# Projects with the Industry for the Development of Professional Competences in Industrial Engineering and Management

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**Abstract**

Training engineering students has been evolving towards the development of professional competences, both technical and transversal. These competences will enable new engineers to apply learning resources in professional contexts with greater efficacy. Thus, these engineers will be closer to the needs of industry. A learning methodology that has been used in these contexts is Project Based Learning (PBL). This paper presents a learning process based on PBL concepts, in which five teams of 5 to 7 students of Industrial Engineering and Management from the University of Minho, Portugal, developed projects in interaction with companies during a semester. This project is supported by 5 courses of the 7th semester: Organization of Production Systems, Information Systems for Production, Integrated Production Management, Ergonomic Study of Workplaces and Simulation. The objective of the students' project is to make the analysis and present proposals for improvement of a part of the production system of a company. With the support of teachers, students should manage the interaction with an industrial company under the established partnership and present suggestions for improvements to their production system, considering contributions from the 5 courses of the semester. The aim of this paper is to describe the operational model of this PBL process, evaluate the results in terms of students' learning and in terms of the perception of industry, and finally make proposals for improving the model. The evaluation of learning outcomes is based on the analysis of students' project results, a questionnaire and a closing workshop of the project with students. The evaluation of the perception of industry partners is achieved using informal interviews with company representatives. The evaluation process shows that, from the participants' perceptions, students have developed the competences that are expected and, in general, the teams are motivated by the outcome of their projects. They referred that there should exist better mechanisms of differentiation of individual classifications within the team. From the point of view of industry, the results are considered good, but there is a tendency to propose a greater focus on the objectives and results of the project. Considering these results, a change to the model is proposed, in order to increase the direction of the project. The proposal organizes the project into two very distinct phases: (1) analysis and diagnosis phase; (2) improvement phase. This change would explore the contents and competences expected of all courses during the analysis and diagnosis phase, and in second phase, the project would focus on developing specific solutions for the enterprise.

Keywords: Project-Based Learning; Professional Competences; Interaction with Industry.

## 1 Introduction

The higher education all over the world is adopting teaching and learning methodologies more student-centred and where the student plays a more active, participatory and collaborative role in the learning process. In Europe this trend was clearly enhanced by the "Bologna Process" which started with the "Sorbonne Declaration" signed in 1998 and was reinforced by the Bologna Declaration, signed in June 1999. This declaration advocates the construction, in a time horizon of ten years, of a cohesive, harmonious, competitive and attractive European Higher Education (Bologna_Declaration_CRE, 1999; Eurydice, 2010). The Bologna Process implies a new kind of education, focusing on acquiring and developing competences by active involvement of students in the learning process. But the Bologna Process also changes of focus on competences since the goal of higher education is not only the development of technical competences but also the development of transversal competences. According to Veiga-Simão (2002), emphasis should be given to problem solving, creating an environment conducive to the development of technical and transversal competences. Some of these transversal competences, like the ability to communicate effectively and the ability to work in multidisciplinary teams, are listed by ABET (2011). Communication competences, teamwork and project management are also referred by EUR-ACE (2008), as part of the competences to be developed during

the first cycle of studies in engineering. The UNESCO (2010, pp. 16, 311, 338) report for engineering describes Project-Based Learning as one of the effective methodologies whose implementation could help engineers to develop the required competences.

Project-based leaning is an active learning approach that is aligned to the main trends of today's engineering education and for many reasons it was selected by a group of teachers from the Department of Production and Systems at the University of Minho to be included in their courses. The PBL approach adopted in the Industrial Engineering and Management (IEM) degree followed the Project Led Engineering Education (PLEE) model developed by Powell & Weenk (2003) and is for many years being implemented in the first and fourth year of the IEM degree (Lima et al., 2007). This paper is focused only on the PBL editions involving students from first semester of the fourth year taking place in a real industry context. The main believe behind the PBL in industry context is that it improves the learning effectiveness and efficiency both in terms of developing technical and transversal competences. Learning by doing and the link between theory and practice can be effectively achieved by project work. This project work can be developed in academic contexts or in real industry context. As suggested by Katajavuori et al. (2006) practical training increases students' understanding of theoretical knowledge and motivation to study. Similar suggestions are referred by Nandikolla et al. (2008).

This paper describes the Project Based Learning approach that is being carried out in industry context in the IEM degree, at the University of Minho, Portugal. The main objective of this work is the evaluation the effectiveness and efficiency of the learning process in terms of the development of competences, analysis of the PBL model and the interaction with the companies. The evaluation of the learning process and the analysis of the PBL model is based on project results' analysis, questionnaires and a closing workshop with students, regarding the 2011/2012 PBL edition. Furthermore, the perception of the industry about this type of projects is based on informal interviews with company representatives.

