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Consolidation of an EV Project Based Learning program integrated within a complete Bachelor Engineering Degree

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Summary

After several year organizing an EV racing team with engineering student to participate in competitions a more ambitious innovative educational program has been developed. It enrols every year freshmen students from all the Industrial Engineering Grades of our University and integrate them within older students from previous years in a process that involves the design, optimization and testing of Electric vehicles. Specific activities are combined with tasks, homework and specific projects from several corner-stone courses of the degree that are adapted to this environment. It is also an opportunity to participate in activities that are not common for many students: international EV conferences, congress and competitions. Overall, they achieve better qualifications and develop more competences than conventional students.

Keywords: light vehicles, education, efficiency

1 Introduction

Engineering studies suffer a high dropout rate in their first years. Although there is not a single cause for this problem, some studies [1] show that there is a lot of responsibility in the contents studies in the first courses, which are common in all the engineering degrees of the European Higher Education Area (EHEA)

This degree is composed of basic science subjects that are the structure of all the technological discipline. On the following courses, subjects more related to concrete engineering appear but, often, they are treated independently. This create in the student a disjointed perception and a poor understanding of their utility [2]. In many cases, student who pass the second course has not yet faced real multidisciplinary engineering problems. This type of perspective is not usually reached until the last course of the degree or even until the development of the work of end of degree. Experience shows that a significant number of students lose their motivation before reaching this level, with the consequent abandonment of studies.

Some authors [3] [4] propose the development of project-based teaching (PBL) and, in particular, cornerstone courses. The methodology of these courses, in this context of EVs, propose to the students a

design problem of systems related to a vehicle whose solution requires of different disciplines. The project extends throughout several courses so that the student can apply all the knowledge that is acquiring to solve it.

2 Methodology

This work shows an experience of a continuous learning group program developed in the Technical School of Industrial Engineering of the University of Málaga were newer students of first courses of several degrees are included every year replacing those who finish their studies. The basic idea of this project has been used from long time ago in engineering studies [5] but they are being adapting and improved with newer teaching techniques, the use of TICs and improved mobility options. The main content of the experience presented is the design, manufacture, analysis and optimization of an experimental electric vehicle. See figure 1.

The development of this activity requires the application of most of the technologies of the industrial engineering: electronic, automatic, structures, fluids, mechanics, energy, graphic expression, manufacturing, projects,…. It breaks with the conventional teaching concept that separate departments for the study of engineering disciplines [6] and promote an integrative focus "to foster a culture of engineering design and multidisciplinary problem solving throughout the curriculum" [7]. We focus on showing the relationship between these areas and how the choices made in the design (for example, the chassis as seem in figure 1), directly influence the rest of the vehicle elements: engine, aerodynamics, … (see figure 2 and 3)

