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Fostering Employment through Interdisciplinarity: A Project-Based Case Study in Mechanical and Industrial Electronics & Automation Engineering Degrees

M. Aznar (1), A. González(1), J. I. Silvestre(1), J. López (2), R. Sánchez(3)

(1) Dept. of Engineering. Florida Universitària. Rei en Jaume I, 2, 46470 Catarroja (Valencia). +34.961220380 maznar@florida-uni.es

(2) Dept. of Electronics. Universidad de Barcelona. C/ Martí i Franquès, 1, 08028 Barcelona.

(3) Dept. of Applied Physics. Universidad Politécnica Valencia. Camino de Vera s/n 46022 Valencia.

Abstract
Present youth unemployment rates show that it is essential to deliver new initiatives that should focus on labour market realities. The objective of this paper is to present how through the Project-Based Learning (PBL) methodology, students can deliver a technical innovation project to a real company. The main parties involved are on the one hand, students belonging to the three years of both Mechanical and Industrial Electronics & Automation Engineering Degrees; and on the other, all the teachers who conduct classes in the Degrees curricula. As encouraging the acquisition of transversal competencies is fundamental towards employability, a description will be given on how these are gradually introduced throughout the Degrees. Likewise, interdisciplinarity cannot succeed without the coordination and integration among all the parties involved and therefore, this paper will present how the students, the faculty, and the company worked giving input on both positive results and pitfalls.

Keywords: PBL methodology, transversal competencies, interdisciplinarity

1.Introduction

1. Introduction – Almost 20 years have passed since the Bologna Declaration came into effect and although its implementation cannot be said to have shown a homogeneous character in every EU member country, the common ground has always been a shift from traditional teaching methodologies (where emphasis was placed on content) to a focus on the development of competencies. However, present youth unemployment rates show that this hasn´t been enough. According to Eurostat (April, 2015), youth unemployment rates in Spain have decreased: the males figure shows 21.7% in March 2015 compared to 24.4% in March 2014 (-2.7%), whereas female rates represent a difference of -1.5% in the same period (which is a significant figure of the still evident gap between males and females concerning labour market). And although these data leave room for optimism, the problem is far from solved.

Undoubtedly, high rates of youth unemployment imbalance countries' economies and affect these in the short and in the long term 1 (Aznar & Amor, 2014). Consequently, a step further is needed: real hands-on practice that would make theory and practice converge in such a way that students can perceive the actual applicability of specialized knowledge, i.e. the professional world is brought into the classroom 2 (McNair et al., 2011). What companies expect from their employees is on the one hand, an interdisciplinary focus on transversal disciplines; and on the other, the capability to work in self-managed teams that become truly operative 3 (Aznar et al., 2012). Therefore, it is of paramount importance to ensure that new initiatives (both educational and supportive for youth employment) should focus on labour market realities. Only in this way can we, educational professionals, lead our students along the path to employability. Problem-based learning makes students become closer to the professional setting and as a result, trains them towards their future careers 4 (Yadav et al., 2011). In this way, students become active and also, actors of their own learning process 5 (Dillenbourg, 2000). In order to succeed, teamwork is the key to this methodology, since it is an efficient method to acquire general competencies that could not be achieved otherwise by using traditional learning methodologies. Moreover, it enhances collaborative work, which is fundamental in the development of professional endeavours, and consequently, a motivation and a willingness to learn 6 (Alberola & Aznar, 2014).

Teamwork results are outstanding 7 (Pimmel, 2003), as there is an improvement in the quality of the technical work developed as well as in the students' teaming skills and in their attitude towards teamwork; likewise, there is clear recognition by students of their performance towards completing a somewhat complex assignment and also, of the fact that teamwork makes it possible.