## 2 PBL Review

Project Based Learning (PBL) is a learning methodology that puts students in the centre of the learning process, analysing an initial problem that is solved through a project, with a specific outcome. Learning approaches that put students with an active role on learning process can be linked back, among others, to Dewey (1916) work that was based on progressive education movement. This educational movement, in the 19$^{th}$ century, was focused on an approach of learning by doing, where problem solving, critical thinking and cooperative environments were central issues. PBL assumes these principles with a renewed attention. This attention comes from the aware that are some competences, in particular, transversal competences that are not learnt by the students in the traditional teaching methodology, i.e., centred on the teacher. Transversal competences like teamwork, interpersonal development competences, project and time management, problem-solving competences and creativity thinking are some competences that need learning and challenging environment where the students feel they can be involved. In this involvement, the students assume an active role and the learning responsibility and commitment come from them, not from the teacher that assumes a facilitator role. Thus, one characteristic of PBL is the opportunity to provide learning situations where students have an active participation. The commitment referred implies also having a purpose or meaning, being this other characteristic of project work defended already by Kilpatrick (1918).

Project works have been used as a platform to integrate various courses and/or academic and practical work, which can be used in projects developed in cooperation with industry (Heywood, 2005). Most of engineering students are, in general, motivated to go to industries and apply their competences on practice. Project work in the industry provides a scenario with real situations and problems. So, the inclusion of this kind of projects in curricula programmes create, usually, strong motivation and engagement in learning process, through the link between theory and practice (e.g. technical contents included in the project). This means that the learning process is based on action, assuming that people learn most effectively when working on real problems in a work environment that they know it will be their own work environment (DeFillippi, 2001).

There are some well-known project approaches to learning like the ones from Aalborg, Delft (Graaff & Kolmos, 2007) and Twente Universities (Powell & Weenk, 2003) in north of Europe. A growing interest has increased

the application of PBL in other engineering schools like the School of Engineering, University of Minho in Portugal (Fernandes, Flores, & Lima, 2012; Fernandes, Mesquita, Flores, & Lima, 2014; Lima, Carvalho, Flores, & van Hattum-Janssen, 2007) and the Faculty of Technology, University of Brasilia in Brazil (Aquere, Mesquita, Lima, Monteiro, & Zindel, 2012; Lima, Da Silva, Van Hattum-Janssen, Monteiro, & De Souza, 2012).

PBL approach with industry participation reinforces the demands of European policies to stimulate the relation between universities and enterprises (CEDEFOP, 2012; European_Commission, 2008). This purpose is based on the concern to prepare students to labour market. That is why PBL methodology can be a valuable opportunity for students to develop competences that are recognized by the employers and society.

# 3 Methodology

This paper draws upon a study that intends to describe the operational model of PBL process with interaction with industry, through an integrated analysis that allows the presentation of proposals in order to improve the current model.

This is a study with a descriptive methodological approach, concerned with finding out "what is" in a specific context, situation or phenomena (Lakatos & Marconi, 1999; Sampieri, Collado, & Lucio, 2006). According to Krathwohl (1993) the value of description emerges from the exploration and helps to organize the findings in order to fit them with explanations that can be developed into recommendations.

The dimensions considered in this study evolved, from several other studies (Alves et al., 2012; Fernandes et al., 2012; Lima et al., 2007), using emergent analysis and a reflection between researchers involved in this PBL context along several years. These dimensions have been used, with slight evolutions along the years, in an evaluation questionnaire used in this PBL approach since 2011. The analysis of results is focused on perceptions from the participants, using these dimensions, which are listed in the structure of section 5. It is a study in a small scale but the conclusions addresses improvement points or recommendations that can be considered in other similar contexts.

Descriptive research uses both quantitative and qualitative methods for gathering data, to describe the context, situation or phenomena which is considered in the study and then organizes, tabulates, depicts, and describes the data collection (Glass & Hopkins, 1984). Thus, the data collection was based on different methods and expresses the students' results achieved with the project, as well as their perceptions about the process. Perceptions from industry representatives which participated in the projects were also considered. This set of data was collected at the end of the project using four methods:

- Documental analysis: in order to describe the project, the assessment model, the expected learning outcomes and specific contents applied in the projects. The outcome of this process resulted, mainly, in the description of the project put forward in section 4.
- Survey: is composed by closed questions aggregated in six dimensions related to the project (1. project and industry cooperation; 2. learning and competences; 3. teamwork; 4. teachers' and tutors' role; 5. assessment and evaluation; 6. PBL as a learning methodology) and three open questions where students must identify positive and less positive aspects in the project, as well as suggestions to improve the projects. Questionnaires were answered by 21 students from a total of 31, which corresponds to a response rate of 68%.
- Open Discussion: during a closing workshop, with the students and teachers staff, two topics were discussed in small groups, namely the project model and assessment. After discussion each group have to share the results in order to involve all participants in the dialogue. The results are gathered in a table summarizing the perceptions for each dimension of discussion.
- Informal interviews: representatives from two companies involved in the project were questioned in relation to the overall perception about the project process and results, to the possibility of repeating their participation and potential improvement suggestions, and final about students' behaviour and results.

