THE MOTOSTUDENT PROJECT AS AN EXAMPLE OF TRAINING IN MECHANICAL ENGINEERING BASED ON COMPETENCES, INTERDISCIPLINARITY AND COLLABORATIVE STUDENT WORK

Juan Carlos Fortes-Garrdio[1]*, Miguel Ángel García Romera[2], Juan Manuel Enrique Gómez[3], José Miguel Dávila Martín[4], Montserrat Hidalgo Hidalgo[5], Belén Fortes Hidalgo[6]

[1]Dr. University of Huelva, SPAIN, jcfortes@uhu.es
[2] Mr. University of Huelva, SPAIN, miguelangel.romera@alu.uhu.es
[3]Dr. University of Huelva, SPAIN juanm.enrique@diesia.uhu.es
[4]Dr. University of Huelva, SPAIN jmdavila@dimme.uhu.es
[5]Dr. University of Huelva, SPAIN hidalgo@denf.uhu.es
[6]Ms. University of Huelva, SPAIN, belenfortes_96@hotmail.com
*Corresponding Author

Abstract

This paper presents an educational experience developed in the fourth year of Mechanical Engineering degree at Huelva University (Spain). The object is to participate in a motorcycle championship in order to develop the direct application of knowledge and skills required in the classroom. A new educational project is presented, based on an inter-university championship, developed over three semesters. It consists of designing and constructing a motorcycle racing prototype of category M-3, with a regulation similar to that of the World Championship. Students also have to present and defend the business project that involves the construction and sale of 500 units, with technical and economic constraints imposed by the organization.

Current education involves a deep exercise of thought about teaching-learning method, because the student must be the basis and a greater effort is needed. We apply novel educational methodologies in order to achieve lasting and meaningful learning, with a more innovative teaching and interactive methods that produce in the student the search for information. Taking this premise as our starting point, the MotoStudent project is a perfect example for engineering students to become interested in mechanics and the championships (Carpio, 2005). They are an ideal framework for developing and implementing competencies and skills that are intended to be acquired in the classroom, and tend to complete their training in a self-taught way. It provides the understanding of the matter and causes an acquisition of knowledge and know-how, effective and permanent over time.

The championships also offer students the opportunity to meet people with other perspectives in their field and contrast the work each one has done. This type of activities makes students understand the difference between doing calculations in the classroom and doing them in a real case. Since it is not the same to calculate a beam of a practical case of a book, than to calculate the resistance of a chassis, which they have designed and will manufacture. For example, to calculate the chassis they have to consider the shape of the motor, the grips and the swinging design, amongst others limitations.

Keywords: Skills, mechanics, championship, group work.

1. INTRODUCTION

Training based on competences involves integrating disciplines, knowledge, skills, practices and values. Disciplinary integration is a fundamental part of curriculum easing, especially of the study plans; in order to train more universal professionals and fit to meet the rapid changes in skills and knowledge.

The European Higher Education Area (EHEA) has promoted the development of a series of structural transformations, curricular and organizational skills in the university field (De Haro, 2012). The implementation of new university degrees and adaptation to the EHEA has performed to concrete design proposals and the development of university curricula based on competencies and learning objectives.

The competences in the European university area are connected to the process of transparent harmonization of degrees and link, directly, university education with professional world.

Also, these tests need an extra effort; the students have to solve the problems as they arise. They must discover and understand the disadvantages in order to find the best answer.

The main objective of this project is that students of Mechanical Engineering acquired specific or professionals competencies, (targeted to work performance in defined situations, proven with a pattern or standard of expected performance and showing the ability to work as a team and build relationships), and transversal outside the classroom, carrying out a program with real business world commitments.

1.1. Competence, performance and ability

The concept of competence is diverse, depending how you look at it or the emphasis given to one or the other element, but the most widespread and accepted is to know how to do in a context. Know-how, far from being understood as doing dried out alone, require knowledge (theoretical, practical or theoretical-practical) affectivity, commitment, cooperation and compliance. For example, when someone reads a text and interprets it (know-how), it executes an action (performance) in a theoretical context (text content).

When an empirical mechanic repairs a vehicle (performance) applies a practical knowledge in a practical (situation and conditions in which the performance is given) context.

For some authors (Sladogna, 2000), competitions are complex capacities that have different degrees of integration and are manifested in a wide variety of situations in the various fields of personal and social human life. They are expressions of the different degrees of personal development and of active participation in social processes. The author adds that all competition is a synthesis of the experiences that the subject has managed to construct within the framework of its broad environment, past and present. It must considered that the concept of competence can be elastic and flexible, designed to bridge the gap between intellectual and manual work.