Assignments must show a close interrelationship among the subjects belonging to every semester and / or academic year 8 (Aznar et al., 2015). And although interdisciplinarity helps develop transversal competencies, it cannot succeed without coordination and integration among all the parties involved 9 10 (Aznar et al., 2014; Aznar et al., 2015). These transversal competencies should facilitate our students the path onto the labour market on equal and competitive terms, compared to other European countries. For this reason, the institution established a steady way on the acquisition of those competencies, starting from the very first year of the Degrees by means of an Interdisciplinary Project (IP) (see Table I below):

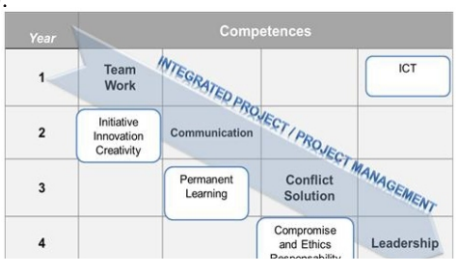

Table I: Competencies development throughout the IP

Nevertheless, they cannot be seen in isolation, since there is a clear interrelationship among them all 11 (Ortega, et al., 2013). The objective is to have reached a good command of all those competencies by the end of the Degrees in such a way that students have not been fully aware of their acquisition, and consequently, a full integration within their learning process is brought about. This gradual development must also be considered concerning the acquisition of specific content and hence, during every academic year in the Degrees, students must undertake a particular task (which is then, broken down in a number of set assignments established by every teacher in relation to their distinct subjects).

All the subjects belonging to both first and second semesters contribute to the IP and therefore, it has an annual character. Furthermore, in order to develop it, students must participate in a number of tailor-made activities: specialized seminars, which will help students develop transversal competencies on teamwork and Information and Communication

Technologies (ICTs); scheduled meetings with the team leader and the Project Coordinator, aiming to plan the work to be implemented, check on processes and outcomes, and identify areas of improvement and needs; classroom work in every subject of the year, in which students must develop the precise work established by their teachers, these becoming facilitators in every session; and finally, both autonomous and teamwork sessions are arranged in order to complement the above and are arranged by students themselves depending on their needs in order to achieve outcomes within set deadlines (the class-plan already allocates 2 hours so that teamwork is fostered among students). These activities vary depending on the semesters involved.

Therefore, the objective of this paper is to present how through the Project-Based Learning (PBL) methodology, students can deliver a technical project to a real company. The main parties involved are on the one hand, students belonging to the three years of both Mechanical and Industrial Electronics & Automation Engineering Degrees; and on the other, all the teachers who conduct classes in the Degrees curricula. As encouraging the acquisition of transversal competencies is fundamental towards employability, a description will be given on how these are gradually introduced throughout the Degrees. Likewise, interdisciplinarity cannot succeed without the coordination and integration among all the parties involved and this paper will present how the project outcomes giving input on both positive results and pitfalls.

2. Experimental – The Interdisciplinary Project (IP) described here resulted from a close cooperation between academia and the business world. The IP has been called U-builder and was proposed by the company Umnixok [12] aiming to design and pre-manufacture a robotic system to optimize both working timelines and quality in construction and, in particular, in building. This innovative project requires a technical study that matches the subjects belonging to all the semesters in Mechanical Engineering as well as in Industrial Electronics & Automation Engineering and consequently, it fits entirely the IP methodology of our institution. The major challenge in the implementation of a business innovation project in a formal education environment lies in adapting the natural stages of an industrial project to the sequencing of the subjects in the curricula. However, the scale of the objectives for the U-builder project allows the definition of many fields of study that can perfectly fit into the contents and competencies of the curricula subjects in engineering. Therefore, the teaching aim of the IP methodology could be implemented suitably without any additional limitations or difficulties other than those inherent to any interdisciplinary project. Furthermore, most of the subjects belonging to both engineering curricula could deal with certain issues towards the development of U-builder to a greater or lesser extent.

