

How can we prepare future engineers to the labour market? A University-Business Cooperation project using Context and Problem-Based Learning approaches

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Abstract

The goal of this paper is to characterize the impact of a University-Business Cooperation (UBC) project on the students' learning outcomes and its added value for companies. It is based on an experience which was implemented in a 2015/2016 Mechanics Engineering Master's degree, focusing on one component of the Industrial Management course syllabus (operations and lean management). Students got acquainted with the industry/business world and experienced how companies tackle the challenge of operations' continuous improvement. Based on quantitative and qualitative analysis of students' and experts' general expectations, perceptions and attitudes towards the experience, results show very positive outcomes, pointing out critical factors to take into account for the success and improvement of this kind of UBC projects.

Keywords: Context-Based Learning, University-Business Cooperation, Active Learning, Problem-Based Learning, Engineering Education

1 Introduction

University-Business Cooperation (UBC) projects are nowadays of utmost importance in the preparation of future workers and participatory citizens. Employers frequently complain about the existing gaps between the graduates' competencies/profiles and the labour market needs, in particular with respect to the called "soft skills" (Andrews and Higson, 2008; Jackson, 2014). Current changes in society, mainly due to the rapid technological innovation, make hard skills rapidly obsolete in the search for new solutions to complex problems and tasks. Efforts need to focus on the development and daily practice of soft skills, less tangible to quantify, which include the ability for complex thinking (e.g. taking initiatives and solving problems), interpersonal communication and participatory learning (e.g. team-working, communication and leadership), personal shaping of knowledge (e.g. progressive mastery, internal drive/motivation, long-life learning) and managerial abilities that will turn individuals ready for today's dynamic and unpredictable career paths.

Growing European awareness of this concern (European Commission, 2013; OECD, 2015) has led to the inclusion of these skills in higher education curricula, along with an attempt to change the pedagogical methods and develop closer collaboration with experts and companies for curriculum reform and the redefinition of learning outcomes. Nevertheless, even though promoted by educational policies, the opportunities to develop the aforementioned skills (which are not intuitive) are generally scarce and undervalued within the Higher Education Institutions (HEI) standardized curricula - which still, in a large scale, underline the memorization, retrieval and transmission of knowledge. Evidence on this matter suggests that the adoption of UBC projects for educational purposes is less common than for research and development. Furthermore, there are few studies which assess the benefits of UBC for the educational process (European Commission, 2014), and most of them focus on technology and knowledge transfer procedures.

This paper presents a UBC project using active learning approaches in order to prepare the transition of engineering students to the labour market. It aims to contribute with a reflection on the impact of UBC projects' adoption, offering pedagogical guidance on how these can be effectively developed, retrieving a set of key conditions for their success. It discusses the results of an academic semester experience in an industrial management course, linking university and local business companies, and characterizes the impact of this approach, both at the students' and companies' levels.

2 Background

Context-Based Learning (CBL) refers to a pedagogical methodology in science and technology education that uses real-life cases in order to help students to learn through the practical experience on a subject rather than just by its mere theoretical knowledge (Rose, 2012). Some authors (Kelley and Kellam, 2009) highlight that Context and Problem-Based Learning (PBL) approaches can work together in order to produce highly conceptualized and meaningful learning experiences that focus on real-world problems, thus helping students to develop flexible problem-solving activities. However, CBL and PBL challenges teachers to acquire new competencies, such as: context handling (the transfer of concepts to other contexts), regulation (the guide and regulation of students' own learning), emphasis (the practical reason that argues why the concepts should be learnt), design (the flexibility and skill to adapt learning activities and problems to student's needs) and school innovation (these approaches should be supported by a large number of teachers in a collaborative and professional development way) (De Putter-Smits *et al.*, 2013).