The data analysis is based on the information collected from different sources, accomplishing an integrated analysis about the PBL process. Thus, the dimensions defined in the survey were used as categories of analysis and from this process important evidences to be discussed arise.

# 4 PBL Model

The Integrated Master in Industrial Engineering and Management (IEM) of the School of Engineering of the University of Minho (UMINHO) is a 5 year, 10 semesters, program with 300 European Credit Transfer System (ECTS) (ECTS_EC, 2009). Each credit corresponds to 28 hours of integral work of the student. This program has three PBL semester projects, in the first, seventh and eights semesters of the program. With these projects, the course aims to have students more motivated and engaged with curricular objectives, developing both technical and transversal competences. Additionally, with the project of the seventh semester here analysed there is also the objective to put students in interaction with industrial companies.

## 4.1 Curricular Context and Assessment Model

Since 2005/2006, 7 editions of the PBL project in interaction with industrial companies have been carried out, involving almost 220 students and 13 companies from several industrial sectors (textile, footwear, wood, metal-mechanical, car electronics, and hospital equipment and measurement systems). As previously mentioned, this project occurs in the seventh semester of IEM and all the courses of that semester are Project Supporting Courses (PSC): (i) Organization of Production Systems II, (ii) Information Systems for Production, (iii) Production Integrated Management, (iv) Ergonomic Study of Workplaces, and, (v) Simulation. A sixth course – Integrated Project I – materializes the PBL project in terms of IEM curricular structure.

This paper is focused on the most recent project edition (2011/12) which engaged 5 teams, totalling 31 students, and 5 distinct companies (section 4.3). Besides the usual classes, each PSC teacher is also responsible for 2 contact hours/week (in the ambit of Integrated Project I course) dedicated to the accompanying of the students' teams, to ensure the development of the adequate technical competences. Therefore, in this model all teams have weekly contact with a technical facilitator, teacher of a specific PSC. Furthermore, each team of students is entitled to a tutor, whose main role is the monitoring of the project progress, involving a weekly meeting (1 hour). In technical terms, the tutor should only contribute for the development of the team's project management competences (including decision-making, conflict management, etc.), even if she/he has specific PSC knowledge.

The assessment model is somehow elaborated - the final grade of a specific student in a specific PSC course (course X) is computed from:

- Individual grade obtained in the project (weight x%).
- Individual grade obtained in the continuous assessment of course X (weight 1-x%).

Each PSC defines the weight of the project (x%) in its assessment:

- Organization of Production Systems II – 40%.
- Information Systems for Production – 50%.
- Production Integrated Management – 50%,
- Ergonomic Study of Workplaces – 30%
- Simulation – 30%.

The individual grade in the project is obtained by multiplying the team grade in the project by an individual correction factor determined by a peer assessment process. Within the team, the average value of the individual correction factors must be 1. Each team has the responsibility to define the number of peer assessment sessions conducted during the semester as well as the correspondent criteria.

## 4.2 Project Objectives

The project is complex and should be challenging for both students and teachers. Each students' team develops its own solution (different from all other teams). Moreover, students must develop the learning competences related with courses directly involved in the project. The objective of this project of the first semester of 4th year is to make the analysis of the production system of a company and present proposals for improvement. With the support of teachers, students should manage the interaction with an industrial company under the established partnership and present suggestions for improvements to their production system. To achieve this objective it will be necessary to analyze the production system considering the following objectives withdrawn from the 2011/12 project guide:

- Characterize and classify the production system
- Describe and diagnose the existing production system and evaluate its performance
- Identify production wastes
- Identify the key functions of production planning and control, how they relate to each other and the processes / techniques currently used for implementation
- Identify the information used and respective flows
- To characterize the workplaces from the ergonomic point of view
- To characterize the physical environment of production workstations.
- Define possible alternatives of action for improvement and expected results

This analysis will form the basis for proposals for improvements to:

- Selection of models and techniques used for production planning and control
- Specification of new performance measures.
- Change of layouts, material flow and its control
- Changes in organization of jobs and production units
- Design of new organization and management solutions for the production.
- Specification of partial configurations solutions for the information system for production planning and control.
- Modifications to the design of workplaces;
- Control parameters of the physical environment of production workstations.
- Selection of the best alternatives.

