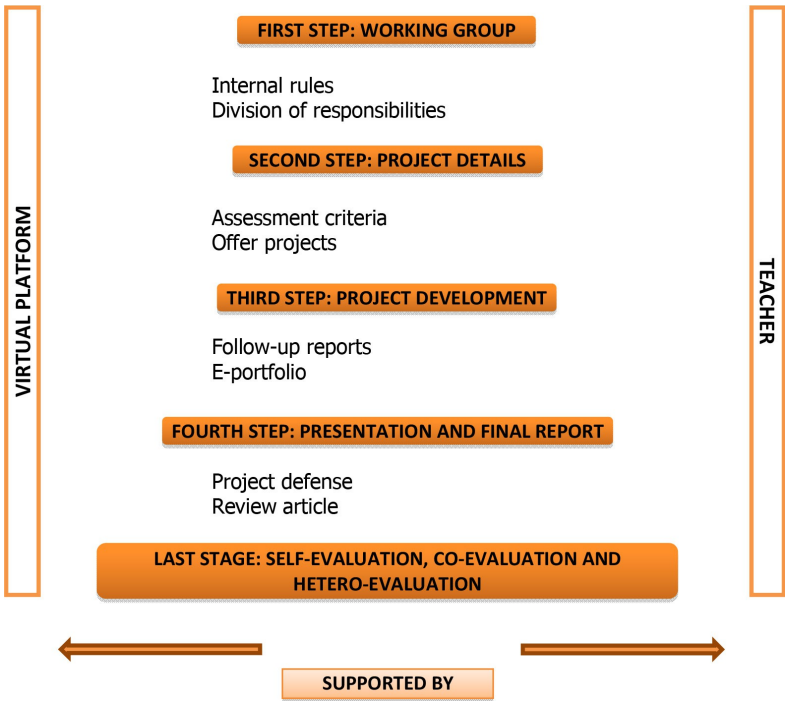

Figure 2. Proposed methodology scheme

The assessment of the subject is performed based on the syllabus for the subject (Table 1)

Evaluation	***Description***	***Percentage***
Development test	*Written test*	*20*
Projects	*Project exposition and defense*	*30*
Systematic observation	*Continuous evaluation*	*50*

Table 1. Evaluation

To check the effectiveness of these new tools, the academic results were analyzed (Table 2). As far as the academic results are concerned, no significant changes are expected. As observed in the table, in the 2012-2013 academic year, an increase of 15.06% in average score was achieved over the previous academic year. It is important to emphasize that in the 2012-2013 academic year, none of the students left the course.

Academic year	***Number of students***	***Average score***	***Description***
2012-2013	*10*	*8,40*	*All enrolled students passed the course on the ordinary examination*
2011-2012	*8*	*7,63*	*One student left the course.*
2010-2011	*9*	*8,33*	*All enrolled students passed the course on the ordinary examination*
2009-2010	*10*	*7,00*	*One student left the course.*

Table 2. Academic results

The academic results suggest that the use of PBL combined with other tools (e.g., e-portfolio, rubric) may facilitate the teaching-learning process. Nevertheless, the small sample size means that these findings must be treated as preliminary results. The standards used to assess each project were the same as in previous years, and it is therefore necessary to modify them to adapt to the PBL methodology.

To facilitate self- and peer-evaluation, a rubric was designed (Table 3). The rubric allows students to evaluate the quality of the task in a transparent and objective way (in this case, a project) because the rubric helps clarify the teacher's expectations while reducing the assessment time.

Continuous evaluation by the report, exposition and defense of the project (Classmates' report).		***10%***
Competence	***Descriptors***	***%***
Written and oral communication	*Distribution of the presentation time* *Correct, concise and exact answers to the questions*	*5%*
Quality of the work	*Technical language* *Clear and concise drafting*	*5%*
Continuous evaluation by personal monitoring (self-reports).		***5%***
Competence	***Descriptors***	***%***
Compliance of deadlines and guidelines.	*Analyze any significant deviation from the guideline.*	*2.5%*
Quality.	*Well-structured work* *Work involvement*	*2.5%*

Table 3. Assessment rubric of the project exposition and defense

The remaining percentage of the evaluation (15%) will be assigned by the teacher. It will be necessary to reach a minimum of 10%. The competences evaluated will be written and oral communication skills, motivation for quality, problem-solving ability, and other aspects to be determined by the academic tribunal.

It should also be noted that teachers encountered difficulties when designing the project list because designing and applying the problem-based learning methodology requires more resources and better planning than do traditional teaching-learning methods.

3 CONCLUSIONS

Per the EHEA, new didactic methodologies are required to cope with new demands for education. Therefore, project-based learning has become an ideal method to anticipate future professional practice for training engineers. Undoubtedly, the implementation of this teaching-learning methodology into a subject requires a great investment of time and effort and the subsequent actualization of the subject's program. Nevertheless, implementing the project-based learning guarantees the acquisition of the competences recorded in the subject teaching guide. Moreover, the three-way evaluation, in terms of self-, hetero- and co-evaluation, provides added value to competence assessment. Hence, the student evaluation will gain reliability. Finally, this procedure facilitates the learning of self-regulation by the students and the analysis of the strengths and weaknesses of the training program.

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