CBL and PBL can be applied within University-Business Cooperation (UBC) projects, helping learners acquire knowledge, skills and competences which are essential in working life. Many studies highlight the benefits for higher education institutions in cooperating with businesses to enrich education (Forsyth *et al.*, 2009), curriculum design/delivery (Plewa *et al.*, 2014) and students' employability skills (Baaken *et al.*, 2015). According to the students' perspective, PBL within UBC projects provides a contextualised understanding of the knowledge acquired in the lectures, enhancing their motivation for learning and encourages social interactions with employers, promoting their entrepreneurial behaviour (Rossano *et al.*, 2016). However, renewing the teaching and learning processes (*e.g.* collaborative learning, solving of real-life problems, teamwork, work-based learning, professional mentoring) requires not only highly professionalised faculty, with openness and flexibility to adopt new approaches, but also the integration of new actors like tutors and trainers from the industry (Quintana *et al.*, 2016).

This rethinking process on higher education is opening alternative learning pathways. It leads to a loss by the Universities of their central role as the learning venue (University-Business Cooperation Forum, 2014), and promotes a global interaction between students and teachers, employees, organizations, public authorities and other stakeholders, creating new opportunities for cooperation through different channels, such as: research (research contracts, joint-ventures, licenses, joint scientific papers), learning/training (internships for students, graduate recruitment, conferences, workshops and seminars) and consulting (consulting services for business partners or for public institutions) (Dan, 2013).

3 Description of the approach and Research Methodology

This UBC project took place in the academic year of 2015/2016 during the 2nd semester of the Mechanics Engineering Master's degree. It focused on one component of the Industrial Management course's syllabus (operations and lean management) which is credited with 3 European Credit Transfer units. Its main objective was to get students acquainted with the industry/business world, learn how companies tackle the challenge of operations' continuous improvement and present solutions to some problems provided by the companies.

More specifically, this UBC project involved 21 mechanical engineering students who had to get acquainted with 1) value and waste concepts/activities in an industrial environment (and in general), 2) the potential of some of the most popular tools of lean management and 3) management metrics. One of the main personal and interpersonal expected outcomes included the improvement of self-confidence in solving problems and in tackling the real-world entrepreneurial challenges.

The teacher established a close collaboration with 13 different companies: 7 from the service sector (food and drinks, hospital, car parts distribution logistics, large retailer, consulting, car sales and repair, bus transportation), and 6 from the industrial production (optic lens, optic glasses, paper bags, jackhammers construction, air force, ventilation systems), which resulted in the delivery (by the contacted professionals) of a 2 hours session in the classroom with an interactive discussion of their case and context with the students, or in an interactive on site visit by the whole class in which industrial challenges were presented as well as how companies tackled them.

A previous talk between the teacher and each one of the professionals was held in order to clarify the objectives and the content of the course. It focused, in particular, on the need for the professionals, either in class (4) or in the visits (9), to provide the necessary conditions for students to observe, question and discuss the problems (inefficiencies in the processes) and the tools used to solve them.

After students went through all the visits and talks, students were organized in groups of 4 and challenged to characterize/draw the operations flow of one of the companies (each group worked on a different company) to identify the main wastes (pointed out by the lean management literature) and offer a solution for one of the identified problems using the Toyota A3 systematic problem solving sheet (Shook, 2009). Finally, they were incited to share their work with the companies. In this course component, students were evaluated based on their individual visits' reports and A3 output.

Besides preparing the visits and talks with each company, the teacher's role was to help students preparing themselves for an active engagement in the project (giving insight on "questioning" strategies), to give an overview on lean management theory, to create (with the students) and provide a template for their reports (to make sure that all the important points were covered and as a way to prepare the talks and the visits), and to review students' A3 problem sheet work with frequent feedback. It also involved the evaluation of the whole project with the collection and analysis of the companies and students' opinions about the project as well as the delivery of feedback to the companies on the results of their cooperation.

The research methodology was based on a case study research (Yin, 2013) supported by participatory observation and two questionnaires of quantitative and qualitative questions applied to all students and companies' experts involved in the experience. Both questionnaires were designed to collect students' and experts' general expectations, perceptions and attitudes towards this UBC project in order to evaluate how this kind of projects and pedagogical approach can impact students' learning and to which extent it can bring value for the companies involved.