## 4.3 Industrial interaction

The 5 teams of students participating in the 2011/2012 PBL edition carried out their project in completely different companies. The process of selection of companies was performed entirely by students and therefore they end up with 5 different enterprises, varying in terms of products type, size and organizational culture. The characteristics of each company were:

- A company dedicated to car multimedia products. Large company integrated in a large multinational group, pursuing lean culture and with high degree of lean tools implemented. This company includes automatic and manual insertion of electronic components as well as manual assembly of car multimedia products in many assembly cells and lines.
- A company in the garment industry sector. Small company with around 50 employees, without any lean culture or lean tools implemented. This company is organized around two main sewing lines.
- A metalworking company dedicated to the production of components to water taps. Small company with around 40 employees, without any lean culture. The production is organized in a traditional job shop layout.
- A metalworking company dedicated to the production of saws and files. It is a small plant with around 70 employees, integrated in a large multinational group, pursuing lean culture and with an interesting degree of lean tools implemented.

- A large manufacturer of steel cylinders for low-pressure gases, with around 300 employees in the plant where the project took place. They are just starting the implementation of lean tools.

The degree of interaction between the students and the company varied but in most cases the companies' representatives followed the projects very closely and with high interest in the results.

# 5 Results

The evaluation of the project was focused on the six dimensions defined for the survey and used for the analysis of the data collected using several methods. The referred dimensions are: project objective and results; competences and learning; Project-Based Learning methodology; assessment model; teamwork; teachers' role. The results were compiled in this section presenting some graphs and analysis.

## 5.1 Project

Regarding the perception about the project (Figure 1), in general students have a positive view, mostly averaging between 3 and 4 (in a scale from 1 to 5). The main disagreement is in item 6 in which most students find that the company should not be selected by themselves. From the 21 responses to the questionnaire only two students assigned a positive weight exceeding 3. Another item, 5, is the one with greater dispersion of responses, with a standard deviation of 1.5. Therefore, this indicates that the item is less consensual, with students who feel that should be the same company for all groups and others who do not give so much importance to this aspect.

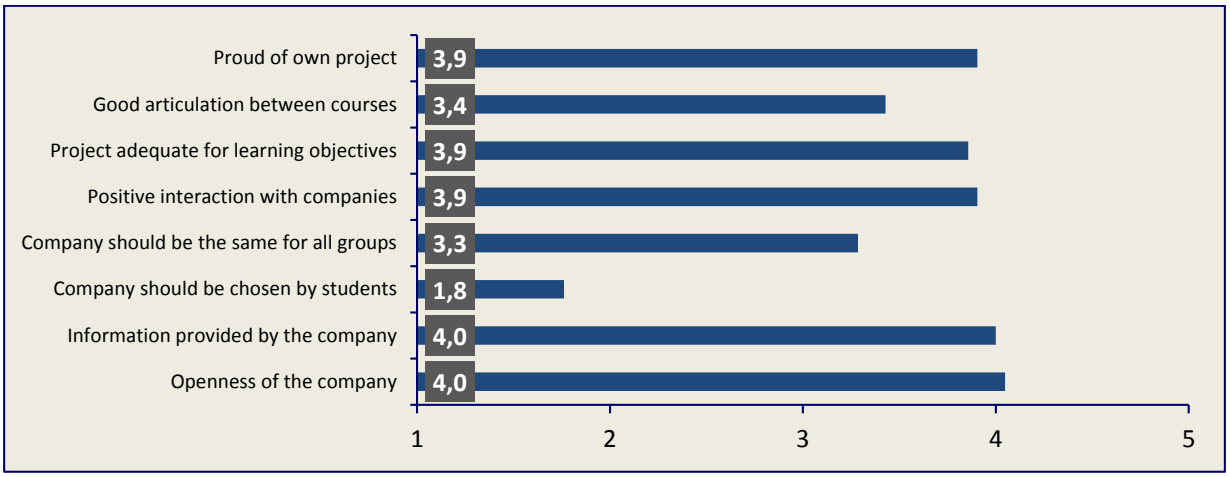


Figure 1: Project general perceptions

In the open questions of the questionnaire this dimension has two items that have been strengthened: interaction with industry; learning is in accordance with the professional profile of IEM area. A sample of two answers to the question "what you considered more positive?":

> *"Interaction with people outside the university, companies and workers, summarizing what awaits us in the world of work, because it is a small sample of the problems and difficulties which we may face. Thus we get an idea of what awaits us and we are become more able to solve problems by ourselves." Student 9*

> *"The teamwork and interaction with the industrial environment and the company's employees." Student 12*

A less positive aspect of this interaction is the difference between companies and the need to be selected by the students.

> *"The beginning was no so good and the working groups got very different companies that do not allow a fair evaluation of all groups. The weight that the project has in certain courses with some areas being assessed, in some cases, three times (project, tasks, and testing)." Student 12*

The representatives of the two companies that were interviewed showed some similarities and some differences. Both companies have shown understanding of the project model related with the integration of

various courses. Therefore they consider that the project cannot be too focused on a specific issue of the company although the company B would prefer this second approach. The company A said that a variety of methodological and conceptual approaches from the various courses has been interesting for the company. The second company (B) reported a not so deep knowledge about the outcome of the students, but still feels that the students managed a project of interest to the company. The first company (A) considered that the students presented an innovative proposal, which surprised them and deserves to be studied. To this company the result obtained by the students was a good result as can be seen by the following excerpts: "*Considering the time of the project the students got to where I did not expect*"; "*They understood the operation and found alternatives that deserve to be studied*"; "*Positive project with a lot of interest*" - *Company A*.