It can be seen that the concept of competence is broad and integrates not only knowledge, but also skills, practices and actions of variously kinds (affective, collective, personal, cultural and social) in different learning and performance scenarios.

In the definition of performance we identified three conditions: observable **performance** in correspondence to a **responsibility** and achievement of certain **results**.

Therefore, performances are the observable proceedings of the person that can be described and evaluated and that express their competence. They have to do with the achievement of expected learning and the execution of assigned tasks. It is assumed that the manner in which such tasks are carried out reveals the person's basic competence.

Currently the skills are divided into hard and soft. Hard skills are identified with all academic curricular knowledge got during the formal training process. Soft or transverse skills have to do with the integrated implementation of skills, personality features, knowledge and acquire values.

Among the most sought are communicative and relationship skills, creativity, ability to work as a team, responsibility, honesty, commitment and proactive problem solving and innovative that help drive the growth of the organization.

2. OBJECTIVES

The main objective of this project is for students of mechanical engineering to acquire specific or professional competencies and transverse outside the classroom, carrying out a program, with real-world

business commitments. The competencies most demanded by the companies are:

- Work group.
- Troubleshooting.
- Communication skills.
- Ability to organize and plan.
- Proactivity / Initiative.
- Honesty and professional ethics.
- Positive attitude.
- Capacity for empathy.
- Adaptability to change.
- Pressure tolerance.

All the skills will have to be demonstrated to them or they will have to be worked in a project as presented to them. Students will have to work as a team and against other teams. They will have a tight budget, fulfil a schedule and deadlines, work closely with companies and institutions directly related to the world championship, take advantage of the freedom of engineering programs (credits of free choice, final degree project, etc) to integrate them and improve their curriculum, use the most advanced systems in the design and analysis to carry out a real project.

Ultimately, they will work as if they were a real motorcycle manufacturing company, since they will be submitted to technical constraints and economic limitations, and will be evaluated many aspects of their work.

3. METHODOLOGY

It is an educational project where students participate in an international championship, against Europe and South America universities, of motorcycle races. To do this, they have to design, manufacture and evaluate a prototype of a championship motorcycle with a cylinder capacity of 250 cc. It was begun to build from a kit provided by the organization (brakes, suspension, tires and motor), the other choices are free for students. These choices are put to the test and are valued in a final test in an official circuit of the motorcycling world (MotorLand Aragón, Spain).

Participants test their creativity and skills to innovate, implementing their abilities as engineers against other teams. They have a lot of flexibility in the overall design of the motorcycle, they must fulfil with a minimum safety measures and dimensions in the assigned areas. The challenge for the students is to develop a motorcycle that is able to successfully pass all the tests throughout the championship. This will provide teams the opportunity to test and demonstrate their engineering skills, creativity and business skills.

The different teams have to try to sell their product to the general public, as if they were a firm in the sector, as in any other industrial project. The challenge is not just an engineering project, but also a business model.

During the test in the circuit acceleration, braking, handling and durability were evaluated. Also they evaluated aspects in the design as manufacturing, economic considerations, aesthetics, maintenance, innovation in the design and reliability.

The team consisted of 11 students and a tutor teacher. The regulations specify a minimum of six students without a maximum limit. Each student has to pay to participate; it is the organization that sets the price per student.

The project lasted three semesters, beginning in April 2015 and ending in October 2016.

Once the team is formatted (students of the last degree courses in mechanical engineering and of the master in industrial engineering) they begin to study the bases of the competition, previously published in the web site of the organization (http://motostudent.es/). This information includes all requirements that participants and motorcycles had to fulfil.

The work to be developed has two parts: the construction of the prototype and the creation of the industrial project that are performed at the same time.

3.1. Prototype construction

The order was as follows:

- It was received the parts kit of the organization, of mandatory use by all participants and proceeded to weigh and measure all the elements and to model them by computer software.
- It was made a study of the possible chassis to construct, studying the advantages and disadvantages of each, until the final decision was made. The solution accepted was designed all through computer software.
- After designing all the parts that made up the prototype, the assembly was proceeded. The interferences between the different elements were removed and the measures were verified to comply with the regulation.
- A test and a study of the efforts were made to which the structure of the motorcycle was subjected in critical situations (maxim throttle, maxim braking and step by bend). It was important, at this point, to have well posed the resulting forces. Hereafter, they were introduced into a computer and it was performed the finite element method to achieve the most accurate result.
- For the study of the efforts, it was taken the driver and the motorcycle as a single system, so that the elements that transmit force on these were the wheels, through its anchorages, the chain and the ground through the friction.
- Once that the data was verified correct, it was made the choice of secondary transmission considering the geometry of the circuit and using a calculation table. In our case, we used the one provided by the motor manufacturer.
- To design an appropriate exhaust system, specific software was used for this task and the characteristics of the motor were considered as type of combustion chamber, type of intake, valve overlap, etc. Finally was constructed, verifying that the emission of noises does not exceed the limits established by the organization.
- At the end, with all the parts, the assembly was started and the prototype was tested in the power bank to adjust the motor performance to the maximum.