4 Results

4.1 Students' profiles and expectations

Out of 21 students involved in the experience, 16 responded to the questionnaire (71%). The majority were male (66%), their average age was 23 years old with a very small deviation and 33% had a previous part-time work experience in small businesses like shops or bars. Almost all of them had high expectations at the beginning of the semester with this course. Only one student had a similar experience of participating in this kind of activities during his academic pathway.

4.2 Students' appreciation about the UBC project design

Most of the students (66%) found the total number of visits/talks adequate. The others found it excessive due the repetition of the same theoretical concepts in the first part of the talks/visits: "Despite being interesting and take notice of how companies work, there was a repetition of unnecessary content. It is important to understand how lean is applied in different contexts (I was surprised with the application in the case of the hospital, for example), however in the total of the 13 talks there were some cases that constantly addressed the same theoretical concepts and became repetitive." (Student 4, 29th December 2014). This aspect will lead us to address the design of the activity, namely a better preparation of the visit/talks and the selection of the professionals (e.g. objectives, goals, related topics, necessary background, communication skills and expert profile, etc.).

Most of the students found the talks/visits diverse (80%), covering a large scope of situations and contexts: "Having a talk with the head nurse of a hospital and a visit to the Air Force shows how diverse the activities were" (Student 6, 5th January 2015). Also, most of the students (80%) found the length of each visit (from 2 to 4 hours) and/or talk (2 hours) adequate. They agreed that the topics presented in each visit/talk matched the curricular cognitive objectives. However, two students would like to have a longer contact with each professional/company.

Although some students found the visits more useful than the talks in class, the great majority found both important and complementary (80%). If in the talks they had the opportunity to indirectly get acquainted with professionals' work, in the visits they could observe by themselves and confront different realities: "There is nothing better than checking what each professional transmits in relation to the reality of companies. Professionals explain in detail that information, but it is also important to see how it really happens and is processed, in real, because sometimes a picture is worth than a thousand of words" (Student 9, 10th January 2015).

4.3 Students' perceptions about the UBC project's outcomes

Students had a high attendance rate: they were present in 10 or more visits/talks, the average being 12 (92%). However, when asked about their level of participation (measured by the type and frequency of the questions that they made), results show that the average number of questions per student in each visit/talk was very low (2) - which we found quite worrying. Although we think that the main cause of this situation is students' shyness in public settings (50% of the students who had a low level of participation said that the main reason was shyness, and the others did not question so much because they did not have any doubts), these results will lead us to reflect on how to improve their level of participation.

Most students felt that their expectations were overcome (only 2 did not). They all felt motivated to repeat this experience in other courses. When asked about the teaching and learning approach, 5 students agreed that this approach clearly allowed a deeper learning compared with a traditional one (*e.g.* lectures). The others however found that the efficacy of this method may depend on the course (11).

At the end of the experience, almost all of the students (87%) felt that they understood, in general, what is lean management, as well as the challenges of its application in the enterprises' environment (73%). About 53% had a better perception of what is expected from them (as future engineers) by real companies. However, only 33% of the students felt more confident to work in a company, and more than half would have wanted a deeper exposure to specific lean management tools.

In the end of the experience more than 60% of the students found that they were prepared to identify management problems, to analyse and find the causes of inefficiencies, to propose strategies to solve them, to present and discuss these strategies with other experts or peers.

Students' general satisfaction about the UBC project

In general, students found this experience satisfactory (73%) or very satisfactory (27%) and 93% found it essential for their preparation to work as future engineers. The main reasons are related to the possibility of getting to know more closely the challenges of the industrial companies as stated by a student: "A mechanical engineer needs to have sensitivity and management skills in order to contribute with the continuous improvement in the company where he works. We have a critical role on that, and we can't be lazy with the reality that the company lives in, but we must always try to improve its processes and operations" (Student 7, 6th January 2015).