Initially, students are introduced to U-Builder aiming to implement an industrial project linked to the business world. The first-year Project is titled An Industrial Robot Applied to Construction Engineering. Students must carry out an analysis on the morphology, structure, and variables of a robot as well as its operation in a precise industrial process, i.e. in construction. More specifically, students must analyse the robot's various morphologies, trajectories, velocities, and forces; its energy transfer and consumption; its ways to detect objects and materials; the robot´s advantages before non-automated traditional technologies; and the creation of an SME (Small and Medium-size Enterprise) and their launch onto a specific foreign market (this is done in English in order to enhance students' competence of communication in a foreign language).

In the second and third academic years, the objective of the project is to give solutions to a company´s needs and consequently, both mechanical and electrical engineering students develop specific tasks related to their Degrees. The company Umnixok proposed the students to design and develop a robotic device capable of climbing up between decks and performing as a crane as well as carrying out construction tasks with higher precision and speed than an operator. The company´s desire is for the students to work as consultants and develop their automated construction system.

The U-builder system is based on an extensible robotic arm (U-arm) that is capable of climbing throughout the structure of an under-construction building thanks to a climbing device (U-tower). It should perform and collaborate in the different construction works using a variety of tools (U-apps). Due to the high complexity of the system, each team decided to focus on one of these specific sub-systems: the interchangeable tools, the main robot, or the climbing system (elevation and anchorage).

In order to illustrate this point, a description is provided of the climbing system developed by one of the student teams. They chose this system given that it was an innovative concept and also, that the idea presented room for improvement. The U-tower consists of a set of structural cylinders with four double-effect hydraulic cylinders interconnected by the outer rod to the next set. The work has been focused on the anchorage system and the "worm effect" elevation system to vertically climb throughout the structure. As described by the students themselves, "The objective of our project is the assembly of these different parts in a single, effective, and efficient system. In order to carry out this project we have focused on its different sub-systems. First of all, all the structural components have been designed to fit Umnixok´s needs. Then, the pneumatic and hydraulic systems have been calculated as well as the pumping systems, following the selection of commercial components. These have been assembled and tested using CAD software. And lastly, an automated control system has been designed together with documentation for its preventive maintenance".

3. Results and Discussion – At the end of the IP timeline, students must complete a questionnaire in order to assess the methodology and the work developed within their teams. The results show that students are satisfied with the training acquired through the IP: they granted an average score of 8 out of 10. It is worth stressing the scores from second and third year students in Electronics & Automation Engineering, i.e. 9.6 and 9.7, respectively; the lowest one (6.1) was granted by the third year students in Mechanical Engineering. Students believe this is an interesting methodology although very complex. In general, they value the opportunity that the IP offers them in order to train in transversal and specific competencies that would be difficult to achieve otherwise. Moreover, they emphasize the value of teamwork as a competence to be developed and also appreciate its socializing role and the individual contributions within the team, as the following commentary by one of the students reveals: "The IP is a magnificent experience that has provided us with a number of theoretical and practical competencies, and we have acquired the required competencies for organizing, planning, and implementing all together a number of specialized assignments, as well as having learned how to work in a team and carrying out error detection and correction. In this way our access to the labour market will be easier than for others who do not develop this kind of projects".

During the academic year 2014-2015, the IP links for the first time the needs of an actual Company from the first semester of the degrees, i.e. first-year students. This has been valued in a very positive way by the students: "The topic of the project has been very interesting, since it could give us a wider perspective on the reasons behind the subjects we study within the first year and on how these can be applied in an I+D project". However, there are certain areas that need further improvement in order to facilitate and enhance both students' and teachers' implication, as for instance a closer coordination among the various parties involved: "Some subjects lacked a bit more information from the teacher, even a greater involvement".

In the first year of the Degrees an assignment could be proposed that involves 80% of the subjects, thus making the IP clearly integrated. However, the analysis is theoretical and students still cannot see a direct link to the company. In the second year, the IP assignments are more applicable to the real company´s needs although the various subjects propose independent tasks. In the third year, the subjects take a secondary role so that the U-Builder project becomes the main goal of the IP: "U-Builder is a real concept by a company committed to innovation and creativity. It gives us the opportunity to already work as engineers".