Regarding the question, "would repeat participation in the project?". Both companies showed answered positively only conditioned by the specific time period for its realization.

## 5.2 Competences and Learning

For all the analysed dimensions, those who had a more positive result considering the perceptions of the students were learning and competences development (Figure 2) and PBL methodology (Figure 3). These two dimensions have the highest values regarding the average of results and lower values regarding standard deviations. The development of the professional profile is the item with the most positive result of all inquiry, along with another item related to teamwork. Regarding learning aspects, the students considered that the development of competences is in accordance with the professional profile and that they developed the capacity to face challenges related to project management, communication, application of theory to real situations and strengthen the understanding of the contents, becoming more autonomous. The competence considered less developed is to give feedback and develop critical thinking. Still, it has a positive weight, although with the higher standard deviation of this dimension (1.1) indicating considerable differences among students.

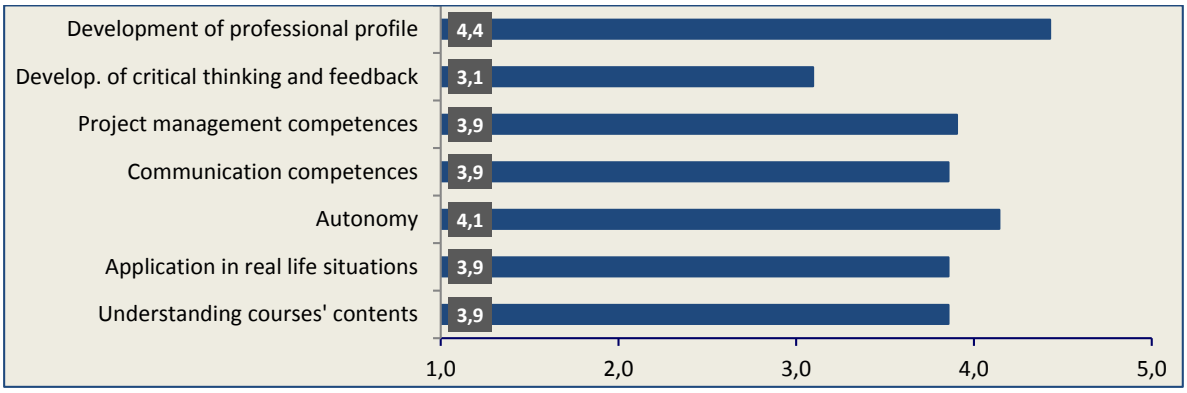


Figure 2: Competences and Learning

## 5.3 Project-Based Learning Methodology

The methodology implemented in this semester of the program has a very positive perception from the enrolled students. It may be noted that students consider that the methodology requires teamwork by teachers and has a positive impact on the relationship between students and teachers. The methodology also contributes to the understanding of the profession and the fact that the project is open is considered a challenge for students. Items with less positive perception are the "importance of the previous experience of the 1st year" and the "organization of the project", both with valuation of 3.2. In both items there is a relevant range from the viewpoint of the responses.

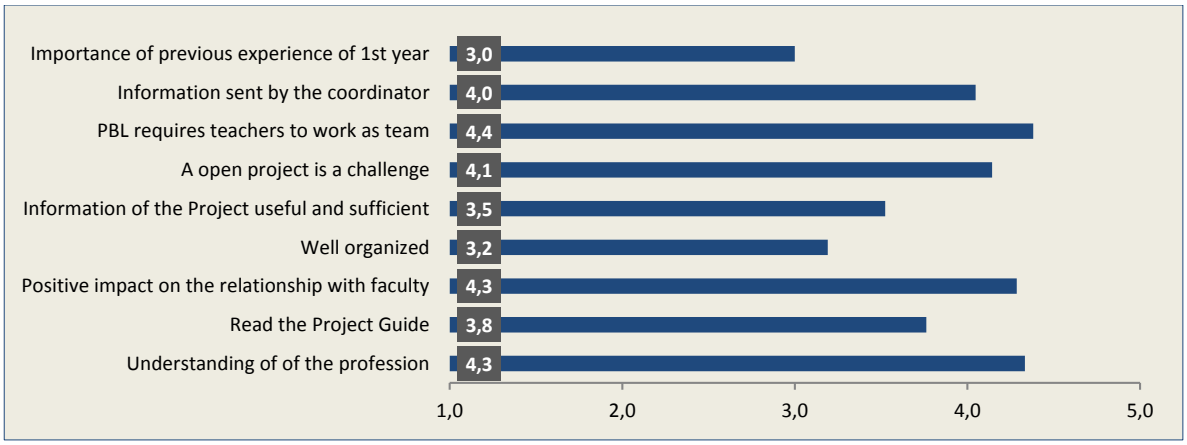


Figure 3: Project-Based Learning Methodology

Analysing the open questions on this dimension, it was possible to identify several references to less positive issues relating to the organization, namely:

> "*Some lack of organization on the part of teachers; absence of posting technical details for preparing the report.*" *Student 18*

## 5.4 Assessment Model

The project assessment is always a critical dimension from the point of view of students. However, students are generally satisfied with the results of the project, the evaluation model (only 4 students with a negative perception valued with 2), with the clarity of feedback from teachers and feel that they have read and understood the assessment criteria.

The most critical aspect is that of the peer assessment performed within each team of students to distinguish the individual grades. This item has an average rating of 3.0 and a standard deviation of 1.5 which shows a great variety in the perception of the students. There is evidence that students consider that the result of peer assessment does not reflect correctly the different performance within the team. It should however be noted that students believe that ratings should be different according to student performance.

Some of the items don't reveal a strict dissatisfaction but rather a position regarding the assessment model, including: weight of the project should be less than that of courses (with high standard deviation of 1.4); as planned, the classification of the project should be individualized; as implemented, they believe a written test about the project should not exist; and the number of milestones should be reduced.

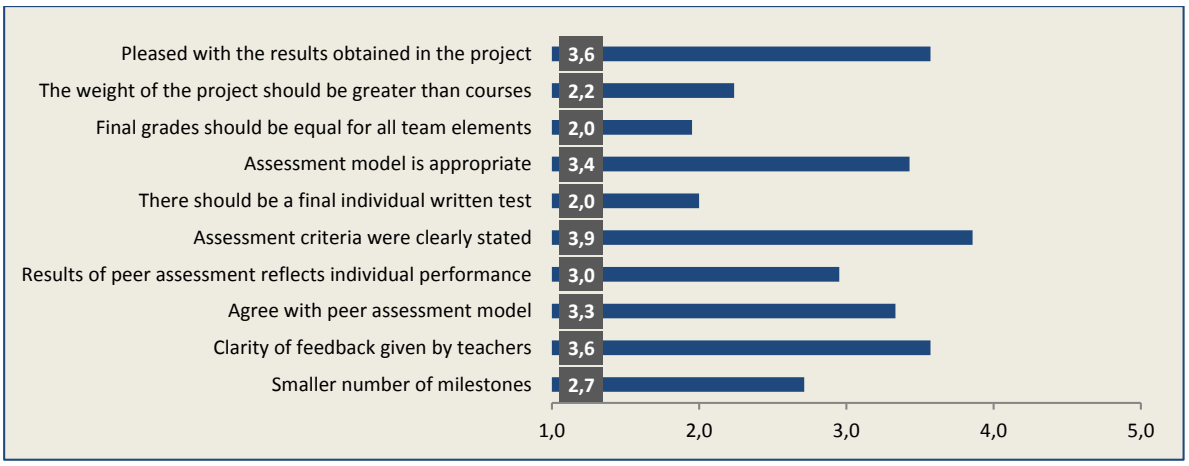


Figure 4: Assessment Model

## 5.5 Teamwork

PBL is an approach centred on teamwork that most students prefer and consider that helps to increase motivation for learning. The two most important competences for teamwork are the active role and interpersonal relationships, followed by the sharing of tasks and a positive resolution of conflicts within the group. It can be observed by Figure 5 that the item students consider less important is the implementation of formal meetings for internal organization of the teams.