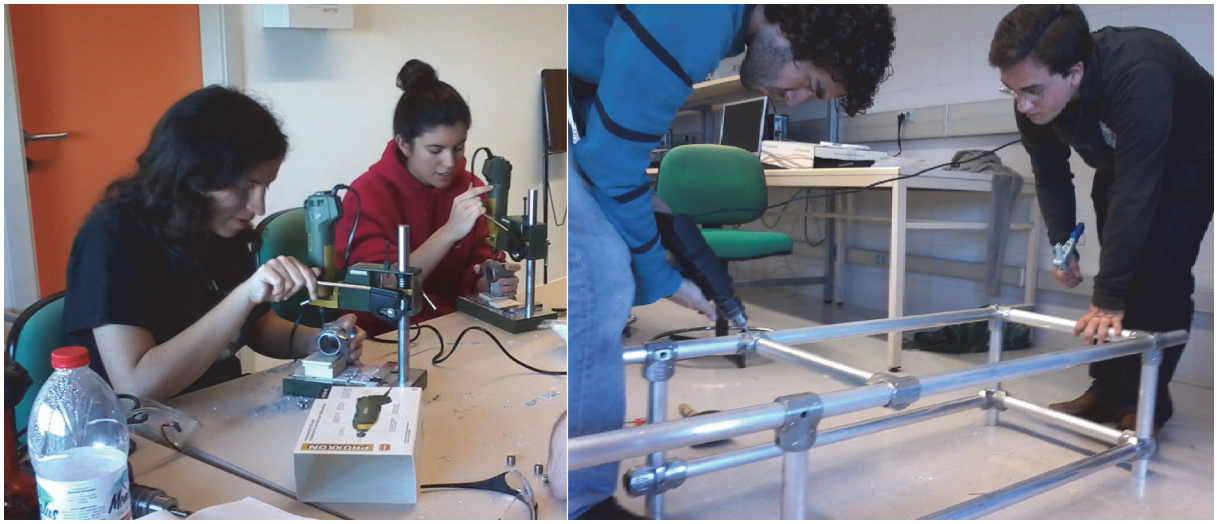

Figure1: Student developing their design of the chassis of an EV

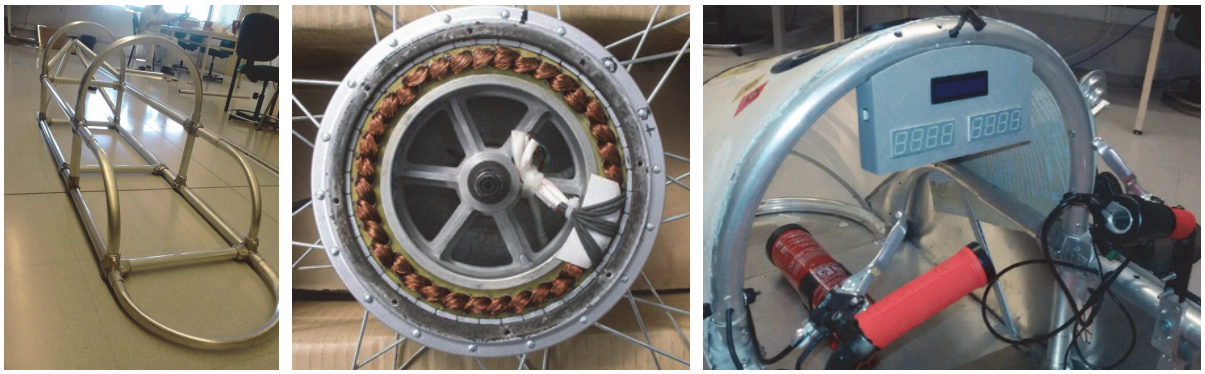

Figure2: Multidisciplinary view of a LEV. From left to right: mechanics, electric engines, electronic control, …

Figure 3: Unified view of the inside of a LEV

The project is not developed on any particular subject or degree; it goes in parallel to the official courses where several specific tasks, homework and projects are adapted to be integrated with the activities being developed at that time with the vehicles.

To participate in the project there is a previous selection of students. An extension course about basic aspects of light electric vehicles is offered every year and among the students who finish the free positions are covered. The first group (academic year 2011/2012) was formed with 26 students. This year we are working with 25 of them and the prescription for the initiation course has reached the 52 application. Consequently, this methodology has manage to obtain a good reputation among our environment of engineering students.

They are divides on 5 basic groups with 5 members and one alternative leader. They are specialised in some particular aspect of their studies and work with a specific tutor that guide them starting new activities and solver their doubts and technical and organization problems: Energy sources and storage systems, engines & power distribution, mechanical structures & aerodynamics, electronics and project management. These are not excluding groups as they are expected to interact and help each other with the most complex tasks.

Another important aspect of the project is the collaboration with companies from the local industrial environment of our university. The experience has been developed in close collaboration with companies that provide materials, equipment and installations and laboratories where manufacture and test some parts of the chassis and the body of the vehicle developed by them.

3 Results and conclusions

The deep evaluation of the results of the project is generated based on qualitatively and quantitatively indicators. At the qualitative level, we take into account the individual degree of satisfaction of students with the project. I was not necessary to perform a survey test, as they are a small group of persons and there is a continuous contact for more than three years. The feedback of students' opinions about all the important aspects of the program are expressed in periodical review meetings, and the participation and evaluation is, in most of the cases, high or very high. Students emphasize the high degree of practicality of all the activities they carried out. The developed model "from practice to theory", in which the students have installed and tested components in the vehicle without having to know its theoretical basis has shown that it reinforces the motivation to study later that theory. In general, these students achieve better qualifications on the courses of the degree and develop more competences than conventional students do.

In practice, we record a great involvement of the students in the whole phases of the project, mainly in the design and manufacture of the 4 full vehicle developed up to this moment (see figure 4). The motivation has been generally very high and participation in competitions or any other activities external to the

university add a lot of valued to the experience. Quantitatively, all these vehicles that they have design and built passed very demanding tests of safety and reliability to successfully participate in the competitions selected (see figure 5). This tests measure the quality of the work performed.

The dropout level of the program is low. We have accounted 8 cases along the 5 years that last the program since its beginning. On the other hand, 18 end-of-grade works have been read up to this date, 6 of which have evolved to publications in congresses such as [8] (see figure 6) or [9]. One of these works won the second prize of the Renault Foundation for Sustainable Mobility in 2015.