3.2. Industrial project development

Here the requirements for the industrial implantation of the new motorcycle were studied. Previously, the students have to decide the characteristics of the company they wanted to build:

- Optimization of plant size for annual production of 500 units per year, imposed by the organization, with the possibility of increasing production.
- Minimization of investment required in machinery and mobility.
- Minimization of cost in the production process.
- Outsourcing of machining and purchase of components.
- Flexibility to introduce modifications to the motorcycle.
- Creation of places of employment.
- High efficiency.
- Sustainability and reduction of environmental impact.

  To complete the project we published it in various media; a driver with a circuit license was needed and external financing through different companies that supported the project.

  The championship was developed in two phases:

- The MS1 phase, which assessed the industrial aspects, it was a demonstrative phase in which the participating teams had to expose and explain the design of the prototype performed and the industrialization project for its series production. In addition, the teams had to orally present their project before the jury and defend and justify their choice.

- The MS2 phase, which was an experimental validation phase, in which the prototypes of the participating teams that passed with a minimum of 40% of the score of the MS1 phase, would demonstrate their quality by exceeding the various test of the motorcycling circuit.

In front of a tribunal of specialists, the team has to justify all the decisions it has made and answer to the questions that the experts ask about the procedure followed.

4. RESULTS AND DISCUSSION

In respect of the didactic aspects, the students express a high satisfaction with this experience since they have carried out a real practice, where they have been able to apply their knowledge and skills, have been related with other universities and have been able to exchange views and experiences. This project also benefits the university because:

- Integrates academic work with the development of practical skills of students.
- Increases connection and exchange between University and Industry.
- It provides the industrial world and the world of motorcycling championship, engineering students with an easy profile to integrate into real needs.
- Keep, adjust and expand relations with participating universities in various forums of academics.
- MotoStudent can be used as a tool for the implementation the Bologna recommendations.

On the other hand, as less positive aspects, carrying out this kind of projects involves a lot of work and dedication. The project needs many more hours than they do in the classroom, but it is rewarding and motivating. And above all, it allows them to acquire and demonstrate competencies and experiences that would not have possible otherwise.

The implementation of educational projects outside the classroom entails a high degree of creativity. The fact that the students take part in real projects, where they can meet people outside educational field involves developing concepts and experiences of creative learning (Jeffrey, 2006).

We all know that in order to encourage the acquisition of lasting knowledge and attitudes over time, it is essential to develop experimental learning and connect the students with the work environments where they can establish relationships between the theoretical knowledge they have acquired and the practices they must develop. In this way, they leave better prepared academically and with more experience of business type.

Participation in these activities increases the opportunities to access knowledge that is difficult to acquire outside the concrete practices. These extra activities are important to develop creativity and increase motivation. And according to Maldonado (2008) it also promotes the acquisition of collaborative social skills.

5. CONCLUSIONS

Educational projects outside the classroom, in the field of championship among universities, are a way to increase the experimental load of the engineering discipline, while it facilitates the acquisition of professional and transversal competences necessary to the business world.

One disadvantage of the MotoStudent project is that it is extracurricular, it has not official recognition (without credits) and it may be difficult for the students, especially those of the fourth year, to make it compatible with passing the subjects.

From the university should be fostered all the educational possibilities that improve the preparation of the students and non-formal education is a good option.

The participation of students and teachers in this type of activities is beneficial for all. The students get a higher level of academic preparation; this will allow them to have greater professional success. On the other hand, the university gets greater academic reputation since it carries out the dissemination in technical congresses, in specialized publications and in the media.

One of the most important effects of introducing these new methodologies and teaching practices, among students, even though these are subjects of different level of education, has been that the development of emotional competencies among the participants has been boosted. Surely the fact of spending much time together, seeking a common goal, depending directly on each other, has been decisive in achieving this.

Both teachers and students have noticed strong emotional ties at the end of championship.

Several students performed their Final Degree Project, compulsory subject in Engineering, related to aspects that were working during the conduct of this activity. They have been able to apply what they learned in the championship to their teaching assignments.

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