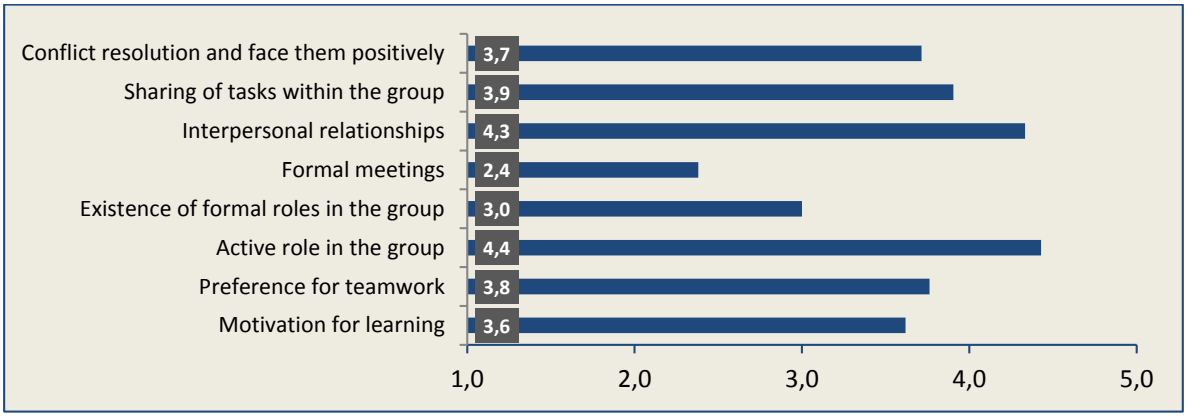


Figure 5: Teamwork

Companies were asked about the behaviour and commitment of students and both said they behaved correctly with professional ethics. The company A said that students prepared carefully the visits and ran all the relevant departments to collect information and manage to correctly understand the company. Comments like this have been recurrent in contacts made with other companies throughout the semester.

## 5.6 Teachers Roles

In this PBL model teachers have two different types of role, the teacher role related to giving technical support on the contents and development of associated competences; and the teacher role (tutor) for supporting one or two teams in developing the project and transversal competences.

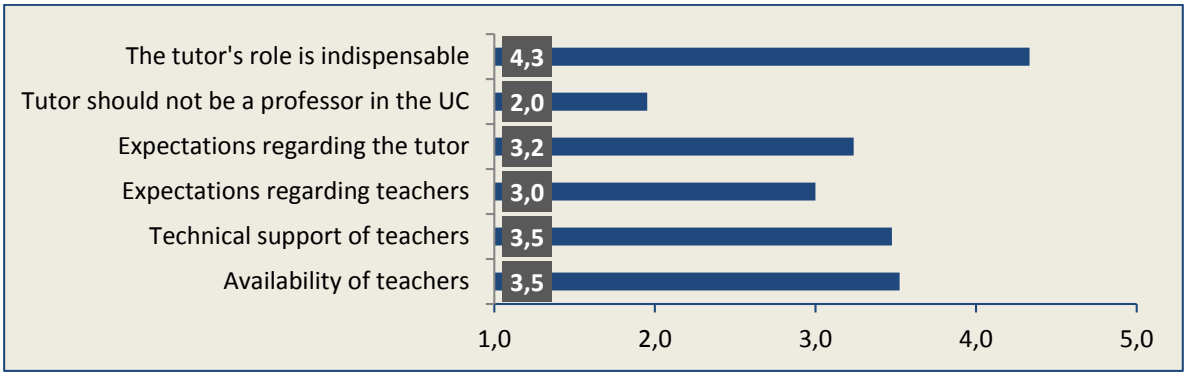


Figure 6: Teacher and Tutor Roles

Analysing open questions it emerged some comments about teachers' role. In particular considering that teachers have little time available or are not sufficiently engaged.

> *"Little willingness of teachers to answer to questions at certain times; low tutor support." Student 18*

> *"They (teachers) criticized some groups for not being integrating contents in the project in a visible way, I think there this requires more support from the tutor and the whole team because sometimes integrating some things was not easy, as regarding EEPT (course on ergonomics) and other things that were required and that in some companies did not make sense. " Student 8*

# 6 Final Remarks

In this work we sought to identify the issues that were considered less positive in a specific PBL edition, by the students and companies involved, and collect possible contributions to the improvement of the current model, according to their perceptions.

The analysis of the results leads us to reflect on this specific PBL model within the principles of project-based learning. Although most results with the students' perception about the dimensions have been evaluated positively, we highlight some pertinent observations, according to the views of students, which should be carefully examined, including: the selection of the companies for project development, project organization, feedback and development of critical thinking, the peer assessment model, final weight of the project regarded the courses, the final individual grades according to the performance of students in the project, number of milestones, teamwork formal organization with meetings and existence of formal roles in the group and finally, teacher role as a tutor. All these considerations should support the coordination team and teaching staff of the program during the planning of future editions, in order to improve the process.

Considering the comments from the companies, the students' and teachers' perceptions on the results of the project and also the interaction with companies throughout the semester and in the final, the teaching staff proposed an alternative organization for the next year project.

The proposal organizes the project into two very distinct phases: analysis and diagnosis phase; improvement phase. This change would explore the contents and competences expected of all courses during the analysis and diagnosis phase and in second phase the project would focus on developing specific solutions for the enterprise.

The first phase would have a development similar to what currently exists and the monitoring of all teachers in order that their marks and influence will have an equally impact on the project.

In the second phase there would be a selection of one or more proposals for improvement in a concerted decision among all stakeholders: students, teachers and companies. So that it is possible to improve the relevance of the project for the company, for students and also for teachers. The evaluation of this phase would be conditioned only by the courses involved in the selected improvement proposals.

A brief feedback was collected to measure receptivity to this new model and both students and companies agreed that this would be an interesting alternative to the project organization.