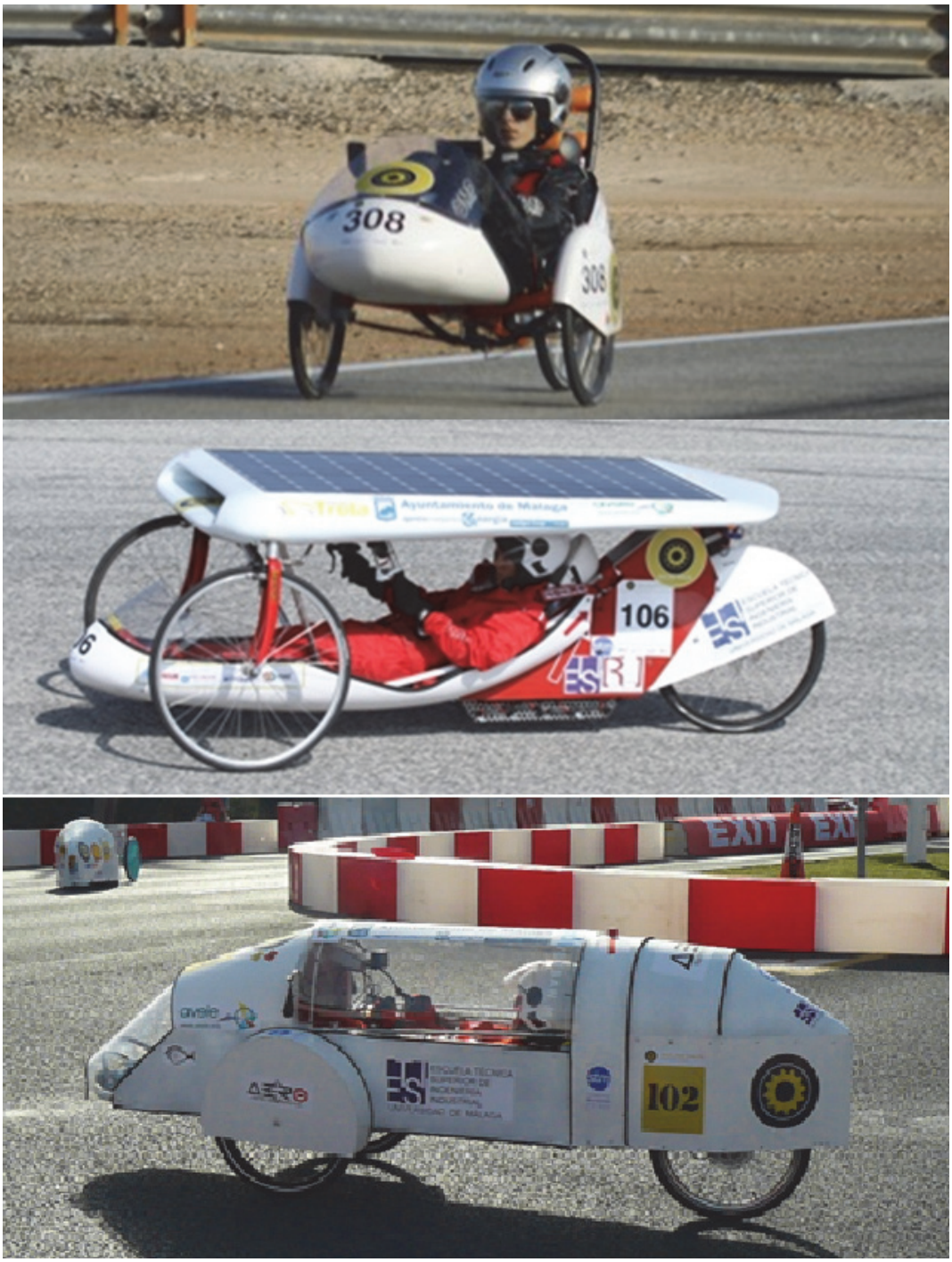

Figure 4: Three EVs designed and built by the students of this learning program

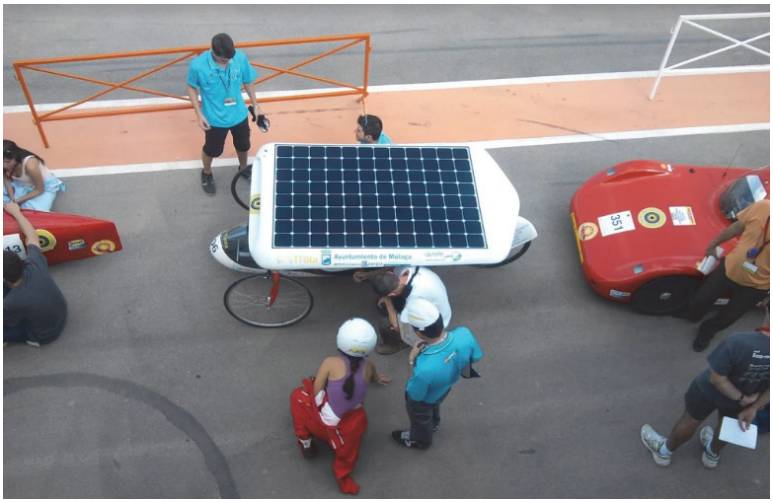

Figure 5: The LEV team in action in the Mucia Solar Race 2014

Figure 6: Three students of the program at the fist conference attended: The EVS27 in Barcelona (Spain)

However, the project is in a constant evolution, adapting itself to the need of the students and professor that are being added. The main aspects being improve in the course are the systematization of the training plan of the students, to establish a more specific and better organized operating structure and to raise more stable fund sources to buy specific manufacturing machinery and to send more students to international conferences and EV competitions.

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