Similarly, 73% of the students thought that this course was undervalued in terms of credits: "It should be, at least, equivalent to the credits of the remaining courses, because it gives us very important tools for the labour market – many of them more important than in other theory-based courses." (Student 2, 20th December 2014). In relation to which visits/talks they liked the most and why, 3 companies were identified as not being that interesting, whereas the others were considered by all the students as very interesting and motivating, either because they presented different contexts of application (diversity) or because the professionals' communication skills were outstanding and their profiles were closely related to the students' field (mechanics).

4.4 Companies experts' profile and motivation for the UBC project

Out of the 13 companies experts involved in the experience, 11 responded to the questionnaire (85%). The majority was male (61%). They were 45 years old, in average, and their position in companies ranged from Nurse Supervisor to CEO. Almost all of them considered the participation in the UBC project as an added value

to their companies (91%), not only because it was a "great opportunity to learn from the interaction with students, making us reflect on our problems and listen to different practical solutions based on research" (Expert 3, 16th January 2015), but also to "improve our performance in problem solving" (Expert 5 and Expert 6, 2nd February 2015) or to "disseminate/open our brand and company to potential workers in the future" (Expert 10, 22nd January, 2015).

4.5 Companies experts' perceptions about the value of UBC project for students

All the companies' experts found the UBC project very positive for students. They pointed out that the link between the academic and the business world "enhances the students' perception of real-world problems, and challenges them to develop practical solutions to overcome them" (Expert 2, 14th January 2015). Also in this sense, this kind of experience can "motivate students to learn and increase their confidence to enter into the labour market" (Expert 5, 2nd February 2015).

4.6 Companies experts' general satisfaction, future expectations and evaluation of the students' proposals

The majority of the experts liked the UBC project and felt useful (66%). Some of them even thought they could have done more activities with the students. All of them stated their availability to keep participating in this kind of projects and also to extend the activities for longer periods of time. The reason for this lies in the fact that although half of the experts (5) received proposals from the students and evaluated them as useful, interesting and viable, the other half (6) did not receive any proposal from the students (due to a mismatch between the number of students' groups and companies). All the experts made suggestions for future UBC project activities such as "research projects and data analysis" (Expert 8, 18th February), "internships with mentors from the companies" (Expert 5, 2nd February 2015) or even "an annual project with more students and classes" (Expert 10, 23rd January 2015).

5 Discussion and Conclusion

This paper contributes with a reflection on the adoption of UBC projects using CBL and PBL approaches. It offers, from the students' and companies' points of view, some insight on how these approaches can enhance learning. Students made a positive appreciation in relation to the CBL and PBL experience and manifested enthusiasm in having similar activities in the future, confirming the findings of Rossano *et al.* (2016) on the benefits of PBL within UBC projects. Not only because they became more familiar with the concepts of lean management, to the point of feeling more confident in finding and presenting their solutions to problems presented by some companies, but also because they got a better understanding of the real companies' challenges and of what is expected from them at the workplace.

At the pedagogical level, like some authors suggest (De Putter-Smits *et al.*, 2013), it was possible to identify some key conditions for the experience to succeed, such as trust building between companies and the teacher (which takes time), clear objectives for each intervention (seminars and visits to the companies), the design of learning tasks and the assessment criteria which should promote a higher students' participation (through the development of critical thinking skills such as questioning). It is also important to ensure an adequate number and diversity of visits/talks, as well as the involvement of professionals with good communication skills.

Also, the experts' perceptions were assessed. All of them recognized the experience as an added value both for students and for companies, considering the possibility to keep developing this kind of projects within a larger period of time - deepening the interaction between students and companies in the problem-solving process. Clearly, the experts were enthusiastic and open to establish a closer partnership in order to strengthen the cooperation and implement/apply the students' practical proposals in their companies.

6 Limitations and Future Work

We presented the preliminary findings of a UBC project implemented with local/national business companies and engineering students. In the future, it would be interesting to run this experience in deeper collaboration between all the actors, improving this approach through a better alignment of companies' real needs and the expected learning outcomes, assessing its impact in the development and acquisition of cognitive and soft-skills by the students. Also, it would be interesting to confront the presented results with the analysis of the students' cognitive outcomes (Toyota A3 systematic problem solving sheet).

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