4. Conclusions – We believe PBL is a relevant methodology in order to implement significant professional competencies and technical expertise, in such a way that it would not be feasible through traditional methodologies. Students enjoy it and particularly, the application of an assignment towards a real company´s needs. However, the coordination and implication of all the stakeholders towards a common project turns out to be very complex: if these two factors fail, the whole project fails.

After this first year of implementation, evidence has arisen that the development of an industrial project in all the years of both engineering Degrees requires an additional effort on technical coordination (and not only academic) derived from the main above-mentioned limitation: the curricula are designed from the need of a coherence in the learning process and not, obviously, from the adjustment to a defined industrial process.

Moreover, the IP was lacking a greater involvement and visibility by the company in order to achieve a greater involvement of all the parties involved. As a result, the project has become too academic and hence, an open working environment should be enabled that would be continuously managed by the project coordinators. Students tend to break the work down by subjects instead of distributing the task into the different stages of an industrial project as for example, precedent studies area, simulation area, and mechanisation or marketing area. This would definitely improve the outcomes visibility.

5. References

[1] M. Aznar, E. Amor, "Innovation in HE and EU employment policy for young people: The Spanish case", 25th SPACE Conference:

Developing Jobs, Careers and Growth via Innovative Higher Education, Barcelona, Spain (2014).
[2] L. D. McNair, C. Newswander, D. Boden, M. Borrego, "Student and faculty interdisciplinary identities in self-managed teams," Journal of Engineering Education, 100(2), pp. 374-396 (2011).
[3] M. Aznar, M. L. Martínez, J. Zacarés, A. Ortega, F. González-Espín, J. López-Sánchez, "Self-managed teams: An integrated approach to engineering education", IEEE EDUCON (Engineering Education Conference) on Collaborative Learning & New Pedagogic Approaches in Engineering Education, Marrakesh, Morocco (2012).
[4] A. Yadav, D. Subedi, M. A. Lundeberg, C. F. Bunting, "Problem-based learning: Influence on students' learning in an Electrical Engineering course", Journal of Engineering Education, 100 (2), pp. 253-280 (2011).
[5] P. Dillenbourg, "Virtual learning environments", EUN Conference 2000: Learning in the New Millennium: Building New Education Strategies for School, Workshop on Virtual Learning Environments, http://tecfa.unige.ch/tecfa/publicat/dilpapers-2/Dil.7.5.18.pdf (2000).
[6] P. Alberola, M. Aznar, "Enhancing employability from an academic perspective", CIET Conference (Contemporary Issues on Economy & Technology), Split, Croatia (2014).
[7] R. L. Pimmel, "A practical approach for converting group assignments into team projects," IEEE Transactions on Education, vol. 46(2), pp. 273-282 (2003).
[8] M. Aznar, J. Zacarés, J. López, R. Sánchez, J. M. Pastor, J. Llorca, "Interdisciplinarity robotics project for first-year engineering degree students," Journal of Technology and Science Education (JOTSE), vol. 5(2), pp. 151-165 (2015).
[9] M. Aznar, V. Contreras, J. Llorca, J. López, R. Sánchez, J. Zacarés, "Design, development and outcomes of a teaching methodology based on an industrial project during the second year of the Bachelor Degree in Mechanical Engineering", ICEILT (International Congress on Education, Innovation and Learning Technologies), Barcelona, Spain (2014).
[10] M. Aznar, R. Pizarro, M. Herrero, "An interdisciplinary experience: Microeconomics, English Language and ICT", Journal Advances in Higher Education, vol. 7(1), pp. 112-125 (2015).
[11] A. Ortega, J. Llorca, M. Aznar, "3rd year interdisciplinary project of the degrees in Mechanical Engineering and Industrial Electronics and Automation Engineering", XXI CUIEET (Congreso Universitario de Innovación Educativa en las Enseñanzas Técnicas), Valencia (2013).
[12] Umnixok. http://umnixok.rehabi-li-tar.com