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# References

ABET. (2011). Criteria for accrediting engineering programs: Effective for Reviews During the 2012-2013 Accreditation Cycle Retrieved from http://www.abet.org/uploadedFiles/Accreditation/Accreditation_Process/Accreditation_Documents/Current/eac-criteria-2012-2013.pdf

Alves, A., Moreira, J. F. P., Lima, R. M., Sousa, R. M., Dinis-Carvalho, J., Mesquita, D., . . . Hattum-Janssen, N. v. (2012, 9-15 november, 2012). *Project Based Learning in first year, first semester of Industrial Engineering and Management: some results.* Paper presented at the IMECE 2012 - ASME International Mechanical Engineering Congress & Exposition, Houston, EUA.

Aquere, A. L., Mesquita, D., Lima, R. M., Monteiro, S. B. S., & Zindel, M. (2012). Coordination of Student Teams focused on Project Management Processes. *International Journal of Engineering Education, 28*(4), 859-870.

Bologna_Declaration_CRE. (1999). The Bologna Declaration on the European space for higher education: an explanation C. o. E. R. Conferences & A. o. E. U. (CRE) (Eds.), Retrieved from http://ec.europa.eu/education/policies/educ/bologna/bologna.pdf

CEDEFOP. (2012). Skill mismatch: the role of the enterprise. In European-Centre-for-the-Development-of-Vocational-Training (Ed.). Thessaloniki, Greece: Publications Office of the European Union.

DeFillippi, R. J. (2001). Introduction: Project-Based Learning, Reflective Practices and Learning. *Management Learning*, *32*(1), 5-10. doi: 10.1177/1350507601321001
Dewey, J. (1916). *Democracy and Education. An introduction to the philosophy of education*. New York: Free Press.
ECTS_EC. (2009). *ECTS Users' Guide*. Luxembourg: Office for Official Publications of the European Communities.
EUR-ACE. (2008). EUR-ACE framework standards for the accreditation of engineering programmes Retrieved from http://www.ihep.org/assets/files/gcfp-files/EUR-ACESTANDARDS.pdf
European_Commission. (2008). New skills for new jobs: better matching and anticipating labour market needs. Retrieved from http://ec.europa.eu/education/news/news1110_en.htm
Eurydice. (2010). Focus on Higher Education in Europe 2010. The Impact of the Bologna Process. Retrieved from http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/122EN.pdf (accessed: January 2011).
Fernandes, S., Flores, M. A., & Lima, R. M. (2012). Student's views of assessment in project-led engineering education: findings from a case study in Portugal. *Assessment & Evaluation in Higher Education*, *37*(2), 163-178.
Fernandes, S., Mesquita, D., Flores, M. A., & Lima, R. M. (2014). Engaging students in learning: findings from a study of project-led education. *European Journal of Engineering Education*, *39*(1), 55-67. doi: 10.1080/03043797.2013.833170
Glass, G. V., & Hopkins, K. D. (1984). *Statistical Methods in Education and Psychology*. Englewood Cliffs, NJ: Prentice Hall.
Graaff, E. d., & Kolmos, A. (Eds.). (2007). *Management of Change: Implementation of Problem-Based and Project-Based Learning in Engineering*. Roterdam: Sense Publishers.
Heywood, J. (2005). *Engineering Education - Research and development in Curriculum and Instruction*: IEEE Press, Wiley-Interscience.
Kilpatrick, W. H. (1918). The project method. *Teachers College Record*, *19*(4), 319-335.
Krathwohl, D. R. (1993). *Methods of educational and social science research: An integrated approach*. White Plains, NY: Longman.
Lakatos, E. M., & Marconi, M. A. (1999). *Técnicas de pesquisa* (4th ed.). São Paulo: Atlas.
Lima, R. M., Carvalho, D., Flores, M. A., & van Hattum-Janssen, N. (2007). A case study on project led education in engineering: students' and teachers' perceptions. *European Journal of Engineering Education*, *32*(3), 337 - 347.
Lima, R. M., Da Silva, J. M., Van Hattum-Janssen, N., Monteiro, S. B. S., & De Souza, J. C. F. (2012). Project-based learning course design: A service design approach. *International Journal of Services and Operations Management*, *11*(3), 292-313. doi: 10.1504/IJSOM.2012.045660
Powell, P. C., & Weenk, W. (2003). *Project-Led Engineering Education*. Utrecht: Lemma.
Sampieri, R., Collado, C., & Lucio, P. (2006). *Metodologia de Pesquisa* (3rd ed.). São Paulo: McGraw-Hill.
UNESCO. (2010). Engineering: Issues, Challenges and Opportunities for Development Retrieved from http://unesdoc.unesco.org/images/0018/001897/189753e.pdf
Veiga-Simão, A. M. (2002). *Aprendizagem estratégica: Uma aposta na auto-regulação*. Lisboa: Ministério da Educação.